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UMTRA-DOE/AL 050510
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United States Department of Energy

Remedial Action Plan and Final Design for Stabilization of the Inactive Uranium Mill Tailings At Green River, Utah

Final

Volume I - Text, Appendices A, B, and C

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

March 1991

Uranium Mill Tailings Remedial Action Project UMTRAP

UMTRA-DOE/AL-050510-GRN0
March 1991

URANIUM MILL TAILINGS REMEDIAL ACTION PROJECT OFFICE

ALBUQUERQUE OPERATIONS OFFICE

DEPARTMENT OF ENERGY

ALBUQUERQUE, NEW MEXICO

REMEDIAL ACTION PLAN FOR STABILIZATION OF THE INACTIVE URANIUM MILL TAILINGS SITE AT GREEN RIVER, UTAH

Approved by

Mark L Matthews

Mark L. Matthews, Project Manager
UMTRA Project
U.S. Department of Energy

U.S. Department of Energy
Agreement No. DE-FC04-81AL16257
Appendix B (Remedial Action Plan)
for Green River, Utah

SIGNATURE PAGE

THE UNITED STATES OF AMERICA
DEPARTMENT OF ENERGY

By: Mark L Matthews

Mark L. Matthews
Acting Project Manager
Uranium Mill Tailings Project Office
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, New Mexico 87115

Date: JAN 22 1990

STATE OF UTAH

By:

Ken Alkema, Director
Division of Environmental
Health
Utah Department of Health

Date: JAN 22 1990

CONCURRENCE

NUCLEAR REGULATORY COMMISSION

By: Paul H. Lohaus

Paul H. Lohaus, Chief
Operations Branch
Division of Low Level Waste
Management & Decommissioning

Date: March 22, 1990

(See TER transmittal letter dated March 22,1990,
for conditions of concurrence)

NRC/UMT/0390.0014

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAR 22 1990

Mark Matthews, Acting Project Manager
Uranium Mill Tailings Project Office
Department of Energy
Albuquerque Operations Office
P.O. Box 5400
Albuquerque, New Mexico 87115

Dear Mr. Matthews:

The U.S. Nuclear Regulatory Commission (NRC) staff has completed it's review of the final Remedial Action Plan and Site Final Design for Stabilization (RAP) and all associated documentation pertinent to the proposed remedial action for the uranium mill tailings site at Green River, Utah. Our review is documented in the enclosed Final Technical Evaluation Report (TER), which discusses the NRC staff's evaluation of the remedial action for compliance with the EPA standard.

Based on our review, we conditionally concur in the final Green River Remedial Action Plan and Site Final Design for Stabilization. The NRC staff has, however, identified one remaining issue. This issue relates to the Department of Energy's (DOE's) deferral of groundwater cleanup until after promulgation of EPA's final groundwater protection standards and is discussed in section 5.5 of the final TER. While NRC staff considers DOE's deferral to be acceptable, it precludes us from being able to fully concur in the final remedial action. Therefore, our concurrence is conditional until the staff determines that DOE has adequately addressed this issue.

As a result of our conditional concurrence, I have also signed the original signature pages transmitted to the NRC for signature on January 22, 1990. These completed signiture pages are included as Enclosure 2.

If you have any questions regarding information in the enclosed final TER, please contact me at FTS 492-0553 or the NRC Project Manager, S. L. Wastler, at FTS 492-0582.

Sincerely,

for Paul H. Lohaus, Chief
Operations Branch
Division of Low-level Waste
Management and Decommissioning

Enclosures:
1. Final TER
2. Original Signature Pages

cc: Elizabeth Damler, DOE/AL
Larry Anderson, Utah

EXECUTIVE SUMMARY

REMEDIAL ACTION PLAN
GREEN RIVER, UTAH, SITE

Background

The Green River inactive uranium [illegible]te is in Grand County, Utah, approximately one mile southeast of the city o[illegible]en River, 0.5 mile south of U.S. Highway 6&50, and 0.5 mile north of Interstate 70. The 48-acre designated site consists of the eight-acre tailings pile, the mill yard and ore storage area (23 acres), four main buildings, a water tower, and several small buildings (see Figure 3.1). The buildings are all structurally sound and are slightly contaminated, except for the more-contaminated roaster building. The excavated quantities of tailings and contaminated materials consist of approximately 204,249 cubic yards of tailings, 138,217 cubic yards of other contaminated material (including windblown contaminated soil), and 39,295 cubic yards of vicinity property contaminated material. The additional contaminated material is mostly windblown contaminated soil with a smaller amount of vicinity property material found after site and vicinity property remedial action had commenced.

Remedial Action

The remedial action will consist of the cleanup, consolidation, and stabilization of all residual radioactive materials in a subsurface disposal cell located out of the floodplain of Brown's Wash and approximately 500 feet south of the existing tailings pile. A cover including a soil infiltration/radon barrier and rock layer for protection from erosion will be placed on top of the tailings. After completion of the remedial action, the U.S. Department of Energy (DOE) will retain the U.S. Nuclear Regulatory Commission (NRC) license and perform surveillance and maintenance at the final restricted site of 22 acres.

Pursuant to the requirements of the Uranium Mill Tailings Radiation Control Act (UMTRCA), the proposed remedial action plan will satisfy the U.S. Environmental Protection Agency (EPA) standards (40 CFR 192) for cleanup, stabilization, and control of the residual radioactive materials (hereafter referred to as tailings) at the Green River site. The requirement for control of the tailings (Subpart A) will be satisfied by the construction of an engineered disposal cell. Compliance with the groundwater requirements of 40 CFR 192 Subpart A will be through meeting maximum concentration limits (MCLs) or background concentration limits (see Section E.3.1). The bottom of the cell will be approximately 40 feet below the original grade. This cell will be covered with a three-foot-thick, fine-grained, sodium bentonite amended soil to form a low-permeability layer that will reduce radon release to well below the standard of 20 picocuries per square meter per second. The infiltration/radon barrier will also limit infiltration through the tailings. The saturated hydraulic conductivity of the infiltration/radon barrier will be approximately 2×10^{-8} centimeters per second. (See Sections E.1.1 and E.3.2.) A coarse-grained, six-inch-thick filter layer will be placed above the infiltration/radon layer at a slope of 20 percent to encourage runoff of precipitation. In addition, a six-foot-thick layer of select soil fill will be placed in the bottom of the disposal cell to retard the migration of any tailings contamination downward to the water table. The combination of these design features will enable the soil layers of the disposal cell to operate together at a net infiltration rate of below 2 x 10^{-8} cm^3/cm^2s (see Section E.3.2).

With the exception of the relic groundwater plume, the standards for cleanup of the site under Subpart B of 40 CFR 192 will be satisfied with the proposed remedial action plan. Cleanup of the tailings pile, ore storage area, vicinity properties, and windblown tailings materials will be accomplished by consolidating the materials into the disposal cell. The DOE will verify that cleanup to standards has been accomplished. Cleanup of the relic groundwater plume will be addressed in a separate process after the proposed EPA groundwater standards have been finalized.

Groundwater monitoring

A groundwater performance monitoring program will be fully developed and discussed in the Green River Surveillance and Maintenance Plan. The monitoring program will include disposal cell moisture monitoring and a network of monitor wells in the saturated bedrock surrounding the disposal cell. Monitoring in the disposal cell will consist of neutron access holes into the infiltration/radon barrier and tailings to determine changes in moisture content. This will constitute an early detection monitoring mechanism for the site. Background monitor wells and monitor wells at the point of compliance will be sampled to compare changes in groundwater quality. Further explanation of the monitoring program is found in Section E.3.4.

Design changes

Changes in the disposal cell design since release of the January 1989 Remedial Action Plan (RAP) have been proposed for two reasons. First, the NRC requested changes in the design specifications (i.e., six percent bentonite added to the infiltration/radon barrier soils). Second, the topslopes of the disposal cell were changed from five percent to 20 percent to accommodate additional quantities of contaminated materials. A justification of the disposal cell design and responses to the NRC comments and agreement issues have been added in this Executive Summary and in Section 4.0.

Major design changes from the February 1988 RAP that are included in this RAP are:

1. An increase in the thickness of the sodium bentonite amended infiltration/radon barrier from 12 inches to 36 inches. (The DOE proposed increasing the thickness from 12 to 18 inches in a letter to the NRC dated August 19, 1988.)

2. The elimination of the select fill layer for frost protection. However, the thicker infiltration/radon barrier will still result in a 15-inch thickness of infiltration/radon barrier below the calculated maximum frost depth of 39 inches.

3. The placement of a six-foot-thick select fill soil layer beneath the tailings on top of the exposed bedrock at the bottom of the cell. This layer will increase the leachate travel time from the tailings to the point of compliance (POC).

4. A revision of the disposal cell toe to increase contaminated material capacity and slightly reduce the amount of type B riprap needed to protect against erosion.

5. The deeper excavation of the disposal cell by 17 feet to provide capacity for additional contaminated materials and the select fill soil layer. By deepening the cell rather than expanding horizontally, the design still minimizes the surface area upon which precipitation will fall and infiltrate into the cell.

6. The infiltration/radon barrier will be amended with six percent sodium bentonite instead of three percent. A requirement was added that the first lift of the infiltration/radon barrier must have 70 percent of the material passing the No. 200 sieve and the remaining infiltration/radon barrier must have 50 percent of the material passing the No. 200 sieve. These requirements were added at the request of the NRC to increase the reasonable assurance that the performance cell would comply with the proposed EPA groundwater protection standards.

Revised specifications and drawings are presented in Appendix F. New calculations and data are in the accompanying calculation volumes.

Technical Evaluation Report open issues

The current status of the thirteen open issues defined in the April 20, 1988, Technical Evaluation Report (TER) is summarized below.

Issue	Resolution
1. The U.S. Department of Energy (DOE) has not submitted all the test data for the amended soil used in the infiltration/radon barrier and demonstration of achieving the hydraulic conductivity assumed in the design . . .	The infiltration/radon barrier thickness has been increased from one foot to three feet (see Section 4.0). The DOE has demonstrated at the Tuba City, Arizona, site that infiltration/radon barriers with a saturated hydraulic conductivity of 1.3×10^{-8} centimeters per second (cm/s) can be constructed. The saturated hydraulic conductivity of the Green River infiltration/radon barrier will be approximately 2×10^{-8} cm/s. Laboratory testing data are contained in Appendix D.4, Volume IIA of the RAP dated January 1988 and in the calculation volumes accompanying this RAP.

Issue	Resolution
2. The DOE has not established the geochemical conditions . . .	The DOE proposes to meet maximum concentration limits (MCLs) or background levels at the POC without taking credit for natural geochemical attenuation. See Section E.3.3.
3. The DOE has not determined whether a tailings amendment is necessary . . .	A tailings amendment for geochemical attenuation is not needed to meet MCLs or background levels at the POC. The DOE considers geochemical amendments to be research-level concepts that are not currently appropriate for use at Green River. See Section E.3.3.
4. The DOE has not determined whether a geochemical liner is necessary . . .	A geochemical liner is not needed to meet MCLs or background levels at the POC. However, a six-foot-thick layer of select soil fill will be placed at the bottom of the disposal cell to extend leachate travel time before reaching the POC. The select fill or buffer layer will also have the capacity to retain construction water in interstitial pore spaces. This six-foot- thick buffer layer has an unquantified capacity to neutralize acidic tailings fluids; however, this has not been considered in the overall performance of the disposal cell. See Sections E.2.1.2 and E.3.2.
5. The DOE has not determined the source of the organics in the leachate . . .	The source of detectable methylene chloride was determined to be from analytical laboratory procedures. Reanalysis of water samples from selected monitor wells at the processing site have shown that no other organic compounds are present in confirmable concentrations. See Section D.5.2.7 and accompanying calculation volumes.
6. The DOE has not specified or proposed concentration limits for all constituents found in groundwater and the tailings under Subpart A . . .	Proposed concentration limits for all listed constituents are listed in Section E.3.1.2.
7. The DOE has not specified a POC . . .	The POC is described in Section E.3.1.3 and is shown in Figures E.3.1 and E.3.2.

Issue	Resolution
8. The DOE has not estimated potential downgradient concentrations for all listed constituents . . .	Estimated potential downgradient concentrations for all listed constituents are not given because the DOE intends to meet MCLs or background concentrations at the POC for the identified hazardous constituents.
9. The DOE has not proposed a groundwater performance monitoring program . . .	The groundwater performance monitoring program is discussed in Section E.3.4.
10. The DOE has not proposed a corrective action plan . . .	The corrective action plan is described in Section E.3.5.
11. The DOE has not specified or proposed concentration limits for all constituents found in groundwater and in the tailings under Subpart B . . .	The DOE plans to address this issue fully after the proposed EPA groundwater standards have been finalized.
12. The DOE has not included a restoration plan to clean up relic groundwater contamination . . .	The DOE plans to address this issue fully after the proposed EPA groundwater standards have been finalized. See Section E.3.6.
13. The DOE has not proposed a groundwater monitoring program to verify plume movements . . .	The DOE will monitor groundwater conditions at the disposal site and at the tailings pile during tailings stabilization and as part of surveillance and maintenance following stabilization of the tailings. See Section E.3.4 for further information.

April 1989 Agreement Issues

Issue	Resolution
1. The DOE commits to provide an adequate written justification that the design of the disposal unit represents the best design to comply with the proposed EPA groundwater protection standards.	A justification of the design was provided to the NRC in May 1989 and a revised justification was provided in August 1989. The latest version of the design justification is included in this RAP in Section 4.3.5.
2. The DOE commits to assessing whether the contaminated windblown and vicinity property materials are significant sources of hazardous constituents.	Samples of contaminated windblown and vicinity property material were subjected to batch leaching and column leaching. A layer of buffer soil was also included in the lower part of the

Issue	Resolution
	leaching columns. Based on the leaching test results, the DOE believes the windblown and vicinity property materials are clean and can be considered to have properties similar to the buffer material placed at the bottom of the cell. Further explanation is provided in Section D.5.2.8 of the RAP.
3. The DOE commits to perform moisture content and hydraulic conductivity testing of the radon barrier to ensure that the as-built saturated hydraulic conductivity does not exceed 2 X 10^{-8} cm/s. The testing should have a frequency of at least one test per 2000 cubic yards of infiltration/radon barrier material.	The testing was agreed to by the DOE and the tests were performed. Results of the tests are provided in the accompanying calculation volumes. The saturated hydraulic conductivity of the radon barrier was found to be lower than 2 X 10^{-8} cm/s.
4. The DOE commits to placing and maintaining contaminated materials in the disposal cell that are less than their average steady state moisture contents and, in any case, less than five percent by volume for tailings and 10.6 percent by volume for other contaminated material.	The DOE committed to placing the material to meet the required moisture contents. However, the DOE also had to comply with requirements of the Utah Department of Health that dust be controlled during construction. Water was sparingly sprayed on construction areas to control the dust. The resulting average volumetric moisture content was 7.1 percent for tailings and 10.6 percent for other contaminated material. An evaluation of the higher moisture content in the tailings was conducted to determine if the transport time of tailings leachate would be shorter than had been predicted. The higher moisture content of the tailings was found to have an insignificant effect upon the leachate transport time. Further details of this issue are provided in Section E.3.2 of this RAP.
5. The DOE commits to mixing no less than six percent by weight of sodium bentonite into the radon barrier.	The DOE revised the specification requiring that the infiltration/radon barrier be amended with six percent (see Section 2200 of the specifications in Appendix F). Records of

Issue	Resolution
	testing conducted during construction indicate that this requirement was met during construction.
6. The DOE commits to constructing the first lift of the infiltration/radon barrier with material that has greater than 70 percent of the material passing the No. 200 sieve and material for the other lifts having 50 percent passing the No. 200 sieve.	The DOE required the subcontractor to comply with the additional particle size gradation requirements. Tests that were performed during construction demonstrated that the requirements were achieved.
7. The DOE commits to evaluating whether beryllium is a hazardous constituent in the contaminated materials at the Green River site.	Laboratory tests performed on contami-contaminated materials from the Green River site revealed that beryllium is not present in the Green River disposal cell.
8. The DOE commits to include arsenic, lead, and methylene chloride in the list of hazardous constituents.	The revised list of hazardous constituents, which includes arsenic, lead, and methylene chloride, is included in Table E.1.1 of this RAP.
9. The DOE commits to the interim concentration limits proposed in the April 1989 agreement.	The interim concentration limits have been incorporated into Table E.1.1 of this RAP.
10. The DOE commits to collecting and analyzing groundwater samples from monitoring wells 807, 812, 813, 818, and 823 on a quarterly basis during construction of the disposal unit. Post remedial action monitoring of the listed wells and new wells will be conducted on a quarterly basis for a period of two years following completion of construction.	The sampling during remedial action agreed to by the DOE was implemented. The sampling for the post remedial action period will be described in the Green River Surveillance and Maintenance Plan and is summarized in Section E.3.4 of this RAP.
11. The DOE commits to a point of compliance that is as close as reasonable to the disposal unit and extends along the entire northwest and northeast edges of the disposal unit.	The agreed upon point of compliance is illustrated in Figure E.3.1 of this RAP.
12. The DOE commits to demonstrating compliance with EPA groundwater cleanup standards of 40 CFR 192, Subparts B and C, after they have been finalized by the EPA.	Agreed.

Design options considered but rejected

Numerous options and features were evaluated for inclusion in the final design of the tailings cell but were rejected for a variety of reasons. The current design incorporates all the design innovations that are reasonable and prudent to ensure that the EPA standards will be achieved. Other concepts that have been considered (1) were found to be impractical for the Green River site; (2) are considered to be unproven technological applications; or (3) would not provide additional assurance of meeting the EPA standards.

A geochemical liner or amendment was considered, which would potentially attenuate contaminants in leachate from the tailings. Attenuation would be achieved through adsorption, absorption, or reduction reactions and could help to lower contaminant concentrations at the POC. However, these technologies have not been applied to full-scale field tests at uranium tailings piles. Thomson (1988) had determined that while batch and column tests show promising results using this concept, considerable additional testing including long-term leaching is required before it can be used with confidence. Other concerns are the possible settlement of peat amendments, and creating a bathtub effect if a lime or calcium carbonate liner clogs up. The degree of attenuation could vary widely with changes in tailings geochemistry. Due to the uncertainties inherent with geochemical modifiers, and the extended leachate travel time associated with the current design, this option was not incorporated into the cell design. The cell design will still comply with the primary EPA groundwater standards (MCLs and background concentration limits) even without a liner or amendment.

Several changes in the cover layers to further reduce infiltration were evaluated; i.e., a sodium amendment to the infiltration/radon barrier, steeper slopes, a CLAYMAX^R membrane, a soil/rock matrix layer, and a vegetated soil cover. Applying additional sodium to the infiltration/radon barrier could create a dispersed soil with a lower hydraulic conductivity. A lower cover flux rate would be beneficial to groundwater protection. However, laboratory testing resulted in only a small decrease in saturated hydraulic conductivity with large amounts of sodium bentonite (25 percent). The infiltration/radon barrier was proposed to be amended with three percent sodium bentonite. At the request of the NRC, the amount of sodium bentonite in the infiltration/radon barrier was increased to six percent. Considering the laboratory test results and that a field test of a sodium amendment for uranium tailings covers has not been conducted, it is prudent not to include an additional sodium amendment in the cover design.

Steepening the top and sideslopes of the cover would have the beneficial effect of shedding direct precipitation faster than the current design so that less net infiltration through the tailings may occur. The current design includes 5:1 (20 percent) slopes. The main drawback of steepening the slopes is that the mean diameter of the rock and possibly the rock thickness would need to be increased to compensate for faster flow velocities. Suitable quality rock for the site is being hauled from a quarry 75 miles away at great expense and relatively high transportation safety risk. Larger rock in sufficient quantities is not available from the quarry. In order to avoid the additional transportation hazards posed by using rock from an even more distant source, steepening cover slopes has not been included in the cell design.

Furthermore, the proposed design will meet the primary EPA groundwater standard without making alterations to the slopes.

Using a CLAYMAX^R geotextile/bentonite layer was considered because it could restrict saturated hydraulic conductivity through the cover to approximately 2 x 10^{-9} cm/s. The current infiltration barrier will have a saturated hydraulic conductivity of approximately 2 x 10^{-8} cm/s. The performance assessment in Section E.3.3 concludes that the current design would ensure that MCLs or background concentrations are achieved at the disposal cell POC for all identified hazardous constituents. Incorporating a CLAYMAX^R layer at the Green River site would necessitate expanding the land area occupied by the cell so that gentler slopes could be used. Sufficient land area is not available without encroaching on geomorphic features that would reduce long-term erosion protection. Considering the current design will meet the primary EPA groundwater standard, using CLAYMAX^R was not found to be necessary.

Alternative surface layers, such as rock with a soil matrix and a vegetated soil cover, were considered for use at the Green River site, but were rejected for the reasons explained below. A rock/soil matrix layer is less resistant to erosion than the current rock cover, assuming the slope angles remain the same. Slopes could be made less steep so that the soil/rock matrix would meet the criteria for protection from erosion. However, geomorphic features constrain the area available to expand the cell for longer slopes; i.e., setbacks required to protect the site from gully intrusion and retreat of the Brown's Wash escarpment. A vegetated cover was determined to be impractical for the Green River site because of the low annual precipitation (six inches). Even if a vegetated cover could be satisfactorily established, it probably would not persist over the 1000-year design life of the disposal cell because of the combination of low precipitation and occasional droughts. Again, because the current design can meet the proposed concentration limits, pursuing the change was not necessary.

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1.0 INTRODUCTION

1.1 PURPOSE

This Remedial Action Plan (RAP) has been developed to serve a threefold purpose. It presents the series of activities that are proposed by the U.S. Department of Energy (DOE) to accomplish long-term stabilization and control of radioactive materials at the inactive uranium processing site located near Green River, Utah. It provides a characterization of the present conditions of the site. It also serves to document the concurrence of the state of Utah and the U.S. Nuclear Regulatory Commission (NRC) in the remedial action. This agreement, upon execution by the DOE and the state of Utah, and concurrence by the 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, Green River, Utah, was designated as one of the sites.

The UMTRCA charged the U.S. Environmental Protection Agency (EPA) with the responsibility for promulgating remedial action standards for inactive mill sites. The purpose of these standards is to protect the public health and safety and the environment from radiological and nonradiological 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 laws and regulations. Under the UMTRCA, the DOE and the state of Utah entered into a cooperative agreement effective January 30, 1981, for remedial action at the Green River site. The DOE will fund 90 percent and the state of Utah will fund 10 percent of the allowable cost.

All remedial actions must be selected and performed with the concurrence of the NRC. In conformance with the UMTRCA, the required NRC concurrence with the selection and performance of proposed remedial actions and the licensing of long-term surveillance and maintenance of disposal sites will be for the purpose of ensuring compliance with the standards established by the EPA. Therefore, the RAP constitutes the initial document in the licensing process. A detailed listing of the responsibilities of the project participants is included in Section 6.0 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 Green River site. It includes specific design requirements for the detailed design and construction of the remedial action. An extensive amount of data and supporting information have been generated for this remedial action that cannot all be incorporated into this single document. Pertinent information and data are included with reference given to the supporting documents.

Section 2.0 presents the EPA standards, including a discussion of their objectives. Section 3.0 summarizes the present site characteristics and provides a definition of site-specific problems. Section 4.0 is an overview of the proposed action and includes a justification of the design. Section 5.0 describes the water resources protection strategy with emphasis on groundwater. Section 6.0 summarizes the plan for ensuring environmental, health, and safety protection for the surrounding community and the remedial action 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 surveillance and maintenance plan. Section 9.0 presents the quality assurance aspects of the project. Section 10.0 documents the ongoing activities to keep the public informed and participating in the project.

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

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

Appendix B, Radon Barrier Design, describes the methodology for calculating the radon cover thickness.

Appendix C, Radiological Support Plan, describes the procedures used to characterize the present radiological condition of the site and the procedures to be used to control and verify the results of remedial action activities.

Appendix D, Site Characterization, includes all pertinent data necessary for the design of the proposed remedial action. It contains a summary of the geotechnical, hydrological, radiological, meteorological, and physical data necessary to describe the existing conditions at the Green River site.

Appendix E, Water Resources Protection Strategy, explains how the remedial action will comply with the proposed EPA groundwater protection standards.

Appendix F, Final Plans and Specifications, contains the bid schedule, special conditions, specifications, and subcontractor drawings.

Two additional volumes should be considered along with the RAP. A volume of calculations and a volume of soil testing data have been compiled for review with the RAP.

1.4 COLLATERAL DOCUMENTS

The Environmental Assessment (EA) (DOE, 1988a) describes the existing conditions at the site and the expected results of the remedial action. The EA describes the proposed remedial action and alternatives, the environmental impacts of the proposed action, and includes details that are not reported in the RAP. The final EA was published in 1988.

Additional supporting documents are the Technical Approach Document (DOE, 1988b) and a document on design criteria (DOE, 1983), which provide 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. This general guidance is to be used in conjunction with the RAP as the basis or guideline for preparation of the final design documentation for 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.

Copies of these documents, as well as supporting data and calculations, are on file in the UMTRA Project Office in Albuquerque, New Mexico.

2.0 EPA STANDARDS

The requirements and considerations for long-term isolation and stabilization of tailings, radon control, cleanup of land and buildings, and protection of water quality have been discussed and published in the Plan for Implementing EPA Standards for UMTRA Sites (DOE, 1984). This document was used as a guide in the development of the RAP and is the basis for the following discussion of the EPA standards.

2.1 GENERAL

Pursuant to the requirements of the UMTRCA, the EPA promulgated health and environmental standards to govern cleanup, stabilization, and control of residual radiological materials at inactive uranium mill tailings sites. The promulgated standards establish requirements for long-term stability and radiation protection and provide procedures for ensuring the protection of groundwater quality.

In developing the standards, the EPA determined "that the primary objective for control of tailings should be isolation and stabilization to prevent their misuse by man and dispersal by natural forces such as wind, rain, and flood waters" and that "a secondary objective should be to reduce radon emissions from tailings piles." A third objective should be "the elimination of significant exposure to gamma radiation from tailings piles" (ref. preamble to Standards for Remedial Actions at Inactive Uranium Processing Sites, 40 CFR 192). These conclusions were based on a determination that the most significant public health risks associated with inactive tailings were posed by exposure of people living and working in structures contaminated by tailings. The EPA further concluded that the potential for contamination of groundwater and surface water should be evaluated on a site-specific basis.

The EPA standards are discussed in the following paragraphs and are summarized in Table 2.1.

2.2 LONG-TERM STABILITY

Isolation and stabilization of tailings in order to prevent misuse by humans and dispersion by natural forces is the primary objective of the EPA standards. Accordingly, long-term stability was emphasized in the development and promulgation of the standards. This is consistent with the guidance provided by the legislative history of the UMTRCA, which stresses the importance of avoiding remedial actions that would be effective only for a short period of time and that would require future Congressional consideration.

The EPA standard-setting process distinguished "passive controls" such as thick earthen covers, below-ground disposal, rock covers, and massive earth and rock dikes, from "active controls" such as semi-permanent covers, warning signs, and restrictions on land use. Active control covers could be expected to need frequent replacement or other

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

major repairs requiring the appropriation and expenditure of public funds. In setting the standards, the EPA called for designs that rely primarily on passive controls.

The standard is framed as a longevity requirement that recognizes the difficulty in predicting very long-term performance with a very high degree of confidence. In establishing the longevity requirement, the EPA concluded that existing knowledge permits the design of control systems that have a good expectation of lasting at least 1000 years. Therefore, a design objective of 1000 years was established to be satisfied whenever reasonably achievable, but in any case, 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, the EPA calls for such controls to be provided as an essential backup to the primary passive controls.

2.3 RADON EMISSIONS CONTROL

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

In establishing the emission limitation for tailings piles, the EPA sought to reduce both the maximum risk to individuals living very near to the sites and the risk to the population as a whole. With regard to individuals very near to disposal sites, the EPA estimates that exposure to radon emissions will be reduced by more than 96 percent. The radon standard 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 radon standards are design standards with compliance to be determined on the basis of predicted rather than measured emission rates and concentrations. The EPA states that "post-remediation monitoring will not be required to show compliance, but may serve a useful role in determining whether the anticipated performance of the control system is achieved."

In establishing the radon standard, the EPA determined that the emission limitation could be achieved by well-designed thick earthen covers and that such control techniques would be compatible with the requirements of the EPA longevity standard.

2.4 WATER QUALITY PROTECTION

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

Rather than establish specific numerical limitations for contaminant discharges or groundwater quality, the EPA determined that the most appropriate course of action would be to require site-specific analyses of potential future contaminant discharge and a case-by-case evaluation of the significance of such a discharge. The implementation guidelines for the EPA standards call for adequate hydrological and geochemical surveys at each site as a basis for determining whether specific water-protection measures should be applied.

Specific site assessments must include monitoring programs sufficient to establish background groundwater quality through one or more upgradient wells, and to identify the present movement and extent of contaminant plumes associated with the tailings piles. The site assessments further call for judgements of the need for restoration or prevention of contamination, or both, to be guided by the EPA's hazardous waste management system and relevant state and Federal water quality criteria. Decisions on specific actions to protect or restore water quality are 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 alternate water supplies, and the degree to which human exposure is likely to occur.

The UMTRCA requires that the standards promulgated by the EPA "to the maximum extent practicable, be consistent with the requirements of the Solid Waste Disposal Act, as amended." In setting the standards, the EPA determined that the statutory requirement for the NRC to concur with the selection and performance of remedial actions and to issue licenses encompassing "monitoring, maintenance, or emergency measures necessary to protect public health and safety" was consistent with the EPA regulations implementing the Solid Waste Disposal Act (47 FR 32274, July 26, 1982). Accordingly, the 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.

On September 3, 1985, the U.S. Tenth Circuit Court of Appeals remanded the groundwater standards (40 CFR 192.2(a)(2)-(3)). The EPA issued proposed standards for comment on September 24, 1987. Prior to promulgation of the final standards, the DOE intends to implement the provisions of Subpart A and C to the extent reasonably achievable within the UMTRA Project regulatory framework. When the final EPA standards are promulgated, the DOE will re-evaluate its groundwater protection plan and undertake such action as necessary to ensure that the revised standards are met. The need for and extent of aquifer restoration will be evaluated in a separate National Environmental Policy Act (NEPA) decision-making process.

In response to the Court's remand, the newly proposed EPA groundwater standards involve:

- Protection of human health and safety and the environment.
- Consideration of radiological and nonradiological hazards.
- Consistency with the requirements of the Resource Conservation and Recovery Act (RCRA), as amended.
- General standards applicable to all UMTRA Project sites (i.e., not site-specific as was the case for the remanded standards).

These items are discussed below.

Subpart A (40 CFR 192.01-192.02) consists of the requirements for control of potential contaminant releases to the groundwater at disposal sites. It incorporates the following:

- RCRA list of hazardous constituents (40 CFR 264.93).
- RCRA maximum concentration limits (MCLs) (40 CFR 264.94), background limits, or alternate concentration limits (ACLs). The establishment of ACLs must be concurred in by the NRC, be as low as reasonably achievable, and satisfy the water quality protection considerations stipulated in 40 CFR 264.94(b).
- RCRA point of compliance (40 CFR 264.95).
- Four hazardous constituents and their associated MCLs (molybdenum, radium, uranium, and nitrate) are added to those taken from the drinking water standards. (Note: an MCL for an additional constituent, gross alpha, is included separately and without discussion in Subpart A, Table A).
- A liner or equivalent beneath the disposal site if tailings contain excess water (40 CFR 192.20).
- Monitoring during a post-remedial-action period to verify design performance.
- Corrective action to be initiated within 18 months after monitoring indicates or projects an exceedance of the applicable concentration limits.

Subpart B (40 CFR 192.11-192.12) lists the standards applicable for remediating contaminated groundwater. It incorporates:

- Cleanup of the listed groundwater constituents to levels specified in Subpart A.
- Extension of the remedial period to allow for natural flushing if:

    - The groundwater is not, and is not projected to be a public drinking water source, and

    - Institutional controls will effectively protect health and satisfy other beneficial uses, and

    - Concentration limits (40 CFR 264.94) will be met in less than 100 years.

Subpart C (40 CFR 192.20-192.22) addresses supplemental standards applicable to Subparts A and B. The supplemental standards provide for alternative actions that come as close to the standards "as reasonable under the circumstances." The NRC's concurrence in the application of supplemental standards is required. The supplemental standards may be applied if protection of human health and the environment is assured (40 CFR 192.22(d)) and:

- The proposed action would cause more environmental harm than it would prevent (40 CFR 192.21(b)), or

- Restoration is technically impracticable from an engineering perspective (40 CFR 192.21(f)), or

- The groundwater is Class III (40 CFR 192.21(g)).

2.5 CLEANUP OF LANDS AND BUILDINGS

The EPA evaluated the risk associated with the dispersion of tailings off the site and concluded that the principal risk to humans was from exposure to radon daughter products inside buildings. The EPA therefore stated that the objective of the cleanup of tailings from around existing structures was to achieve an indoor radon daughter concentration (RDC) of less than 0.02 working level (WL). For open lands, the purpose of removing the contamination is to remove the potential for excessive indoor RDCs that might arise from new construction on contaminated land. The five picocuries per gram (pCi/g) and 15 pCi/g Ra-226 concentration limits for 15-centimeter surface and subsurface layers were considered adequate to limit indoor RDCs to below 0.02 WL. A secondary concern was to limit exposure of people to gamma radiation.

The standard requires that residual radioactive materials exceeding 0.03 WL be removed from buildings. In cases where levels are between 0.02 and 0.03 WL, the Federal government will have the flexibility to use measures such as sealants, filtration devices, or ventilation devices to reduce concentrations to below 0.02 WL.

3.0 SITE CHARACTERIZATION SUMMARY

This section summarizes the present conditions of the Green River site with emphasis on the radiation, geotechnical, and groundwater characteristics due to their importance in the remedial action design. The detailed characterization of the site is found in Appendix D, Site Characterization with additional data in calculation and data volumes.

3.1 SITE DESCRIPTION

3.1.1 Processing site

The Green River inactive uranium mill site is in Grand County, Utah, approximately one mile southeast of the city of Green River and 0.5 mile south of U.S. Highway 6 & 50 (U.S. 6 & 50). The 48-acresite is in Sections 15 and 22, Township 21 South, Range 16 East, Salt Lake Meridian, and is bordered by the mainline track of the Denver and Rio Grande Western (D&RGW) Railroad on the north and the recently completed Interstate 70 (I-70) on the south. The locations of the Green River tailings site, disposal area, and soil borrow site are shown in Figure 3.1.

The 48-acre designated site (Figure 3.2) consists of the tailings pile (eight acres), the mill yard and ore storage area (23 acres), four main buildings, a water tower, and several small buildings. The buildings are all structurally sound and most are slightly contaminated.

Dispersion of tailings by wind and water erosion has contaminated approximately 30 acres. The total volume of contaminated materials, including the tailings, underlying soils, windblown contaminated soils, and vicinity property materials were originally estimated to be approximately 200,000 cubic yards (cy). During construction, a total quantity of 381,761 cubic yards of tailings and contaminated material were excavated and placed in the disposal cell.

Access to the mill yard is restricted by a six-foot-high security fence with locked gates. The tailings pile is also fenced to restrict vehicle and livestock access; however, pedestrian traffic is not restricted. The remainder of the site is not fenced and access is not restricted. Radiation warning signs are posted on the fences at the site.

The surface of the tailings pile was covered with a layer of earthen material averaging six inches thick. This cover has eroded in places. Also, riprap and ditches were placed around the north and east edges of the pile to control water runoff into Brown's Wash, which parallels the site on the north.

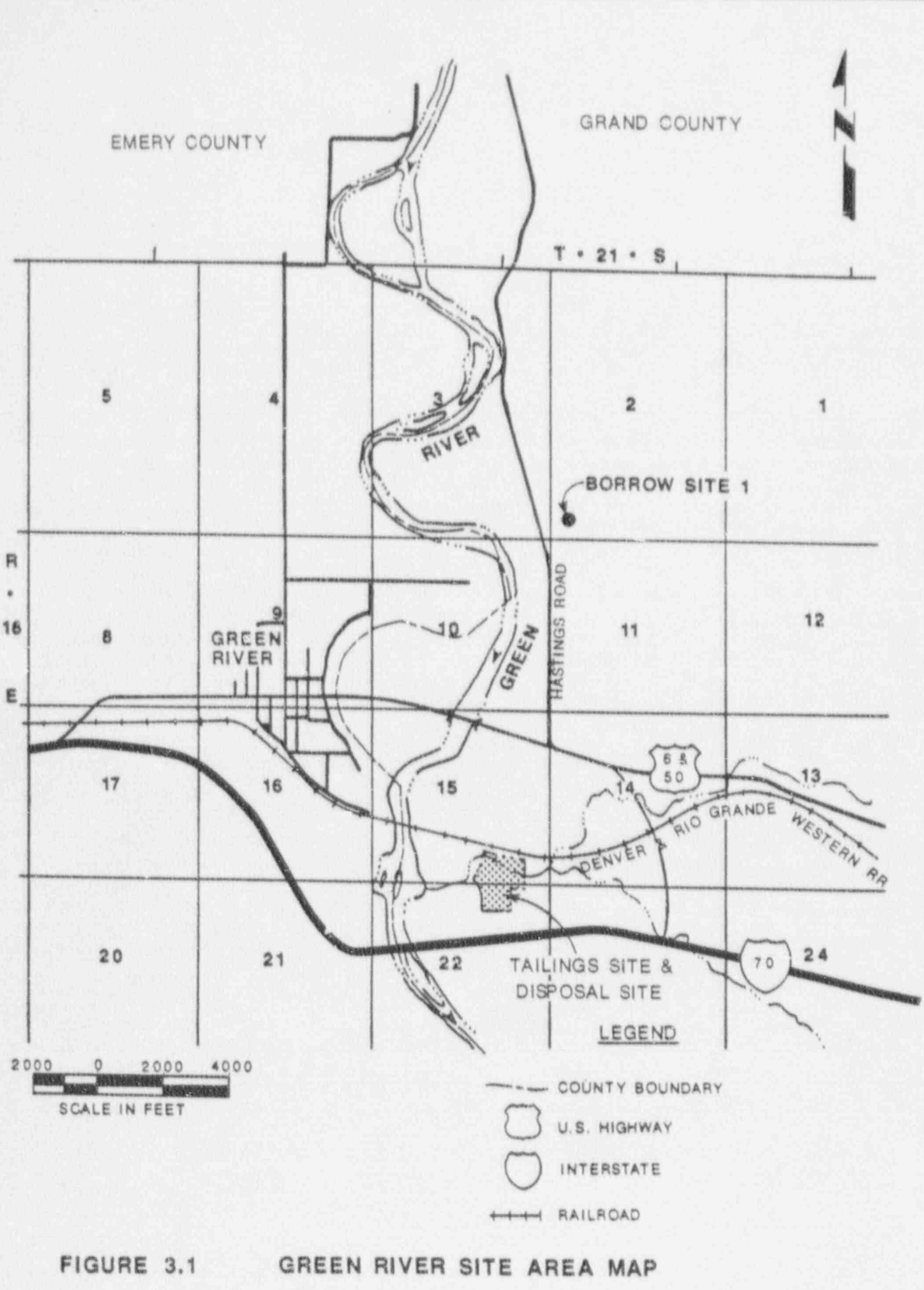


FIGURE 3.1 GREEN RIVER SITE AREA MAP

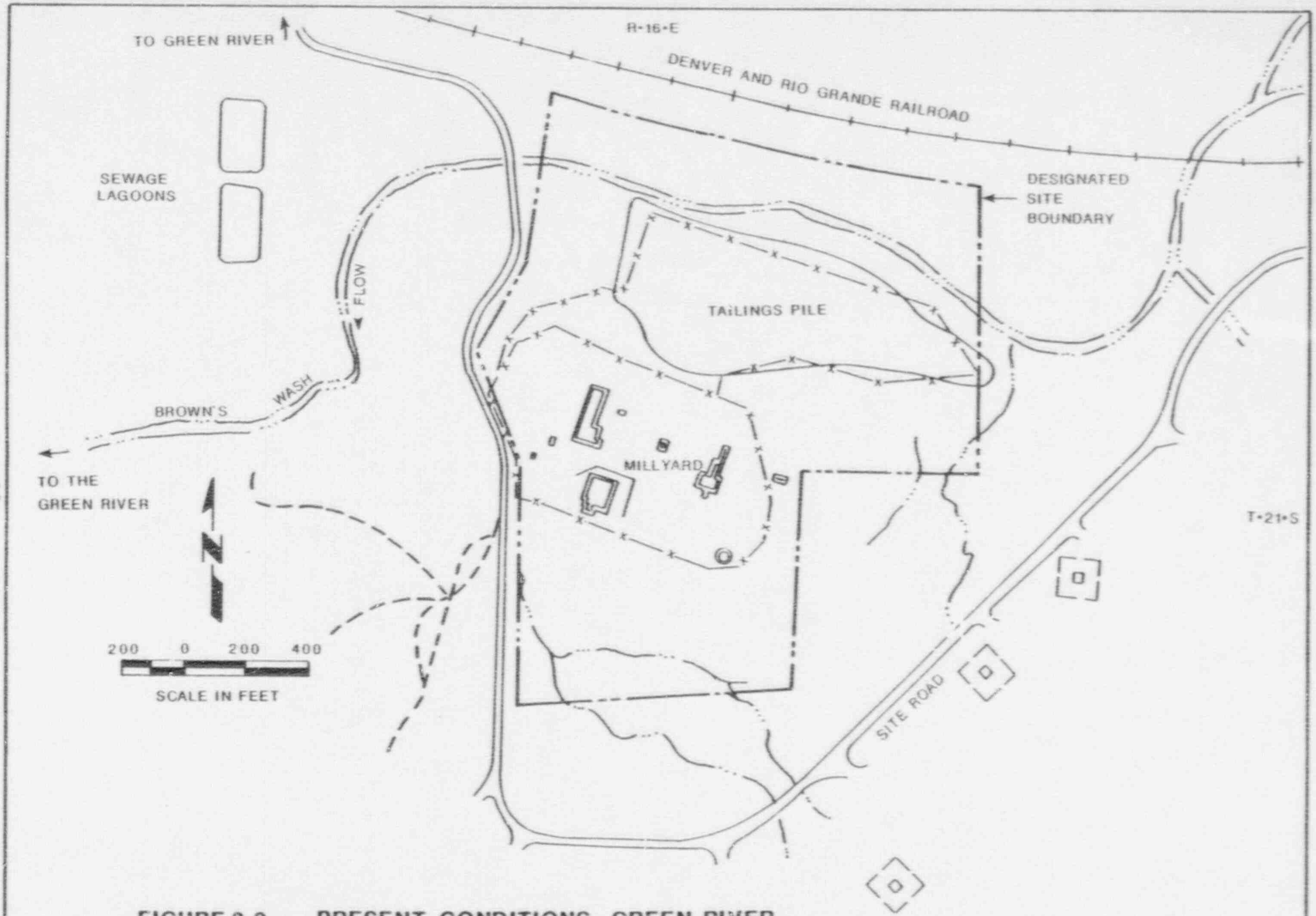


FIGURE 3.2 PRESENT CONDITIONS, GREEN RIVER TAILINGS SITE

Problem description

Three problem areas existing at the Green River site include radiation, groundwater contamination, and long-term stability. These problem areas will require remedial action in order to satisfy the intent of the UMTRCA.

Radon emissions from the site exceed the EPA standard of 20 picocuries per square meter per second (pCi/m^{2}s). Groundwater beneath the pile in the Brown's Wash alluvium and the Cedar Mountain Formation is contaminated. The long-term stability of the tailings and other contaminated materials is not assured because of the possibility for physical removal and/or erosion of tailings. The primary obstacle to long-term stability of the tailings at their present location is the potential for erosion by flood flows in Brown's Wash and runoff from the site vicinity.

3.1.2 Disposal site

In order to stabilize the tailings and meet the EPA standards, the tailings and other contaminated materials will be consolidated into a disposal cell located out of Brown's Wash approximately 500 feet south and 50 feet higher in elevation than the existing mill site (see Figure 3.2). The site occupies a level area that is disected by a shallow, ephemeral stream. This stream drains to the northwest, around the mill site. Bedrock is exposed in the bottom of the drainage near where the mill site fence parallels the site road.

The site surface is formed of pediment sand and gravel and is covered by sagebrush and wild forbes. A power line crosses the site area.

3.1.3 Radon cover and gravel borrow site

A source of radon cover material and small-diameter gravel has been identified in Section 2, Township 21 South, Range 16 East (see Figure 3.1). Access to this site is by Hastings Road, north of U.S. 6 & 50. The area is immediately north of the Elgin Cemetery and the western portion of the site is currently being used as a gravel borrow source. Surface topography is relatively flat. Vegetation consists of sagebrush and native grasses.

3.1.4 Rock borrow source

A larger diameter rock borrow source has been identified approximately 75 miles west of Green River site at Fremont Junction 21. Access is via I-70. The site is a rock quarry of primarily basalt boulders that has been used by the Utah Department of Transportation for construction of interstate highways.

3.2 RADIATION

This section summarizes the characterization of radioactive materials at the Green River uranium mill tailings site. The details of the characterization investigations and of the calculations leading to the summary values are contained in Appendix D, Site Characterization. Radiological data from the site and immediate vicinity have been collected in several investigations since 1976 (Appendix D, Site Characterization). The radiological data summarized here describe the background radiological conditions, increases of radiation above background due to the tailings, extent and degree of the contamination on the site and its vicinity (see Figure 3.3), and volume and average radioactivity of the contaminated materials.

3.2.1 Background radiation

Background radioactivity data provide a reference point to which levels of contamination can be compared in assessing the extent of contaminated areas requiring cleanup and the magnitude of radioactivity released from the site. Measurements of background radioactivity near Green River gave the following results (see Appendix D):

- o Background gamma exposure rates at one meter above the earth average 12 microroentgens per hour (microR/hr).

- o Background radium-226 (Ra-226) concentrations in soil near Green River average approximately one pCi/g.

- o The annual average background radon-22 (Rn-222) concentration in air at locations near Green River is one picocurie per liter (pCi/l) (TAC, 1988).

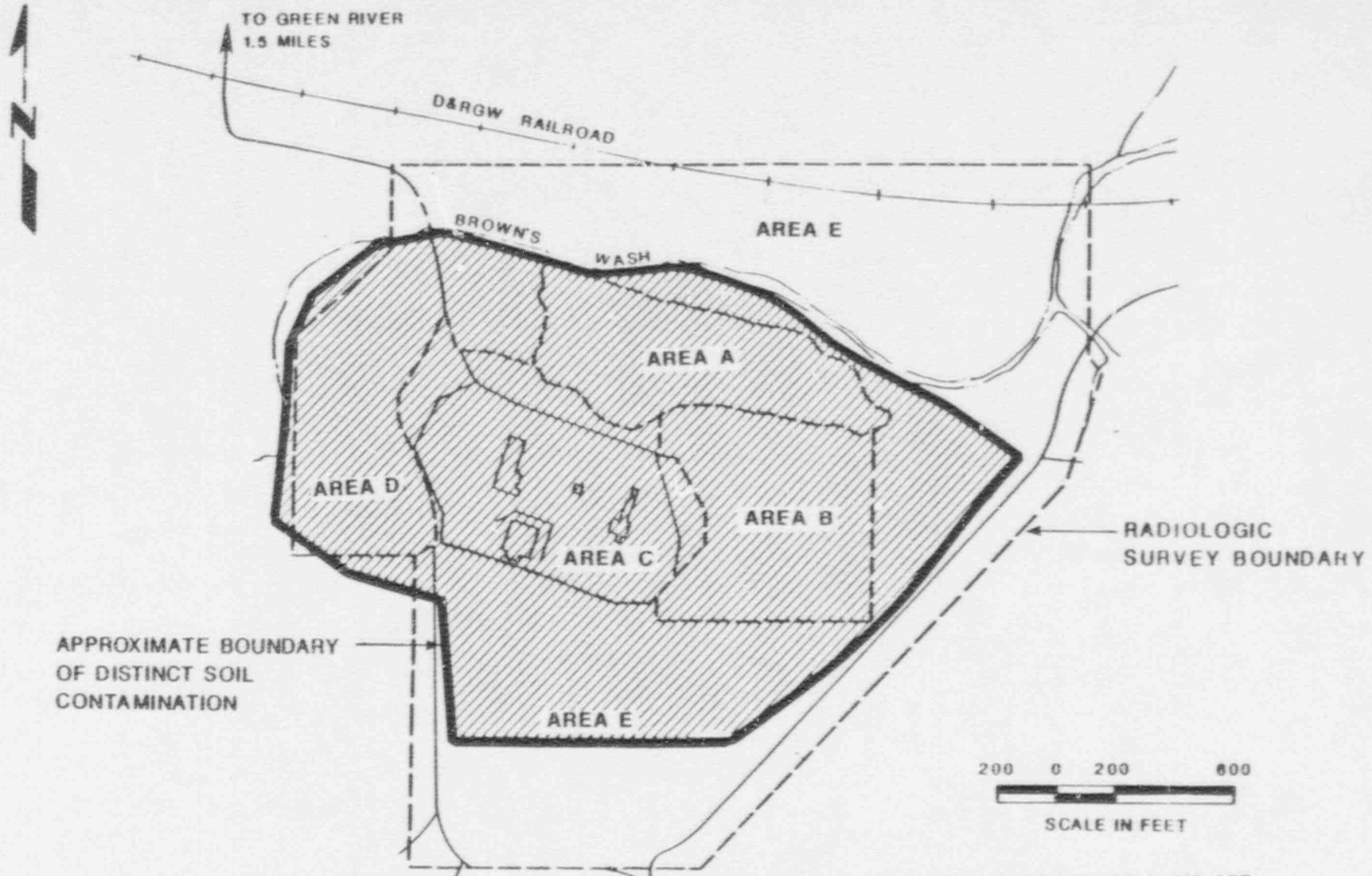
3.2.2 Existing conditions

The radioactive materials at the Green river site cause the ambient radiation levels to exceed background levels. Measurements of on-site gamma exposure rates and radon concentrations in air are summarized below (see Appendix D).

- o Gamma exposure rates on the tailings pile ranged from 30 to 112 microR/hr. Across the remainder of the site the gamma exposure rate ranged from 12 to 403 microR/hr. These measurements were taken at one meter above the surface.

- o Annual average radon measurements at the Green River tailings pile perimeter averaged 3.6 pCi/l and ranged from 1.6 to 5.9 pCi/l (TAC, 1988).

- o No measurements of radioactive air particulates were made.



NOTE: CURRENT RAC AREAS ARE ILLUSTRATED ON DRAWINGS 511 AND 512 OF THE BID SPECIFICATIONS.

FIGURE 3.3 LIMITS OF CONTAMINATION

3.2.3 Contaminant distribution

The mill at the Green River site operated from March 1958 through January 1961 as an ore upgrader. During its operation the mill processed 183,000 tons of ore averaging 0.29 percent uranium oxide, producing an ore concentrate that was shipped to a processing plant in Rifle, Colorado. The upgrading process generated an estimated 137,000 tons of sandy tailings (no slimes) that were placed in one pile near the northeast edge of the site. An estimated 14,000 tons were carried by floodwaters down Brown's Wash in 1959, leaving approximately 123,000 tons of tailings remaining at the site. When the mill was shut down in 1961, the tailings pile was covered with approximately six inches of uncontaminated soil. The plant equipment was dismantled, and the buildings were left intact.

Initial site characterization work estimated that there are 114,000 cy of contaminated material in and around the tailings pile (Area A in Figure 3.3). This volume includes soils beneath the pile contaminated by movement of tailings liquids into the underlying natural soils. The extent of subpile contamination is bounded by the depth of the soil where the Ra-226 concentration is five pCi/g. The tailings pile covers about eight acres and the associated contaminated materials (pile and subpile) have an average Ra-226 concentration of 98 pCi/g.

The former ore storage area (Area B) covers approximately nine acres. This area contains 7200 cy of contaminated soil with an average Ra-226 concentration of 30 pCi/g.

The former mill yard (Area C) contains 18,000 cy of contaminated soil covering nearly 13 acres. The average Ra-226 concentration of these soils is 24 pCi/g. Additionally, the mill yard contains four buildings: the office building, mill building, roaster, and crusher. These buildings are surficially contaminated with windblown tailings or contaminated soil.

The windblown/waterborne contamination at the site covers all of Area D and portions of Area E. These areas cover about 30 acres and contain 46,000 cy of contaminated material. The average Ra-226 concentration of these soils is 50 pCi/g. Area D generally contains deeper contamination and higher Ra-226 concentrations than the relevant portions of Area E. Brown's Wash is considered clean and only spotty, low-level contamination exists between Brown's Wash and the railroad track.

The Remedial Action Contractor (RAC) used a different methodology to estimate the volume of contaminated material and the associated Ra-226 concentration. The RAC volume estimate for the tailings pile was 144,300 cy with a Ra-226 concentration of 104 pCi/g. The RAC volume estimate for the windblown area was 45,700 cy with an average Ra-226 concentration of 34 pCi/g. The total volume of contaminated material at the site is 189,900 cy with an average Ra-226 concentration of 87 pCi/g. An additional 10,000 cy of contaminated material is expected to be generated by remedial action activities at vicinity properties. The RAC volume estimates are summarized in Table 3.1. These volume estimates are based on the areas depicted in drawings 511 and 512 of the subcontractor bid specifications in Appendix F and on subsequent calculations of contaminated material stockpiles.

Additional quantities of contaminated material were discovered at the site and at vicinity properties. The latest quantities are described in the following section.

3.2.4 Volumes of contaminated material

Table 3.1 summarizes the extent, average Ra-226 concentration, and volume of contaminated materials based on the RAC data interpretation. The volume estimates in each area are based on the depth at which the Ra-226 concentration is five pCi/g.

3.3 GEOLOGY, GEOMORPHOLOGY, AND SEISMICITY

3.3.1 Introduction

Detailed descriptions of the geology, geomorphology, and seismicity at the Green River site are presented in Appendix D, Site Characterization. Both the existing tailings pile and the proposed alternative disposal area are described. The purposes of the investigations described was basic site characterization and identification of potential geologic hazards that could affect long-term stability of the pile. Subsequent engineering studies, such as analysis of hydrologic and liquefaction hazards, use the data developed in these studies. The geomorphic information was

Table 3.1 Volumes of contaminated material at the Green River site

Description	Volume (cy)	Area (acres)	Average Ra-226 concentration (pCi/g)
Tailings pile	204,249	13.7	104
Other contaminated	138,217	38.4	34
Vicinity property material	39,295	NA[a]	NA[a]
Total[b]	381,761	52	c

[a] NA = not available.

[b] Average Ra-226 concentration is volume-weighted; quantities stated in excavated cubic yards; total in-place quantity of tailings and other contaminated material in the cell is 339,377 cy.

[c] The average Ra-226 concentration for all materials has not yet been calculated. The average for the 200,000 cy quantified in the February 1988 RAP was 87 pCi/g.

also used in the design of effective erosion protection. Studies of the regional and local seismotectonic setting, which included a detailed search for possible capable faults within a 65-kilometer (km) radius of the site, provided the basis for estimation of seismic design parameters.

Wherever major structural or seismotectonic features, such as the boundaries of seismotectonic provinces, lay outside the 65-km site radius they were generally characterized based on previously published studies, communications with researchers active in the area, and the like. If such information indicated that the features may have a significant impact on the seismic design parameters, they were subjected to the appropriate investigations and are included in the RAP.

The scope of work performed included the following:

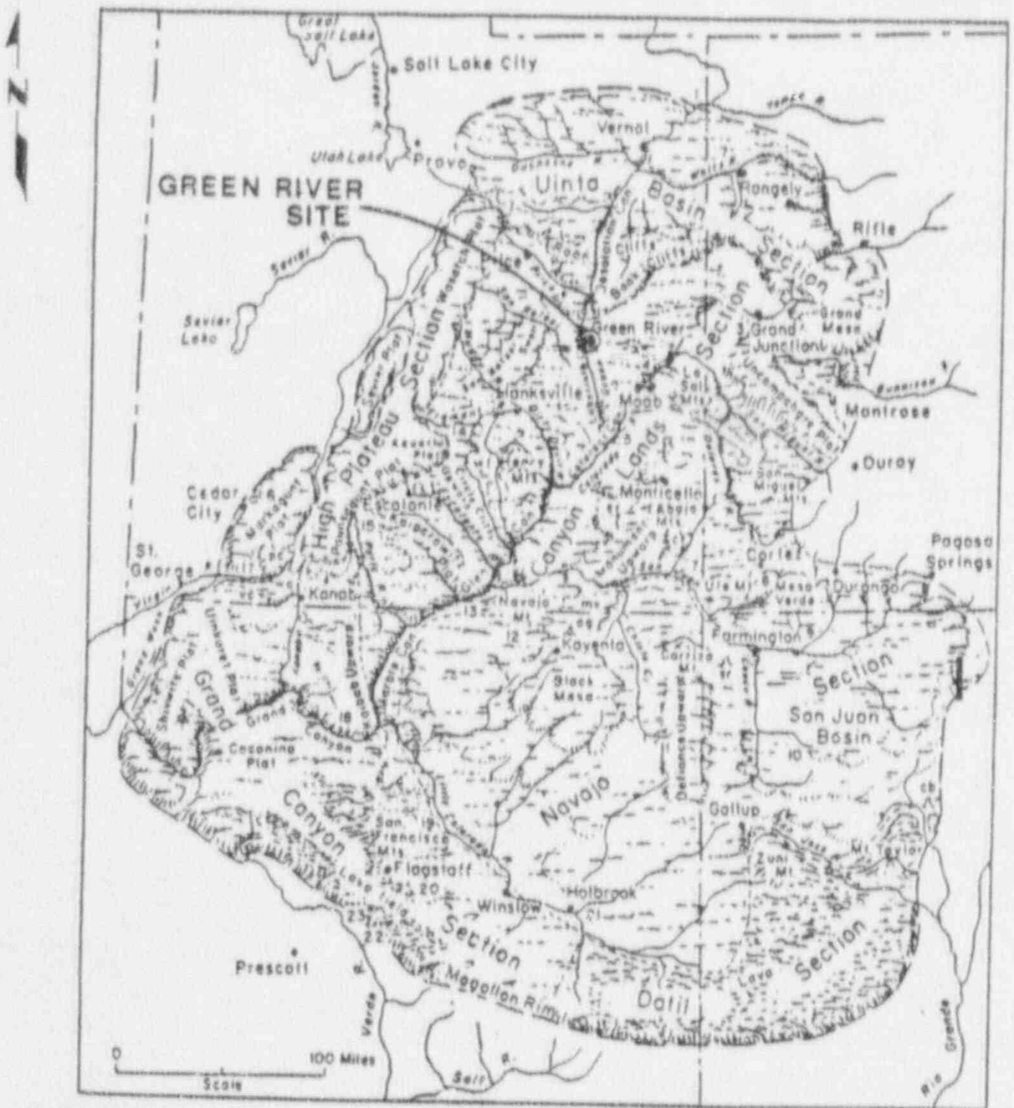
- Compilation and analysis of previously published and unpublished geologic literature and maps.
- Review and analysis of historical and instrumental seismic data.
- Review of site-specific subsurface geologic data, including logs and samples from exploratory boreholes and test pits advanced in the site area.
- Photogeologic interpretation of existing LANDSAT and conventional aerial photographs.
- Low-sun-angle aerial reconnaissance of the site region.
- Ground reconnaissance and mapping of the site region.
- Detailed mapping of the site area.
- Communications with various geologic investigators concerned with problems of the local and regional geology.

This study is substantially in compliance with the NRC's Standard Review Plan and/or 10 CFR 100, Appendix A, IV (Required Investigations).

3.3.2 Geologic setting

Physiography

The Green River site is in the northern part of the Canyon Lands section of the Colorado Plateau physiographic province (Hunt, 1967; Figure 3.4). The Book Cliffs, a few miles to the north, form the southern boundary of the Uinta Basin section. The Canyon Lands section is characterized by large structural upwarps and intervening basins formed mostly in Upper Paleozoic and Lower Mesozoic sandstones and shales. In the Uinta Basin section, thick



National Parks and Monuments

1. Dinosaur Nat. Mon.
2. Black Canyon of the Gunnison Nat. Mon.
3. Colorado Nat. Mon.
4. Arches Nat. Mon.
5. Canyonlands Nat. Park
6. Natural Bridges Nat. Mon.
7. Hovenweep Nat. Mon.
8. Mesaverde Nat. Park
9. Aztec Ruins Nat. Mon.
10. Chaco Canyon Nat. Mon.
11. Canyon de Chelly Nat. Mon.
12. Navajo Nat. Mon. (Betatakin and Kiet Seel)
13. Rainbow Bridge Nat. Mon.
14. Capitol Reef Nat. Mon.
15. Bryce Canyon Nat. Park
16. Cedar Breaks Nat. Mon.
17. Zion Nat. Park
18. Grand Canyon Nat. Park
19. Wupatki and Sunset Crater Nat. Mons.
20. Walnut Canyon Nat. Mon.
21. Petrified Forest and Painted Desert Nat. Mon.
22. Montezuma Castle Nat. Mon.
23. Tuzigoot Nat. Mon.

Escarpments at South End of High Plateaus

pc	Pink Cliffs
wc	White Cliffs
vc	Vermilion Cliffs

Other Prominent Features

wf	Waterpocket Fold
er	Elk Ridge
cr	Comb Ridge
mv	Monument Valley
ag	Agathla Peak
sr	Shiprock
cb	Cabezon Peak

REF: HUNT, 1967

FIGURE 3.4 PHYSIOGRAPHIC SKETCH MAP OF THE COLORADO PLATEAU SHOWING LOCATION OF THE GREEN RIVER SITE

Tertiary and Cretaceous sedimentary formations overlie the older rocks. The most prominent land forms in the site region are broad mesas and pediment surfaces, narrow, rock-walled gullies, and deeply incised canyons.

The site region is drained by the Green River, a major tributary of the Colorado River, which rises in western Wyoming and drains a large area of Wyoming, Colorado, and northeastern Utah. The Green River passes within about 0.5 mile west of the site. Brown's Wash, an intermittent tributary to the Green River, drains an area of about 85 square miles north and east of the site (FBDU, 1981) and flows along the north side of the existing tailings pile.

Elevation in the site region ranges from about 4000 to 9000 feet above mean sea level. Elevation of the site area varies from about 4050 to 4200 feet. To the north of the site area, in the Book Cliffs, and to the west, on the San Rafael Swell, elevations range up to 8000 or 9000 feet.

Major physiographic features of the site region are the Mancos Shale Lowland, which includes the site area, and the Book Cliffs, Roan Plateau, San Rafael Swell, Green River Desert (also referred to as the San Rafael Desert), and Salt Anticline regions (Stokes, 1977).

Bedrock units

Bedrock in the site region consists almost entirely of layered sedimentary units, ranging in age from late Paleozoic to early and middle Tertiary (Figure 3.5) (Lines, 1984; Osterwald et al., 1981; Hintze, 1980; Witkind et al., 1978; Cashion, 1973; Williams and Hackman, 1971a; Williams, 1964). These units consist mainly of sandstone, shale, and mudstone, with lesser amounts of salt, gypsum, potash, limestone, and conglomerate. Units generally decrease in age from south to north across the site region.

Units ranging in age from late Paleozoic (Pennsylvanian-Permian) to Mesozoic are exposed in the San Rafael Swell, Monument Uplift, and Paradox Basin regions to the southwest, south, and southeast, respectively, of the site. The Green River Desert (San Rafael Desert) and Mancos Shale Lowland areas, which include the Green River site area, are underlain by units primarily of mid- to late-Mesozoic (Jurassic-Cretaceous) age. To the north the Book Cliffs-Roan Cliffs and Uinta Basin areas are underlain by sedimentary units of Tertiary (Paleocene-Eocene) age, generally dipping northward at gentle angles toward the east-west-trending axis of the Uinta Basin.

Quaternary deposits in the site region generally consist of thin, discontinuous covers of alluvial deposits, pediment and terrace gravels, eolian deposits, and colluvium.

LEGEND

☐ ALLUVIAL, EOLIAN & GLACIAL DEPOSITS OF QUATERNARY AGE, UNDIVIDED

— CONFORMABLE CONTACT

~ UNCONFORMITY

▤ SHALE, SILTSTONE OR MUDSTONE

▨ SANDSTONE

▩ CONGLOMERATE

▦ LIMESTONE

X X X GYPSUM

▬ COAL

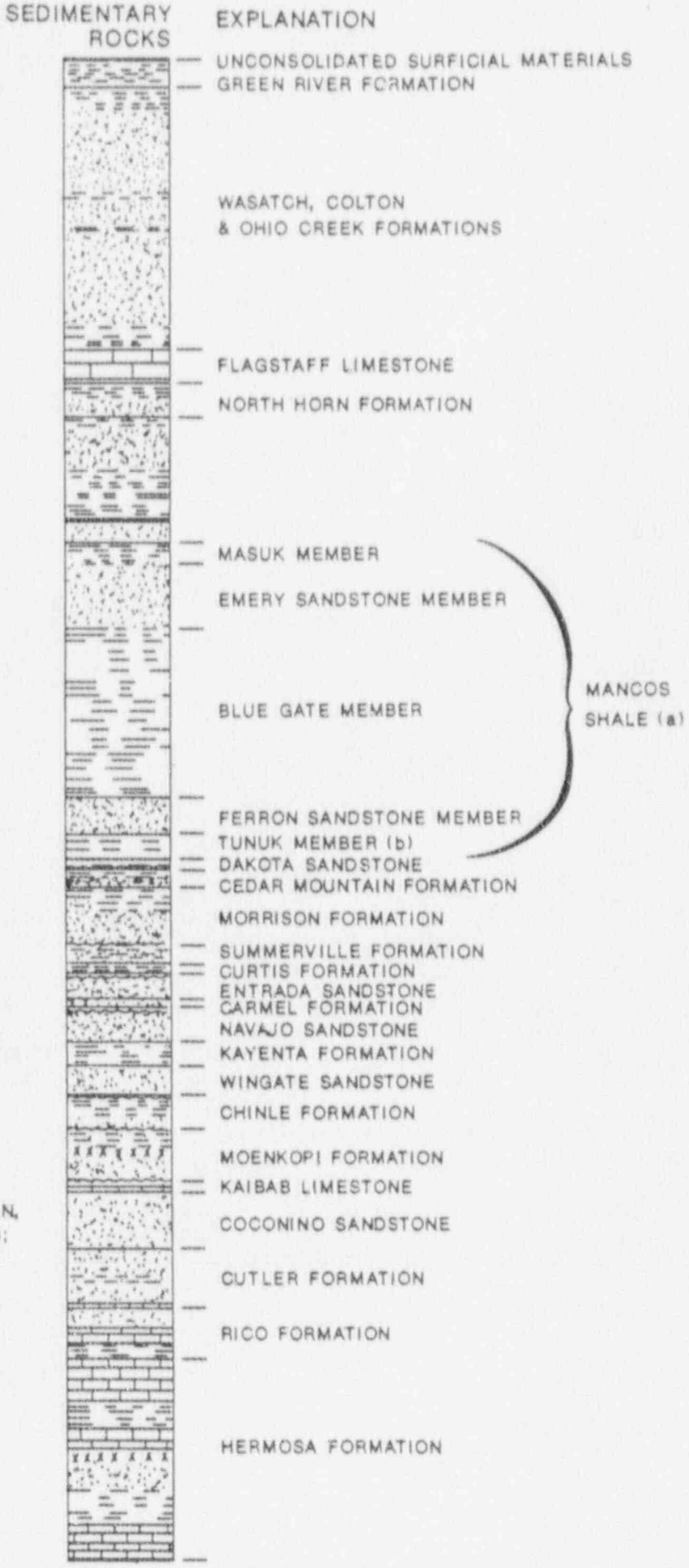
VERTICAL SCALE

0
500
1000
1500
2000

NOTE:

(a) The upper part of Mancos Shale (Masuk, Emery Sandstone, & Blue Gate Members) are undivided in site region.

(b) The stratigraphic position of the site is near the Tunuk & Cedar Mountain Contact.



REF: WILLIAMS, 1964; WILLIAMS & HACKMAN, 1971a; CASHION, 1973; WITKIND, et al, 1978; HINTZE, 1980; OSTERWALD, et al, 1981; LINES & OTHERS, 1984.

FIGURE 3.5

REGIONAL STRATIGRAPHIC COLUMN

Bedrock units exposed in the site area consist of the Tununk Shale Member of the Mancos Shale, the Dakota Sandstone, and the Cedar Mountain Formation, all of Cretaceous age.

The Tununk Shale Member of the Mancos Shale consists of dark gray, grayish brown, and black carbonaceous shale, interbedded with thin lenses of pale yellow sandstone. Exposures of this unit in the site area are strongly to moderately weathered and commonly altered to medium-plasticity silty or sandy clay. A fine shaly cleavage is commonly well-developed parallel to bedding.

Lying at the base of Tununk Shale and underlying a large part of the site area is a series of beds of sandstone, conglomerate, and limestone that are correlative to the Dakota Sandstone. The Dakota Sandstone contains distinctive beds of light gray, brown, and white, laminated to thinly bedded and occasionally banded sandstone and arkosic sandstone, varying from fine to coarse-grained; thickly bedded to massive conglomerate cross-bedding is common and rapid lateral facies changes are characteristic of the unit.

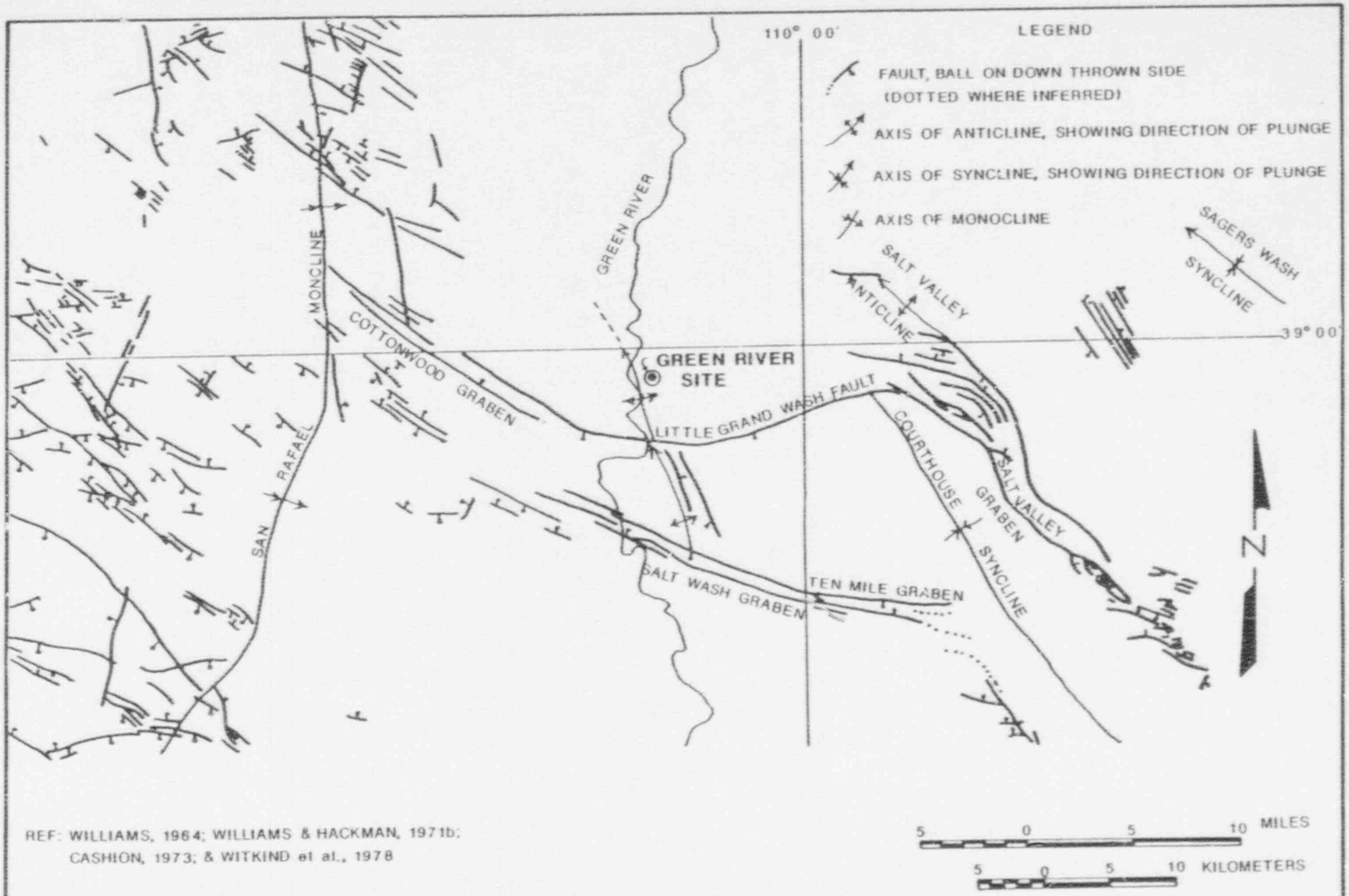
The Dakota Sandstone is unconformably underlain in the site area by a series of interbedded mudstones, shales, sandstones, limestones, and conglomerates of the Cedar Mountain Formation. This formation is correlative to the Burro Canyon Formation of western Colorado. In the site area it consists predominantly of grayish brown shaly mudstone and light gray very fine- to fine-grained calcareous mudstone, with minor sandstone and conglomerate.

Structural geology

The major structural and tectonic features of the Green River site region are the San Rafael Swell, the San Rafael Desert (Green River Desert), the Uinta Basin, the salt anticlines of the Paradox Basin, and the Monument Upwarp (Figure 3.6). These structures are primarily Laramide (Late Cretaceous-Eocene) in age.

The Green River site area lies on the north-plunging nose of a shallow anticlinal fold whose axis approximately coincides with the course of the Green River (Hintze, 1980; Williams and Hackman, 1971a,b). The nose of the anticline is repeated by an arcuate, east-west-trending normal fault that lies about 2.5 miles south of the site. Several thousand feet of Jurassic and Cretaceous strata are repeated by the fault. Crystal Geyser, a naturally occurring carbon dioxide-charged spring, occurs where this fault crosses the Green River. The geyser apparently occurs at a local relief point for carbon dioxide-charged water trapped in the Navajo Sandstone (Baer and Rigby, 1978). A narrow, arcuate graben, whose trace parallels the above fault, crosses the Mancos Shale Lowland several miles further to the south.

Bedding at the site is approximately horizontal with slight northward dips (less than five degrees), but some local folding is present in the site area. Jointing is common in the more resistant



REF: WILLIAMS, 1964; WILLIAMS & HACKMAN, 1971b; CASHION, 1973; & WITKIND et al., 1978

FIGURE 3.6 STRUCTURAL GEOLOGIC SKETCH MAP OF GREEN RIVER SITE AREA units, most commonly displaying north-northwest trends. No faults with significant displacement are known in the immediate site area.

Quaternary geology and geomorphology

Geomorphic processes acting on the site region reflect the influence of the prevailing arid to semiarid climate, variations in bedrock type, and the effects of an epeirogenic uplift of the Colorado Plateau, which began during the Miocene and has evidently continued to the present day. Erosion by fluvial, eolian, and mass-wasting processes, and transport of sediment away from the region by streams have been the dominant geomorphic processes throughout Holocene time, at least. Quaternary deposits and soils of the region record some interruptions, probably climatically induced, in the long-term stream incision process (Woodward-Clyde Consultants, 1982).

Surficial deposits are thin and discontinuous over most of the site region, and bedrock is generally exposed at or near the surface. As a result, the surface topography and landforms reflect the structure and stratigraphic variability of the underlying bedrock. In areas where relatively durable sandstones are exposed at the surface, weathering has produced a fantastic variety of landforms, including cliffs, monuments, pinnacles, fins, alcoves, tanks, natural bridges, and arches. In areas underlain entirely by shale or where interlayered sandstones and relatively less durable shales are exposed, erosion produces rugged badlands topography.

Quaternary surficial deposits consist of alluvium and colluvium, eolian deposits, and terrace and pediment gravels. Large-scale subsidence features in the salt anticlines of the Paradox Basin result from the upward-doming of late Paleozoic salt and gypsum and their gradual removal by ground and surface waters. Glacial processes have not had a direct impact on the site region, although erosion rates were evidently strongly influenced by Pleistocene climate changes.

3.3.3 Seismicity and tectonics

The Green River site lies within the relatively stable interior portion of the Colorado Plateau, about 50 to 100 miles east of the highly active Intermountain Seismic Belt. Most of the major structural and tectonic features of the site region, with the exception of the Intermountain Seismic Belt, are Laramide uplifts and basins. These features are generally considered to be inactive under the present seismotectonic regime.

The site area lies within the boundaries of the Paradox Basin, which is characterized by complex systems of northwest-trending normal faults and landslide and slump features. Typical salt anticlinal collapse features extend to within about 12 miles of the site. These features have been active during Quaternary time and may be active today. However, since they result from very gradual processes of salt solution and flowage, they are probably not capable of generating large earthquakes. Kirkham and Rogers (1981) estimate the maximum earthquakes possible on these features to be about magnitude 5.

The largest recorded events in the site region have been of magnitude (m_b) 4.0 to 4.2. The majority of these are either known or suspected to be related to mining activities.

The lack of large tectonic earthquakes and known active features, and the distance separating the site from highly active regional features such as the Intermountain Seismic Belt, indicate a relatively stable setting.

Recommended seismic design parameters

The recommended design earthquake for the Green River site is an event of magnitude (M_L) 6.2 occurring at a radial distance of 15 kilometers (9.5 miles) from the site. This event is a "floating earthquake" and a design fault is not specified. The resulting on-site acceleration of 0.21g (determined from the acceleration-attenation relationship of Campbell, 1981) is recommended as the design acceleration. The duration of strong ground motion (>0.05g) during occurrence of the design earthquake was estimated using the magnitude/epicentral distance/duration curves of Krinitzsky and Chang (1977). At the existing tailings pile, considered to be a soil site, the duration is estimated to be about 16 to 18 seconds. The alternative disposal site is considered to be a bedrock site and the duration of strong ground motion is estimated to be about ten seconds.

Potential for on-site fault rupture

Results of the detailed analysis of potential design faults in the site region do not indicate that capable faults are present within 65 kilometers (40 miles) of the site. Review of the historical and instrumental seismic records does not indicate any correlation of seismic activity with known or suspected faults. In addition, geomorphic surfaces in the site area ranging from Holocene to late Quaternary in age show no signs of tectonic disturbance, indicating that the area has been stable during at least the last 35,000 to 70,000 years.

Liquefaction potential

The existing tailings rest on a layer of partly saturated Holocene alluvium about 10 feet thick, which may be susceptible to liquefaction under ground motion caused by the design earthquake. However, the alternative tailings disposal area is on bedrock mantled by a thin layer of unsaturated and partially cemented pediment gravels. This area is not susceptible to liquefaction.

Induced seismicity

Low-intensity seismic vibrations may be experienced periodically in the site area as a result of mining and oil and gas withdrawal in the surrounding region. As the pile is designed to be stable in the event of the design earthquake, it will be stable under those events as well. There are no large reservoirs in the site region at present. Future development of large reservoirs on the Green River is unlikely since this would result in inundation of agricultural, residential, and recreational areas. In addition, suitable impoundment areas for large reservoirs may not exist. The potential for reservoir-induced seismicity at the site, therefore, appears to be extremely low during the 1000-year design life.

Volcanic hazard

No intrusive or volcanic rocks crop out anywhere within the 65-kilometer (40-mile) radius study region surrounding the site (Witkind et al., 1978; Cashion, 1973; Williams and Hackman, 1971a; Williams, 1964). None are known to exist within the stratigraphic column underlying the site, above the Precambrian basement. Other indications of a potential for volcanic activity, such as known geothermal resources, high heat flow, or thermal springs or geysers, are also absent.

3.3.4 Geomorphic hazards

The most significant hazard to the stability of the proposed alternative disposal area results from existing gully systems that head within the proposed pile area. Other gully systems that drain small areas southeast of the proposed pile extend along the south side. Development of new gully systems from the former mill site area may also occur during the next 1000 years and could impact site stability. These potential hazards can be mitigated by suitable safety measures (such as aprons) in pile design.

Minor processes that will affect the tailings disposal facility include the following:

- Rainsplash and sheet wash.
- Wind action.
- Chemical weathering of limestone and limey sandstone.
- Shrink/swell effects of shales.
- Frost heave, solifluction, and downslope creep of unconsolidated materials.

The potential long-term impacts of these processes can be effectively mitigated by suitable safety measures in pile design and construction.

Potential for ground subsidence induced by salt solution

The potential for significant subsidence due to salt solution and removal at depth during the proposed design life was carefully considered during the investigation. The potential hazard to site stability does not seem to be significant.

The salt and gypsum-bearing Paradox member of the Pennsylvanian Hermosa Formation is present in the stratigraphic column beneath the site. The occurrence of highly saline groundwater at Crystal Geyser also indicates ongoing salt solution at depth. Furthermore, the location of the site within the boundary of the Paradox Basin and within 10 to 20 miles of large-scale subsidence features in Salt Valley indicates that a potential for subsidence may exist.

However, the site area is near the margins of the Paradox Basin, rather than in the interior, and the amount of salt thought to be present in the area is rather small. None of the conspicuous evidences of subsidence observed in other areas, such as northwest-trending collapsed anticlines, normal faults, and Toreva-block landslide systems, are present near the site.

It does not appear that any significant amounts of subsidence or major differential movements are occurring in the site area at present. Therefore, salt solution-induced subsidence does not appear to present a hazard to site stability during the proposed design life.

3.3.5 Potential impact of future natural resource development

Stratigraphic units that underlie the site area are known to contain economic deposits of uranium and vanadium ores, oil and gas, gypsum, salt, potash, and brines in other areas. Small amounts of these materials may be present in the site area as well, but no economic deposits are known.

No development of uranium and vanadium ores has taken place from the Green River area to date. The nearest known economically mineable deposits are in the Thompson area, 25 to 30 miles to the east, and the San Rafael River mining district, about 12 miles to the west. Units that may contain these ores, such as the Morrison Formation, are present beneath the site but there is no known evidence of development potential. The depth of burial of the Morrison and other potential ore-bearing units will probably preclude economical exploration and development of uranium and vanadium from beneath the site during the foreseeable future.

Little exploration and development of oil and gas resources has occurred to date from the Mancos Shale Lowland area that includes the site. Though some Paleozoic units that contain oil and gas are present elsewhere, the lack of structural traps probably precludes significant deposits. The Elgin Well, drilled in 1891, is the only exploratory well in the site area to date. It did not encounter oil or gas.

Salt, gypsum, potash, and brines beneath the site area are evidently of small volume and too deep to be of potential economic value.

3.4 GEOTECHNICAL

3.4.1 Tailings

Subsurface investigation

The Green River tailings pile was characterized by drilling five borings and excavating three test pits on the pile. The locations of these boreholes and test pits are presented in Figure 3.7. Logs of the borings and test pits are in Appendix D, Site Characterization, of this RAP.

Borings were advanced using standard geotechnical drilling and sampling techniques. These included drilling with hollow stem augers, and sampling at near continuous intervals with the Standard Penetration Test (SPT) and, on occasion, a 2.5-inch inside-diameter ring-lined split-barrel sampler. The SPT tests were conducted according to ASTM 1586 procedures. Samples were driven with a 140-pound weight dropped 30 inches. The mechanism is known as a "Safety Hammer" and was lifted and released by a rope wrapped two turns around a pulley, or a "Cathead." Standard "A" rods were used in driving the sampler as all borings were less than 50 feet deep.

The borings were logged by a field engineer who recorded changes in drilling lithology and blow counts. Water levels were recorded during the drilling operations.

Tailings stratigraphy

Tailings are divided into three categories according to the size of the particles. The three designations are:

- o Sand.
- o Sand-slime.
- o Slime.

At Green River the slimes were removed for upgrading at Rifle, Colorado, leaving only the sand tailings. Sand tailings, as used here, refers to those tailings with up to 30 percent passing the No. 200 sieve. In fact, most of the Green River pile contains

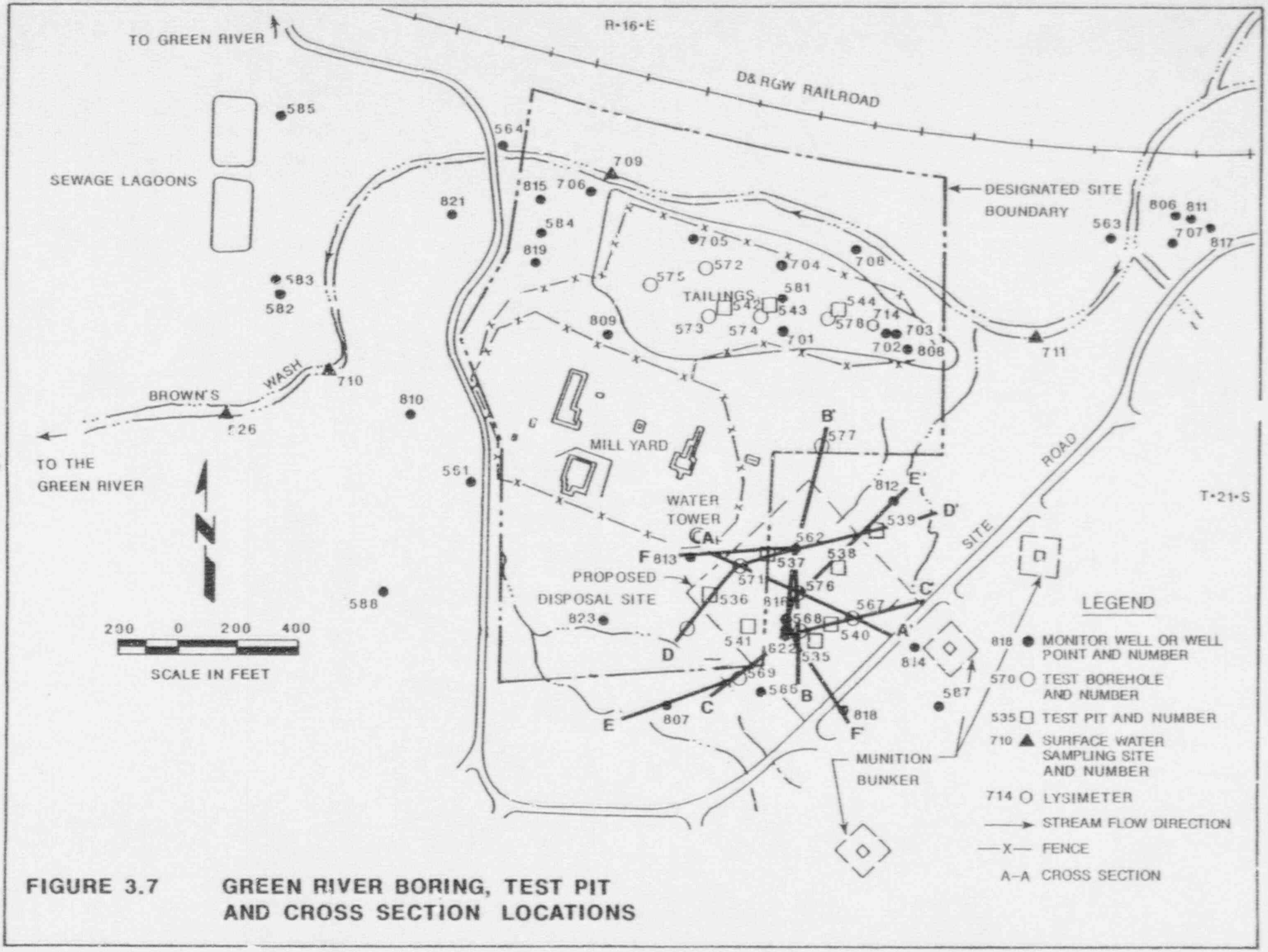


FIGURE 3.7 GREEN RIVER BORING, TEST PIT AND CROSS SECTION LOCATIONS

less than 20 percent passing the No. 200 sieve. The Unified Soil Classification System (USCS) classifies the material as silty or clayey sand: SP-SM, SP-SC, SM, and SC.

Due to the uniformity of material within the Green River tailings pile, only a single cross section has been developed and is shown on Figure 3.8. The location of this section is shown on Figure 3.7. The tailings are covered with six inches of decomposed Mancos Shale and are underlain by alluvium of Brown's Wash. The water table, as measured during drilling activities, is below the tailings-subsoil interface.

Moisture contents within the tailings pile are relatively low and range from 1.2 to 6.4 percent. Blow counts from SPT tests range from four to 16, which correlates with a loose to medium-dense compactness. Groundwater was not encountered within the tailings.

3.4.2 Disposal area foundation soils and windblown material

Subsurface investigation

The Green River disposal area was initially characterized by drilling eight borings and excavating seven test pits. The locations of all borings and monitor wells are shown on Figure 3.7. Logs of the borings and test pits are presented in Appendix D, Site Characterization. An additional 11 monitor wells were installed during a final investigation phase, of which six provided further stratigraphic data for the disposal area foundation soil and rock. The initial borings were drilled using the same techniques described for borings on the pile. Logging procedures were also the same. Boring number 562 was extended into bedrock using NX-sized rock coring techniques. The final borings were drilled using a rotary rig with air to produce an eight-inch diameter borehole. Six of these borings produced HQ rock cores.

Disposal area foundation soils and windblown material

Soils underlying the site were classified according to the USCS as shown in Appendix D (Figure D.4.12). Classification procedures used followed ASTM 2487. Cross sections of the foundation soils were developed from borehole and test pit data and are presented in Figures 3.9 through 3.14. The soils underlying the site consist of from five to 16 feet of loose to dense silty or clayey sand alluvium. Large lenses of clay are contained within the layer. Dense to very dense sand and gravel alluvium underlies these near-surface soils. The soils in turn overlie bedrock consisting of coarse conglomerate, sandstone of the Dakota Sandstone, and shales of the Cedar Mountain Formation. These near-surface soils lie within the area of windblown contamination and are considered representative of this material.

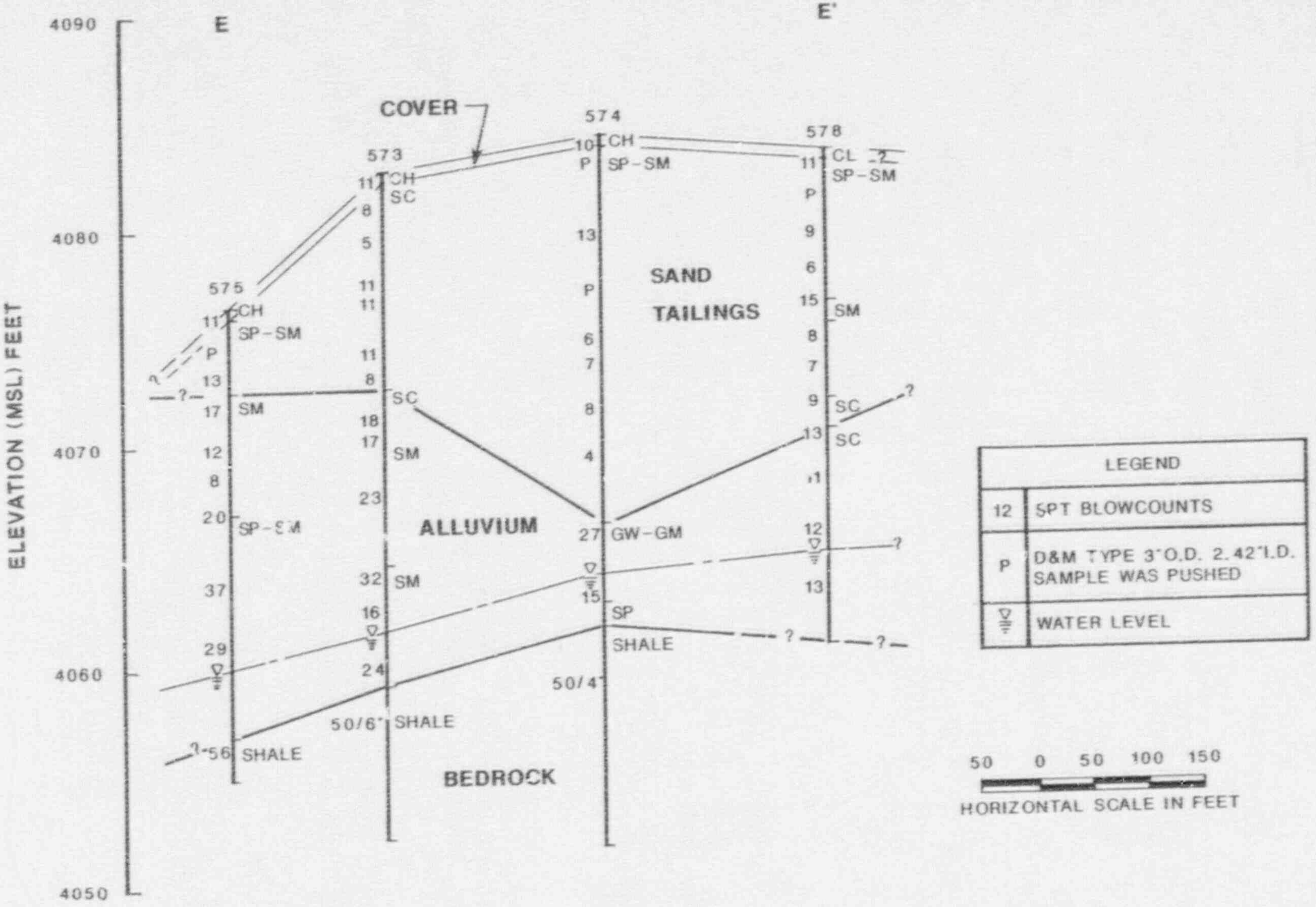


FIGURE 3.8 TAILINGS PILE CROSS SECTION E-E'

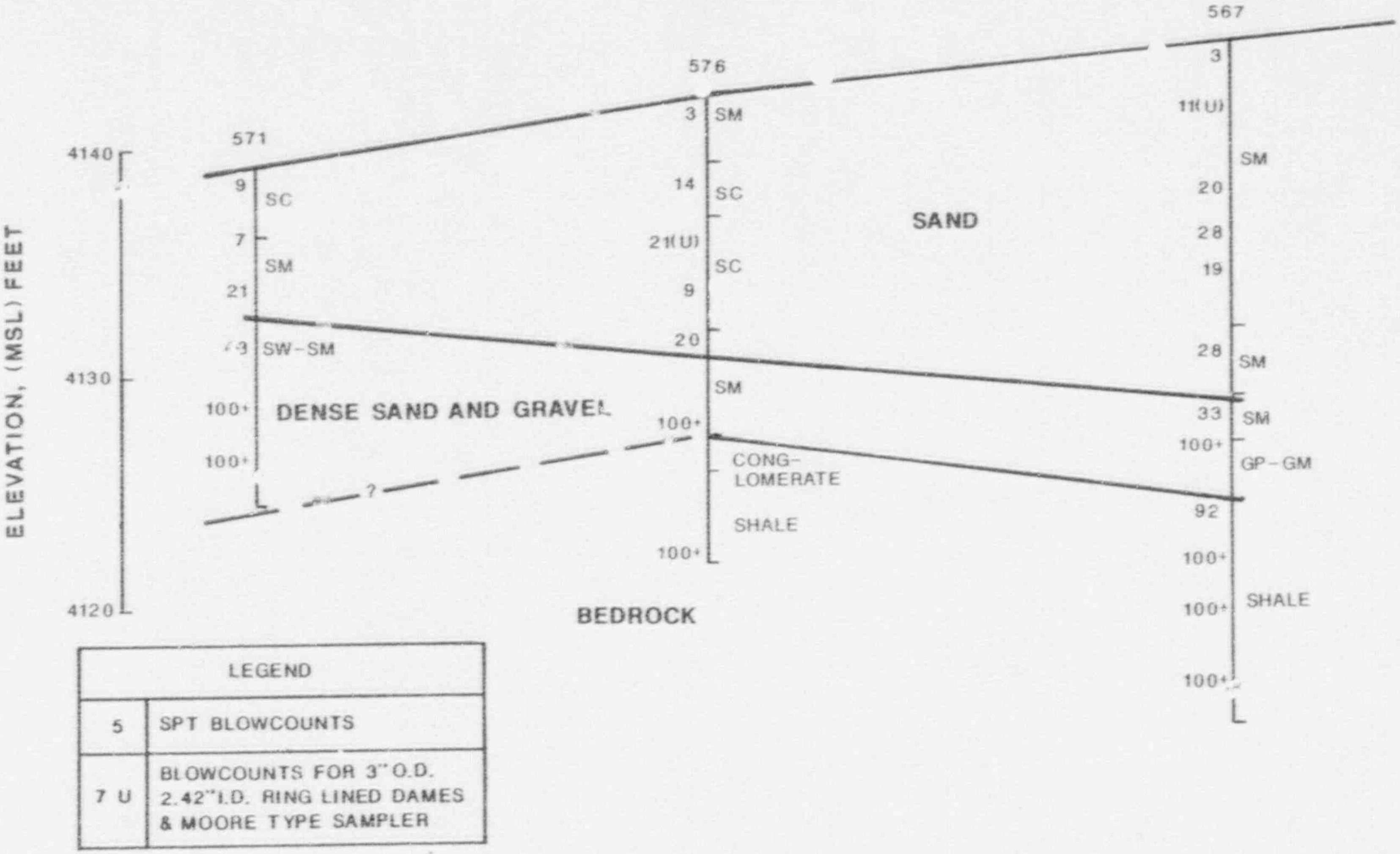


FIGURE 3.9 GREEN RIVER SITE CROSS SECTION A - A'

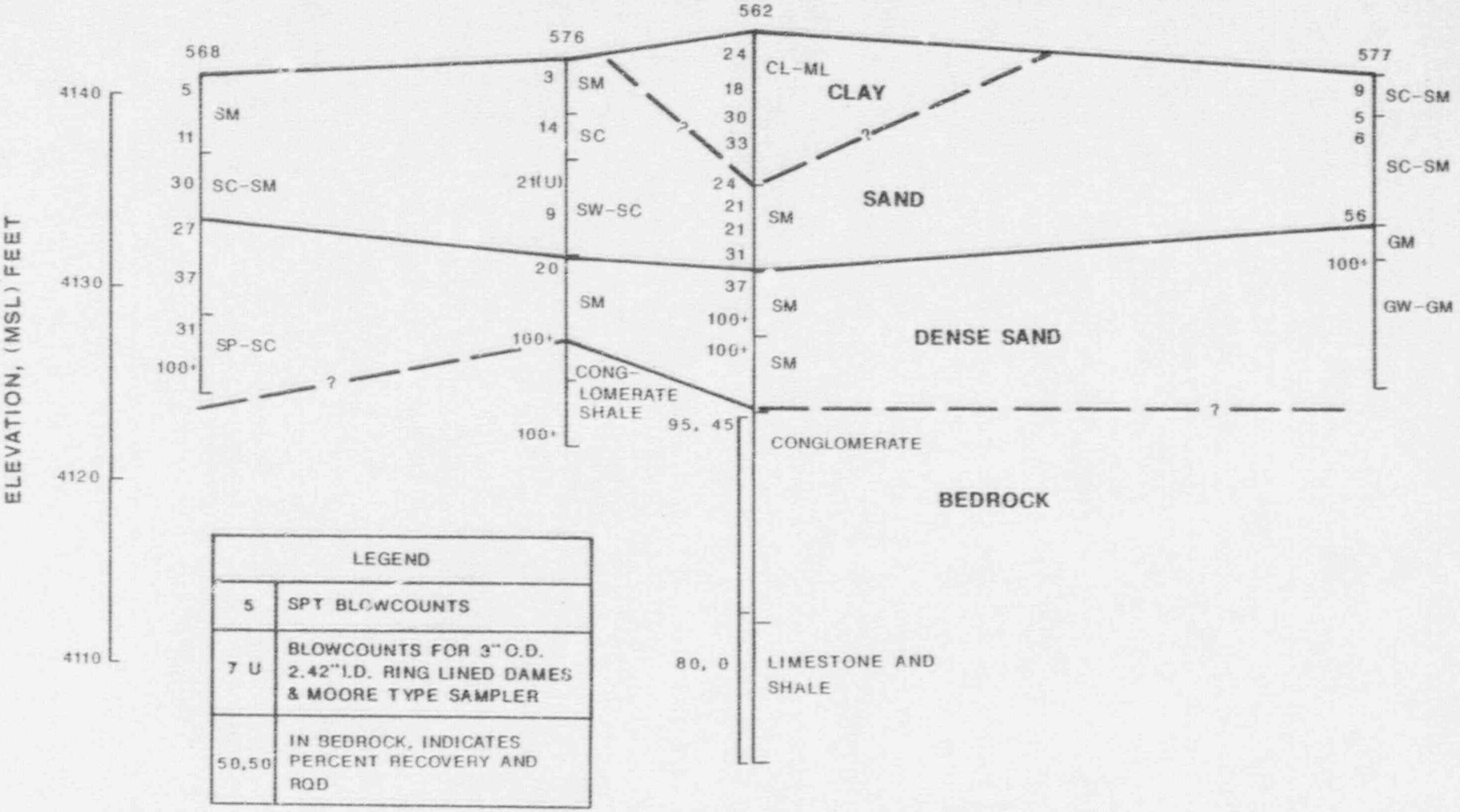


FIGURE 3.10 GREEN RIVER SITE CROSS SECTION B - B'

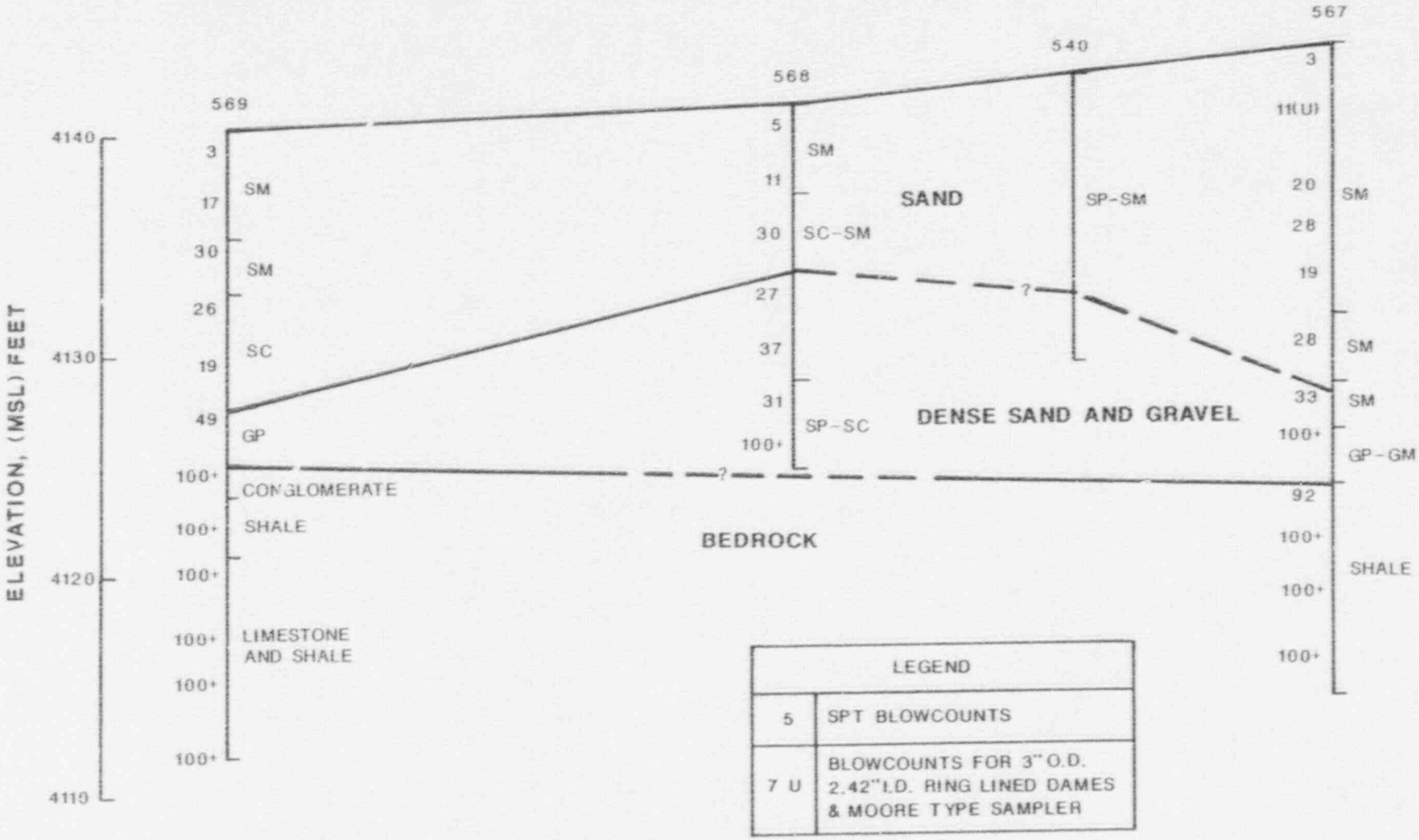


FIGURE 3.11 GREEN RIVER SITE CROSS SECTION C - C'

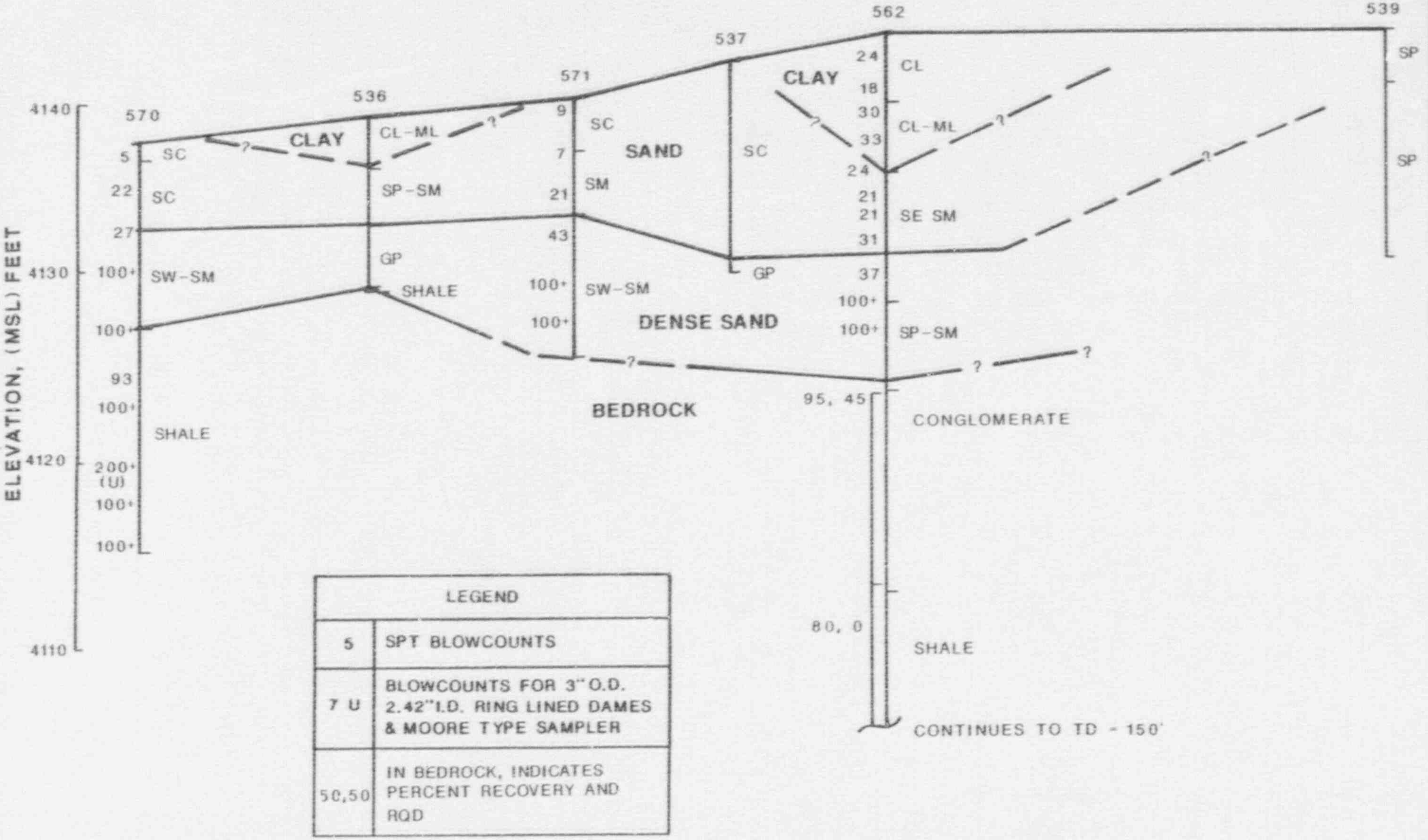


FIGURE 3.12 GREEN RIVER SITE CROSS SECTION D - D'

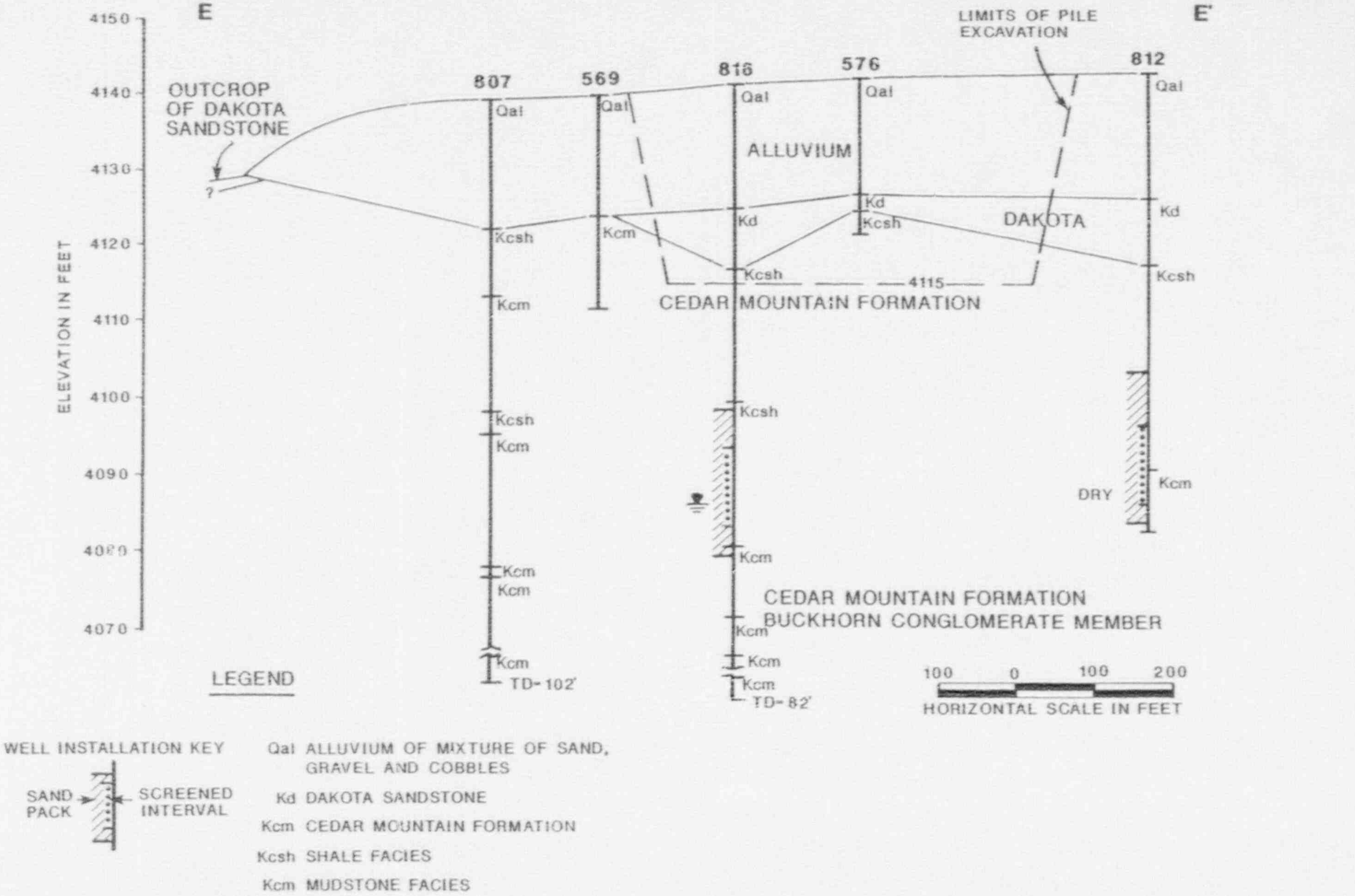


FIGURE 3.13
GREEN RIVER SITE CROSS SECTION E-E'

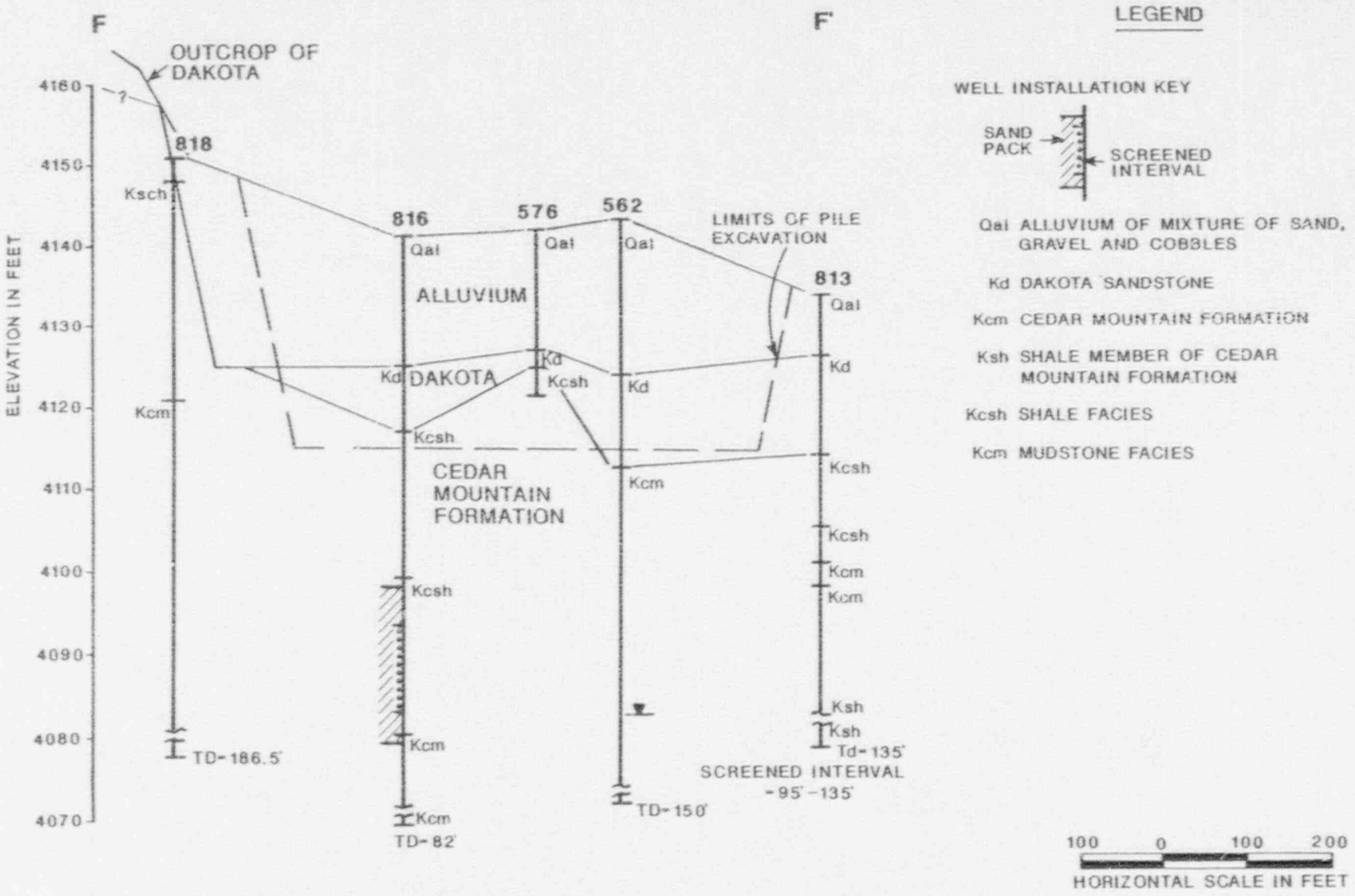


FIGURE 3.14
GREEN RIVER SITE CROSS SECTION F-F'

Groundwater was not encountered within the soils at the site. The first groundwater in this disposal area is within the Cedar Mountain Formation at approximately 55 feet below the ground surface. Section 3.5 describes the groundwater conditions within the bedrock.

3.4.3 Borrow sites

Radon cover and filter materials

Radon cover and gravel filter materials from borrow site 1 (Figure 3.15) were explored during an initial investigation by 14 test pits excavated with a backhoe. The locations of these test pits and cross sections are presented in Figure 3.16. Cross sections of the borrow sites were developed as shown in Figures 3.17 through 3.23. The test pits were logged and sampled by a field engineer. An additional 10 test pits were constructed by MKE during a final field investigation. The location of these are shown on Figure 3.24.

Borrow site stratigraphy

The near-surface soils at the site consist of zero to six feet of clayey to silty sands overlying clean sand and gravel or clay that is in turn underlain by gravel. The near-surface silty and clayey sands are not suitable for infiltration/radon barrier material. The clay layer, which is between four and more than eleven feet thick, is suitable for radon barrier material. This material is primarily in the northeast corner of the area originally explored. The final investigation indicates the clays become more extensive to the northeast. Groundwater was not encountered in the test pits.

Rock borrow materials

Rock of a quality to be considered suitable for use according to NUREG/CR-4620 will be used on the pile. The source is approximately 75 miles west of the site at Fremont Junction.

3.5 GROUNDWATER

Groundwater conditions and groundwater quality impacts resulting from the processing and disposal of uranium at the Green River tailings site are summarized in this section. A detailed discussion is provided in Section D.5, Groundwater Hydrology, of Appendix D. Appendix D also contains numerous tables and figures that are helpful in understanding groundwater conditions at the Green River tailings site.

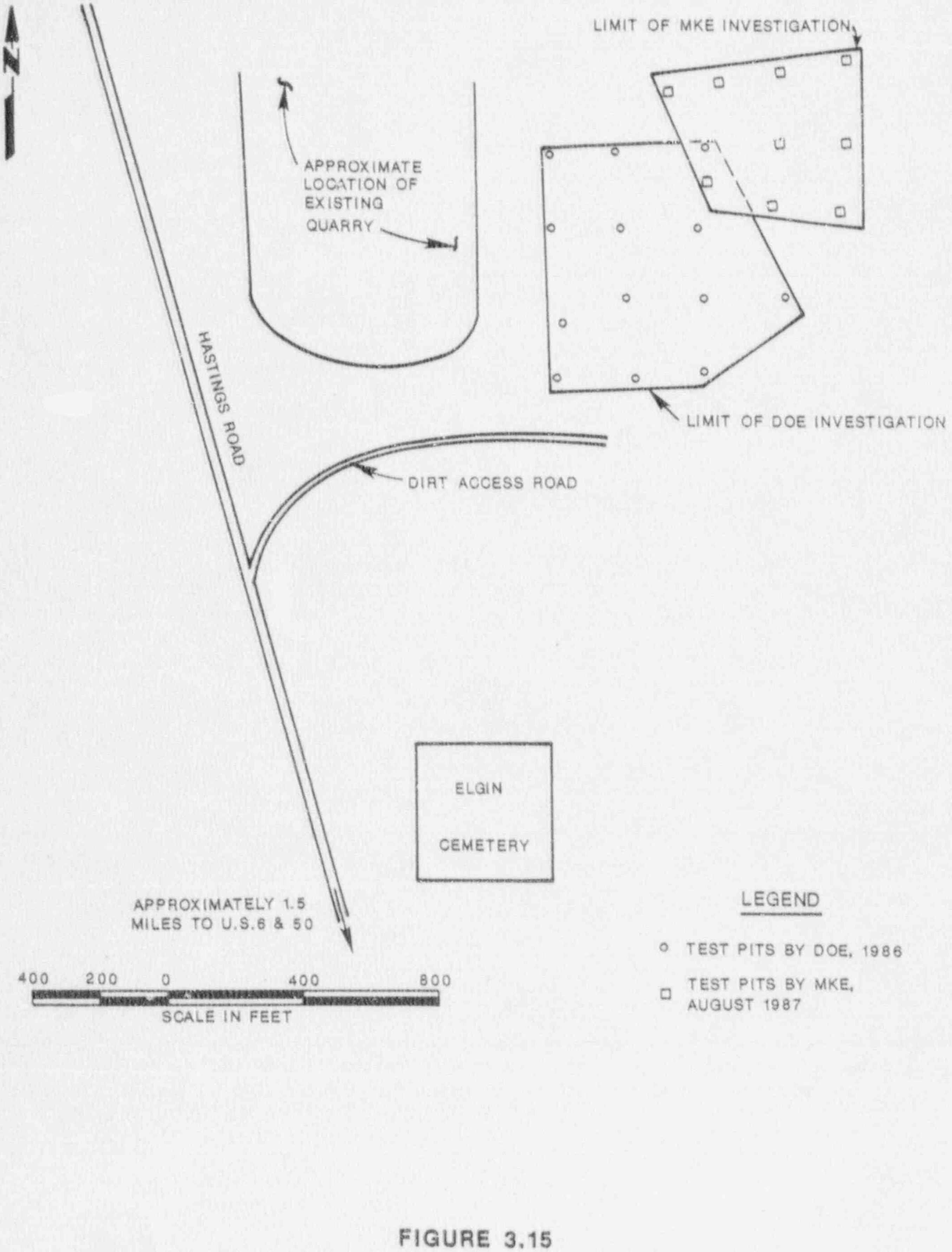


FIGURE 3.15
PROPOSED RADON BARRIER BORROW AREA AND VICINITY

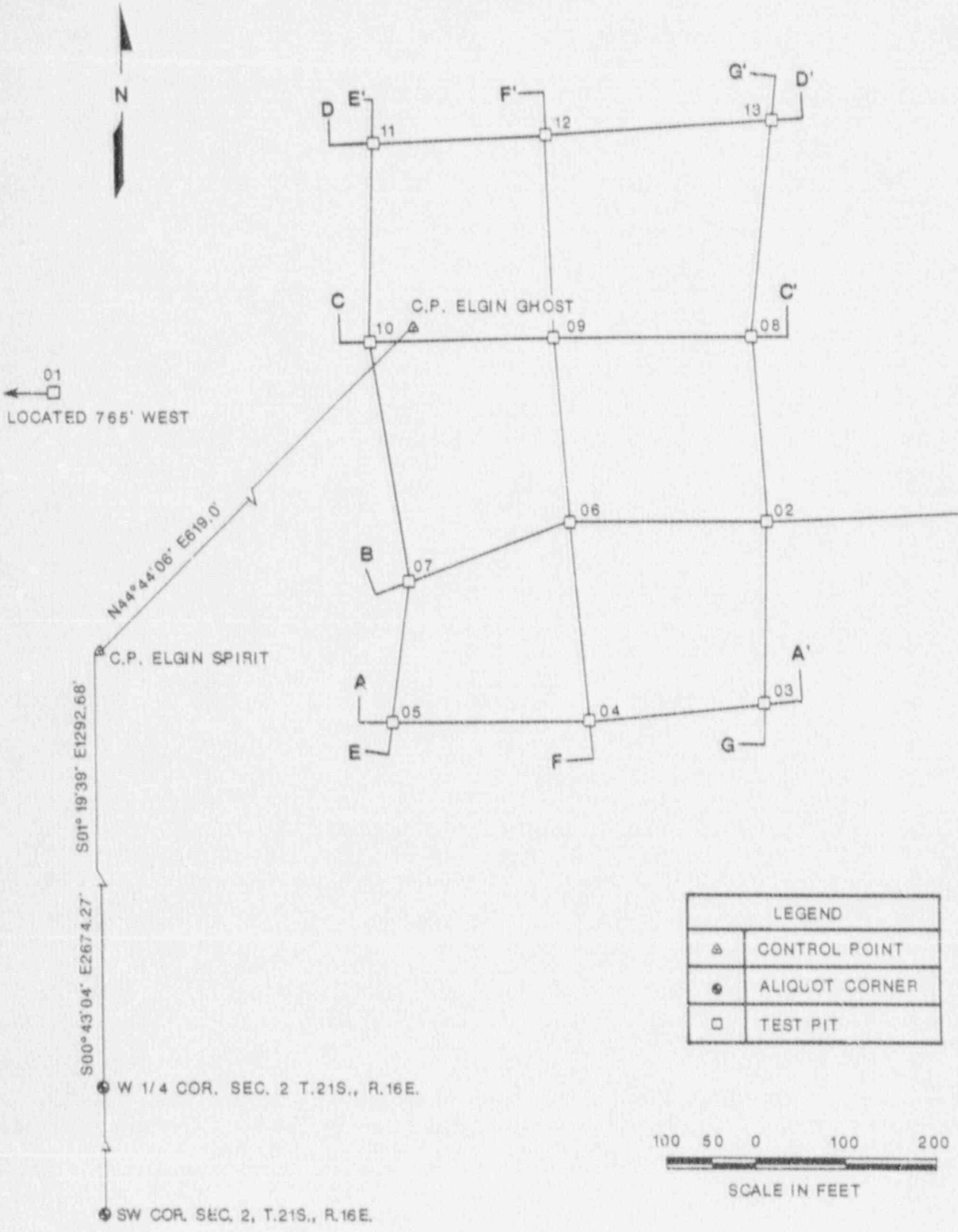


FIGURE 3.16
BORROW SITE 1 DOE TEST PIT LOCATIONS

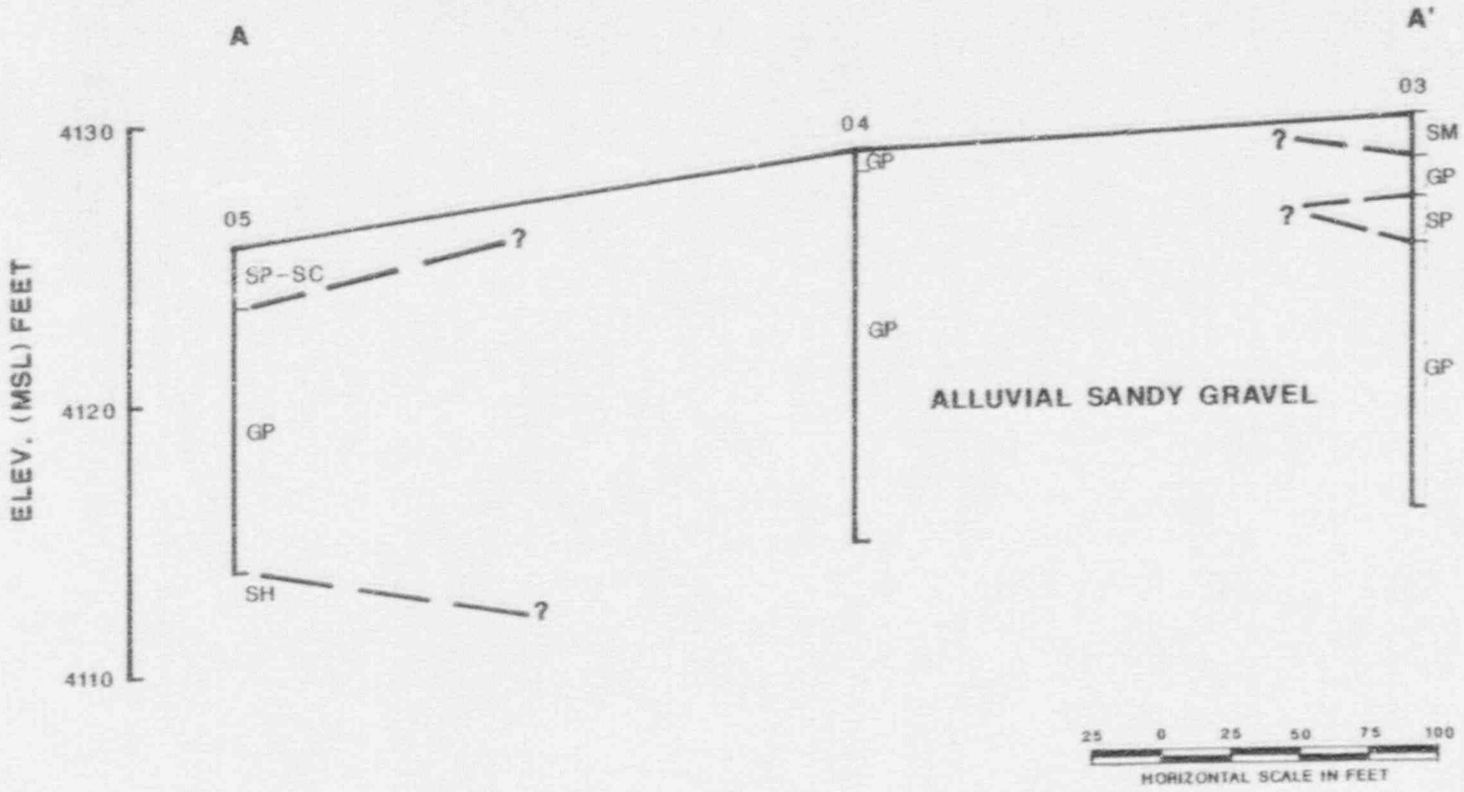


FIGURE 3.17 BORROW AREA 1 CROSS SECTION A-A'

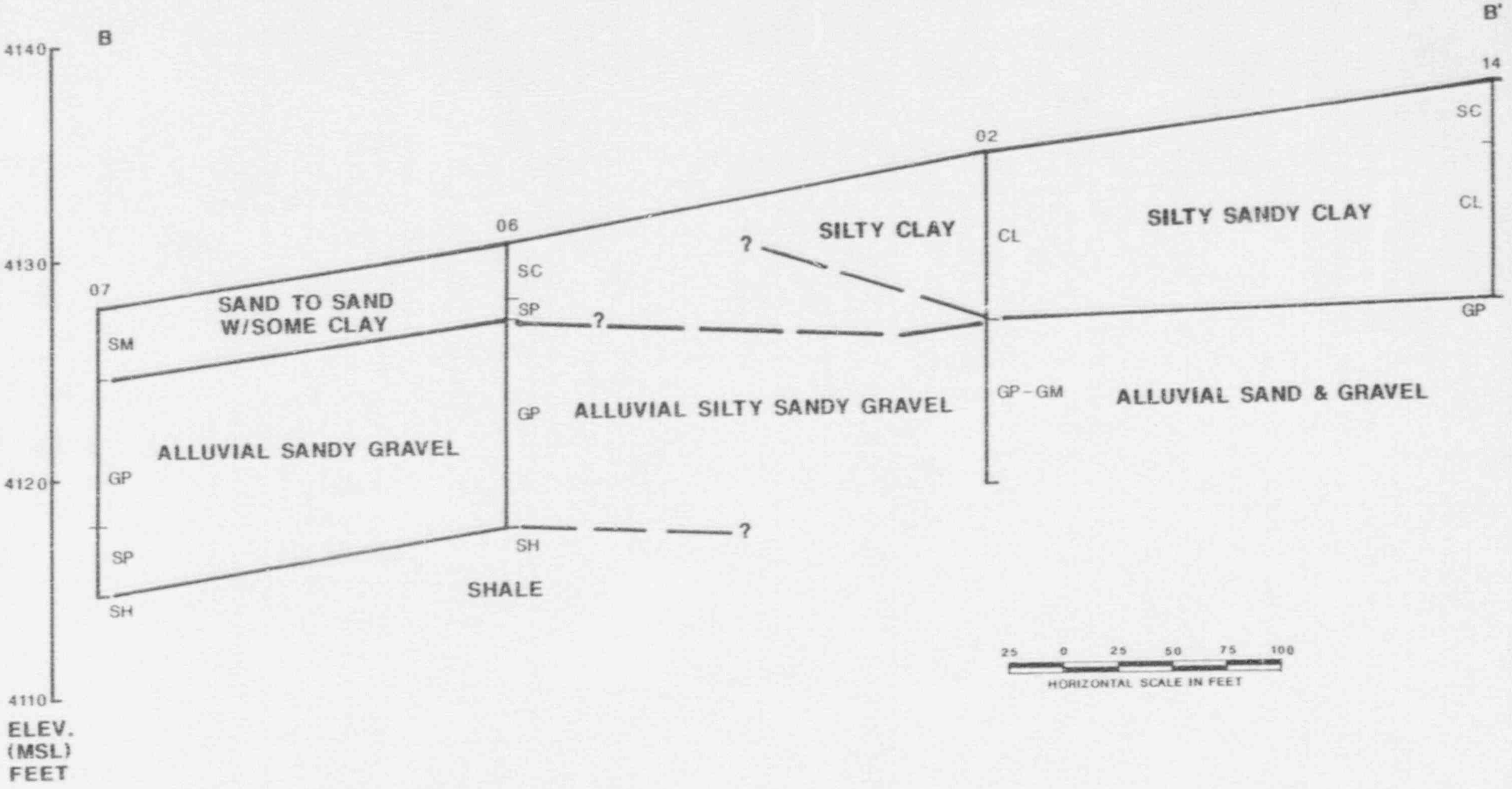


FIGURE 3.18 BORROW AREA 1 CROSS SECTION B-B'

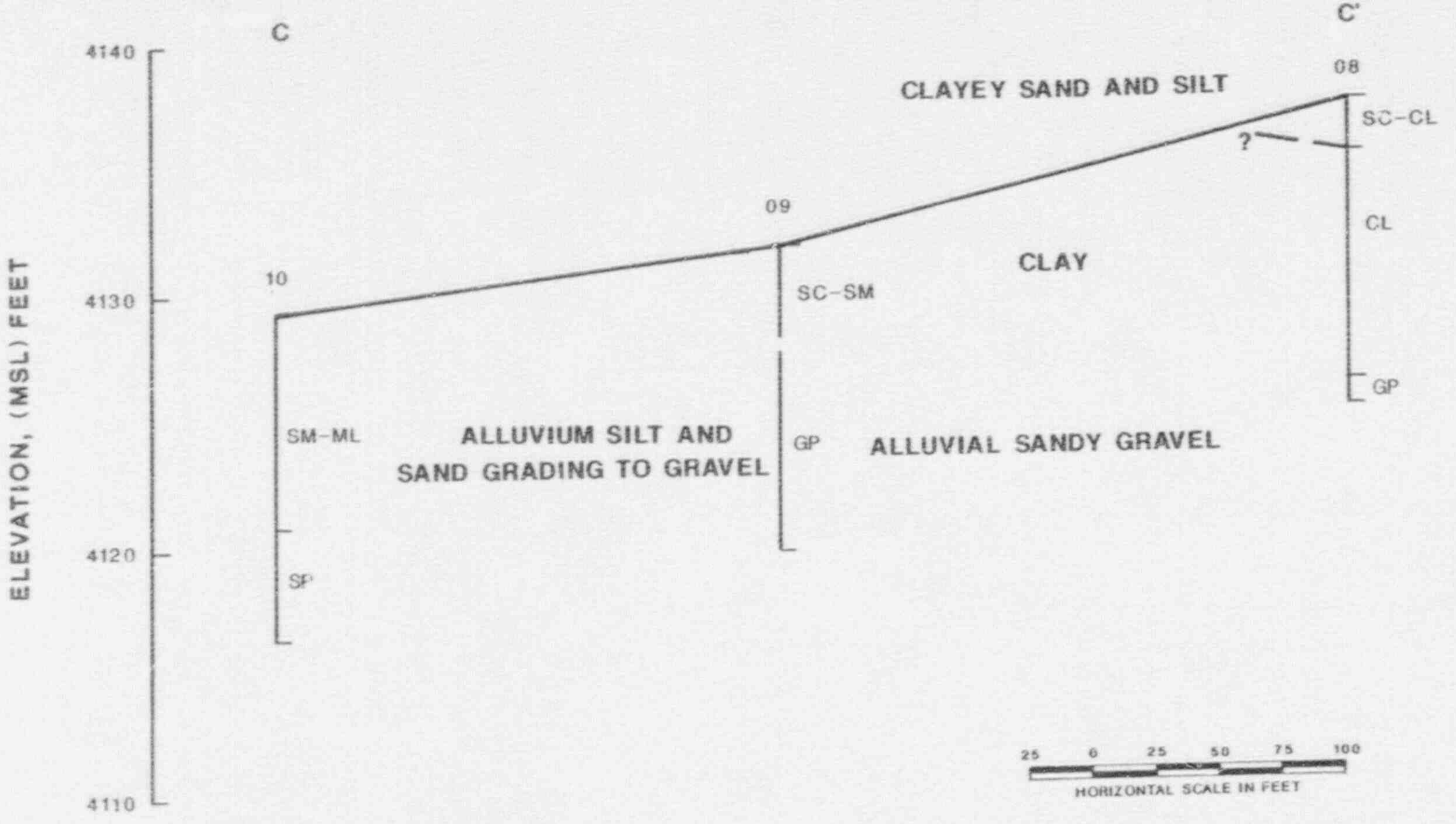


FIGURE 3.19 BORROW AREA 1 CROSS SECTION C–C'

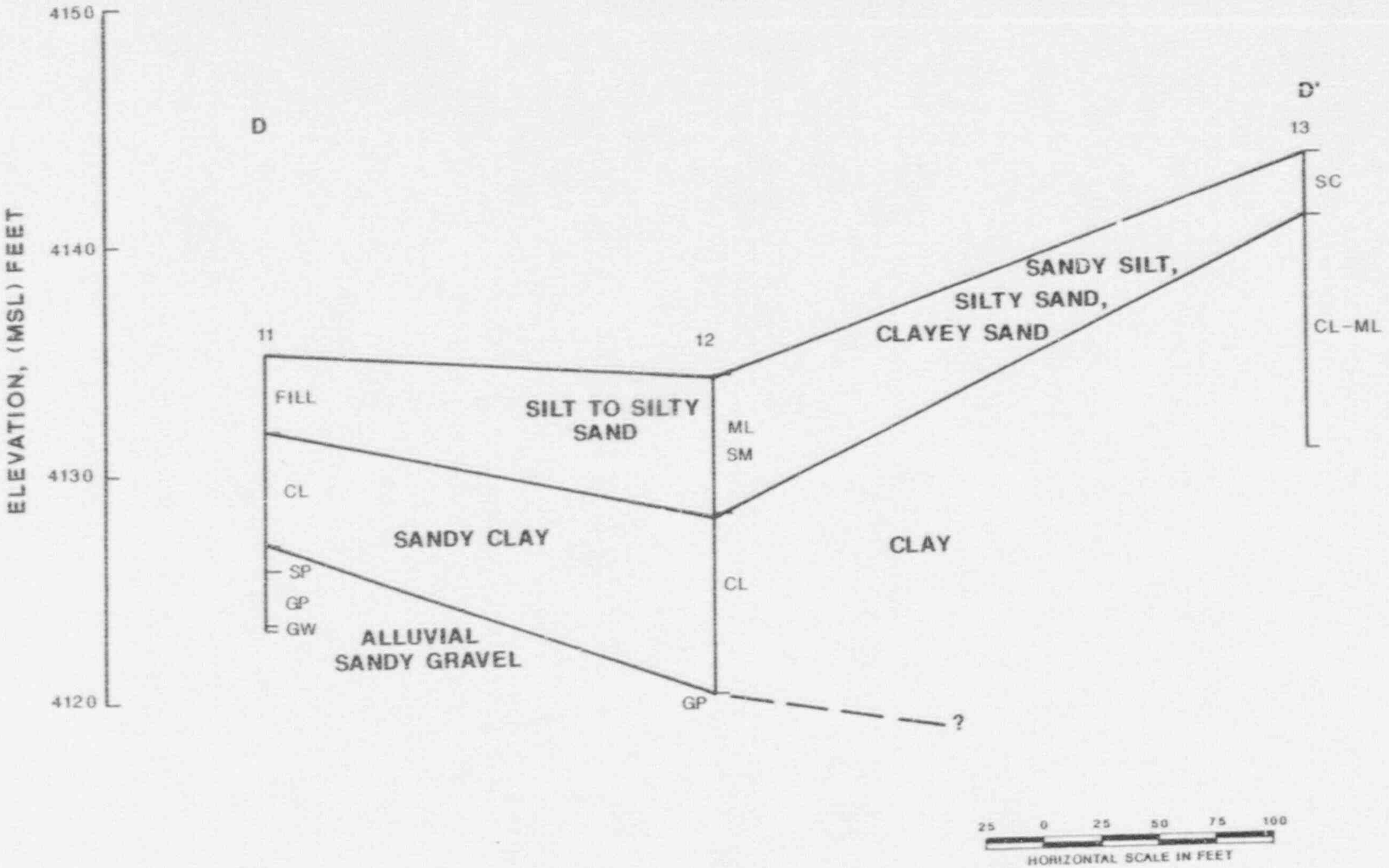


FIGURE 3.20 BORROW AREA 1 CROSS SECTION D-D'

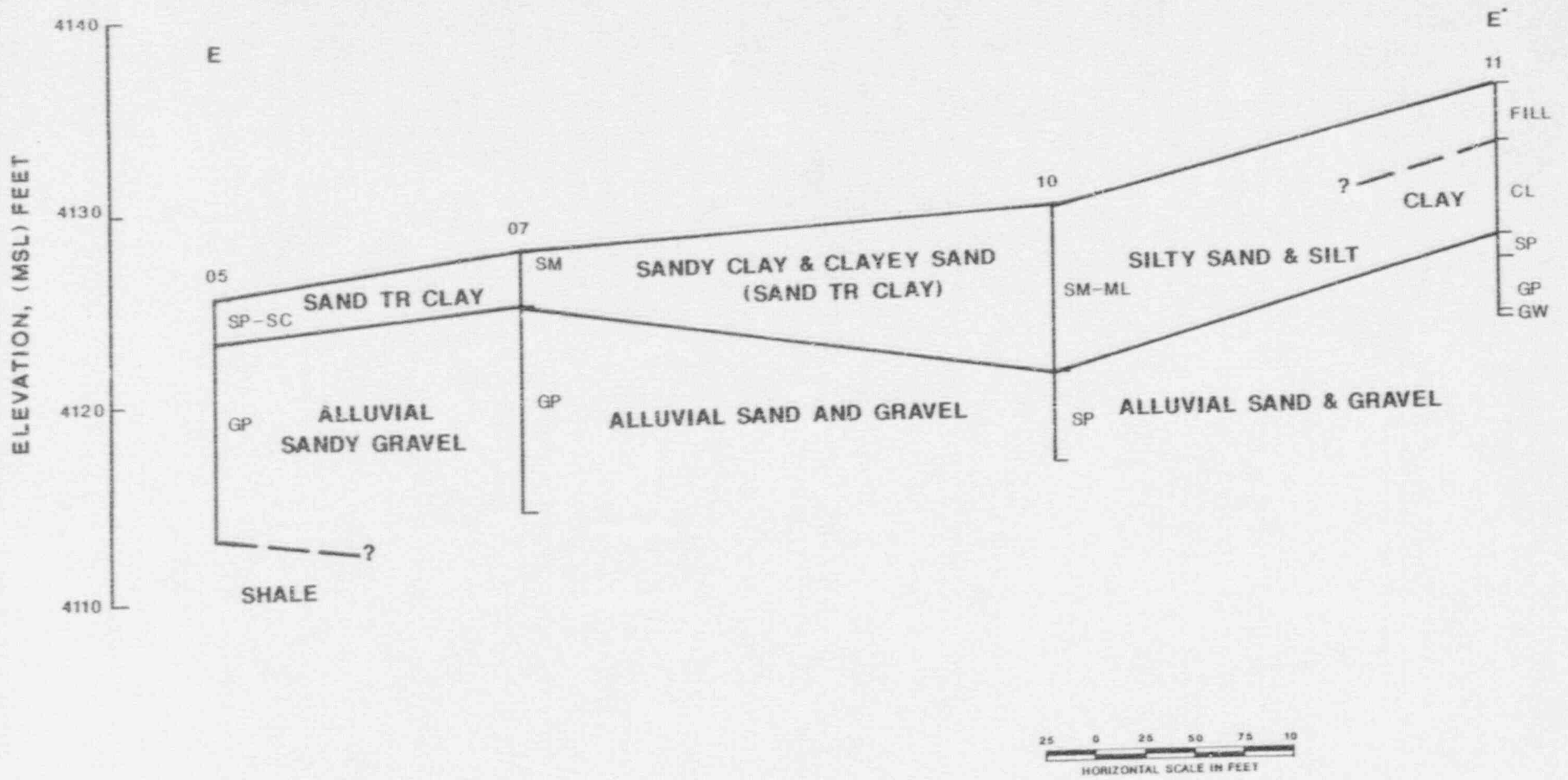


FIGURE 3.21 BORROW AREA 1 CROSS SECTION E-E'

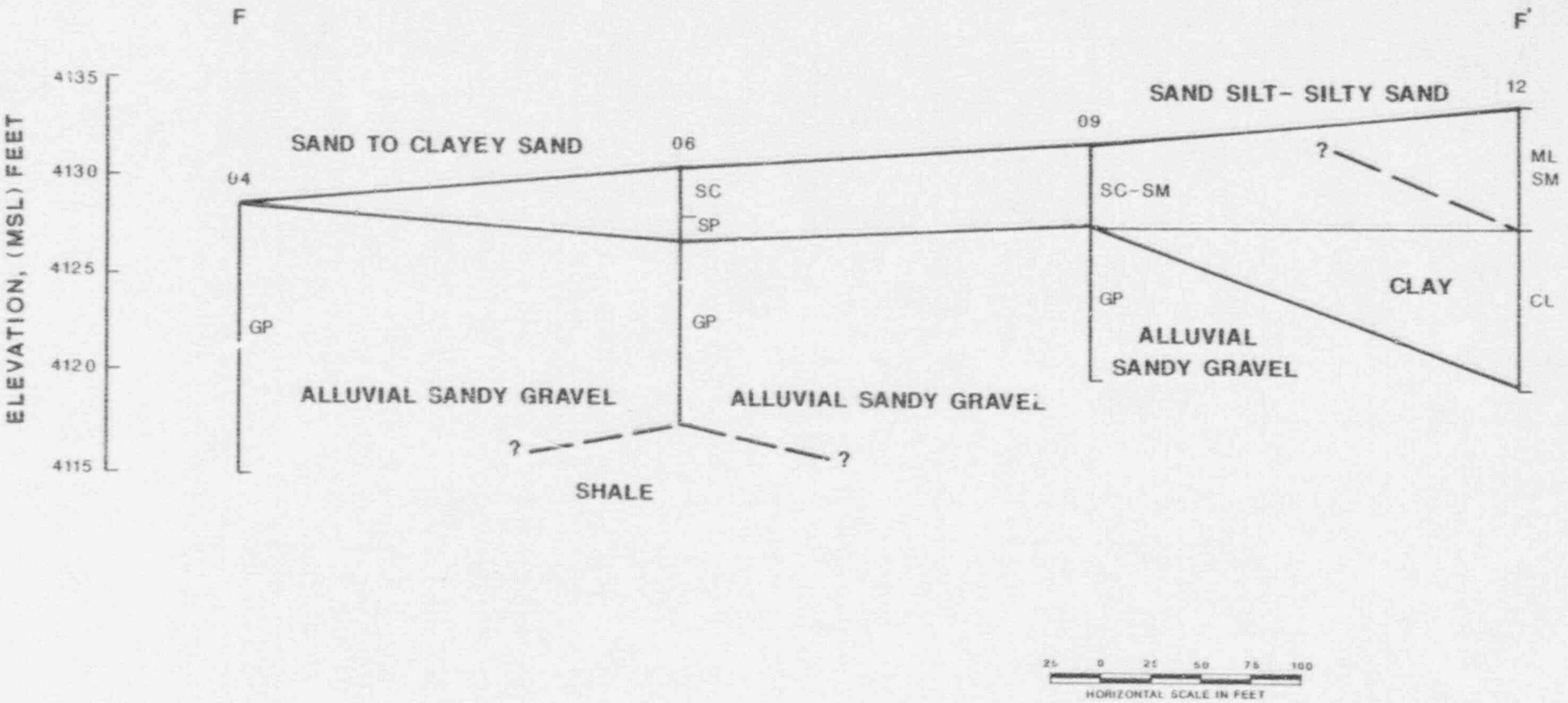


FIGURE 3.22 BORROW AREA 1 CROSS SECTION F-F'

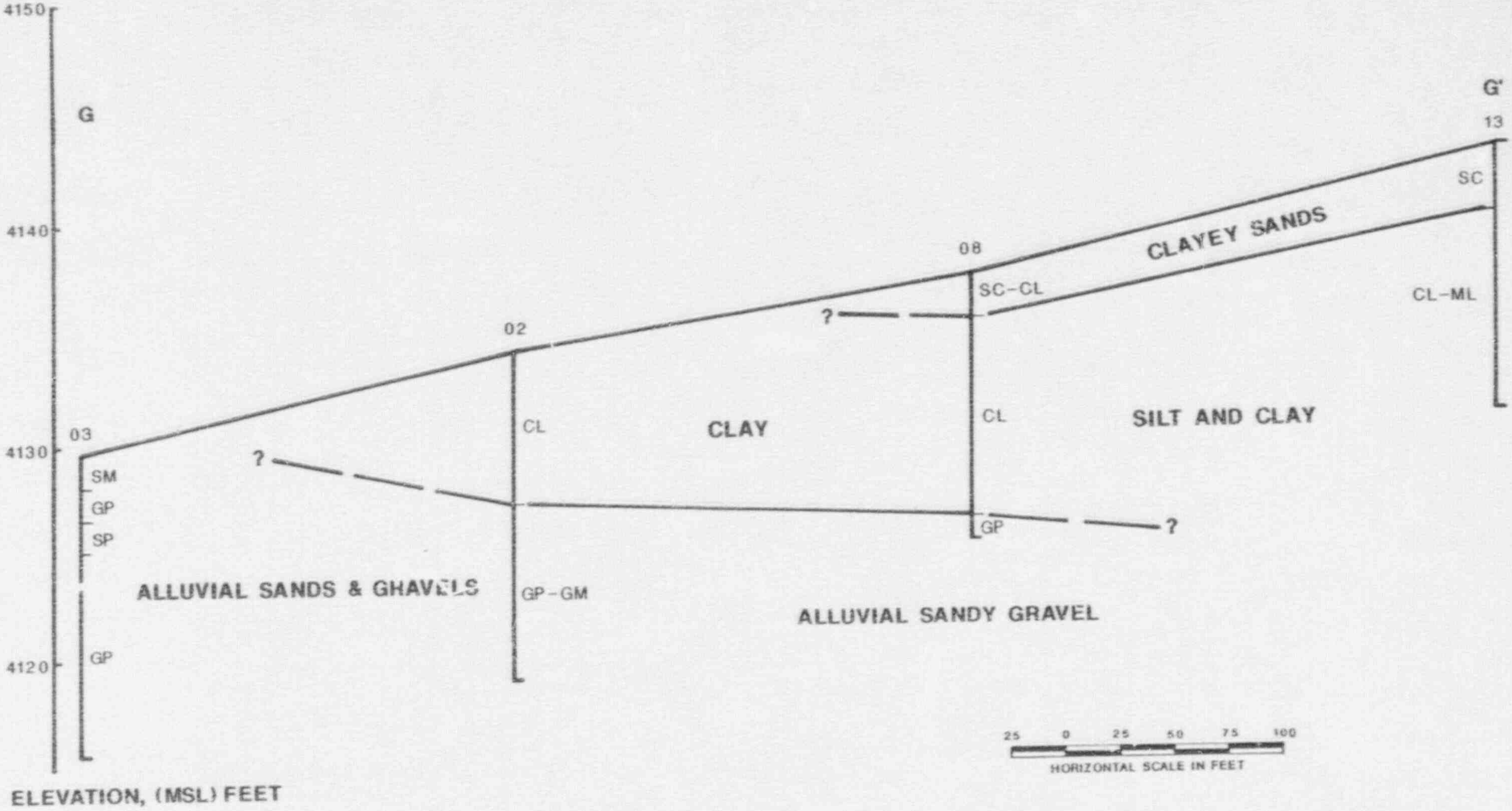


FIGURE 3.23 BORROW AREA 1 CROSS SECTION G-G'

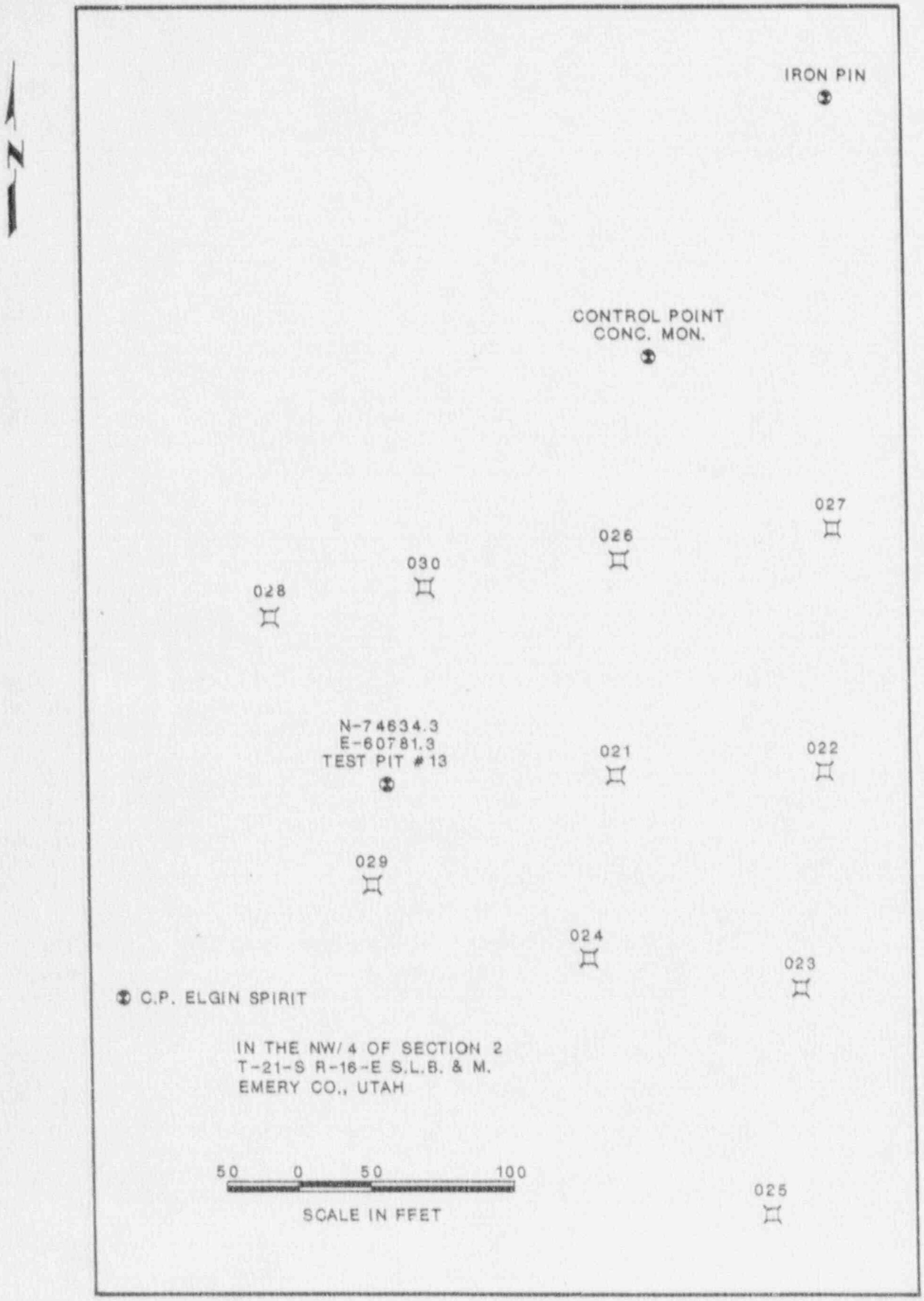


FIGURE 3.24
BORROW SITE 1 MKE TEST PIT LOCATIONS

3.5.1 Hydrostratigraphy

Within the upper 200 feet of Quaternary and Cretaceous sediments, four distinct water-bearing units were defined at the Green River tailings site. The following is a description of these four hydrostratigraphic units.

Top hydrostratigraphic unit

Shallow, unconfined groundwater occurs in the Brown's Wash alluvium beneath the present tailings pile; this alluvial aquifer is the top hydrostratigraphic unit. The alluvium consists of a mixture of silt, sand, gravel, and some small cobbles. The alluvium is limited to an area that extends 300 to 400 feet on either side of Brown's Wash, and varies in thickness from zero to 35 feet. The Brown's Wash alluvium is not present beneath the proposed disposal site.

Upper-middle hydrostratigraphic unit

Confined and unconfined groundwater occurs in the Cedar Mountain Formation beneath the present tailings and proposed disposal area. A sequence of alternating shales, limestones, and mudstones within the upper portion of the Cedar Mountain Formation is the upper-middle hydrostratigraphic unit. This unit is slightly to very fractured. The upper-middle unit is about 30 feet thick beneath the tailings and Brown's Wash alluvium, and 10 to 40 feet thick beneath the proposed disposal area. In some areas, the Dakota Sandstone lies unconformably on top of the upper-middle unit.

Lower-middle hydrostratigraphic unit

The lower-middle hydrostratigraphic unit is a relatively thick, but laterally limited, sandstone and sandstone conglomerate of the middle Cedar Mountain Formation. This unit is also slightly to very fractured, and is beneath the present tailings and the proposed disposal site. East and west of the site area, the lower-middle unit intertongues with the shales and limestones of the upper-middle hydrostratigraphic unit, and the lower-middle unit becomes thin and discontinuous. The lower-middle unit is 20 to 30 feet thick beneath the tailings and proposed disposal site, and is nonexistent in some areas west of the site area.

Bottom hydrostratigraphic unit

The bottom hydrostratigraphic unit is the Buckhorn Conglomerate member of the lower Cedar Mountain Formation. This basal sandstone and sandstone conglomerate unit is 15 to 25 feet thick beneath the site area and is confined by overlying shale and mudstone. This unit is slightly fractured to unfractured. Jurrasic-age sedimentary rocks lie beneath the bottom hydrostratigraphic unit.

3.5.2 Groundwater movement

The presence and movement of shallow groundwater beneath the tailings site is controlled by extensive fracturing of the bedrock; strong, vertically upward hydraulic gradients and movement of groundwater upward between bedrock units; and the attitude (dip) of the bedrock units. Flow of groundwater in the Brown's Wash alluvium is controlled by recharge from the east (upstream); recharge from the upper-middle shale unit south of Brown's Wash; discharge of groundwater into the upper-middle shale unit west (downgradient) of the tailings; and discharge of groundwater into the channel of Brown's Wash at the surface. The occurrence of groundwater in Brown's Wash is also limited by the lateral extent of the alluvium; the top hydrostratigraphic unit is a maximum of 600 feet wide near the tailings pile. The following describes the flow of groundwater beneath the tailings site in more detail.

Top hydrostratigraphic unit

The depth to groundwater ranges from nine to 17 feet below the surface in the top unit. The general direction of groundwater flow in this unit is west toward the Green River; however, the flow is locally controlled south of Brown's Wash channel (beneath the present tailings pile) by recharge from the underlying upper-middle unit. Beneath the tailings, groundwater in the alluvium flows northwest at a volume rate of about 9.9 gallons per minute (gpm); the velocity of flow ranges between 0.55 and 2.19 feet per day (ft/day). West of the tailings, groundwater flowing in the top unit is divided into three major components: (1) surface water flow and subflow in Brown's Wash channel; (2) evaporation and transpiration, primarily near Brown's Wash channel; and (3) discharge down into the underlying upper-middle hydrostratigraphic unit (or through the Dakota Sandstone, where it is present), primarily via vertical fractures in the bedrock. Since two well points and one monitor well completed in the top unit immediately west of the tailings pile have been dry during the sampling period (June 1986 through October 1987), it is estimated that very little groundwater that originates from beneath the tailings pile flows in the top unit much further than 400 feet west (downgradient) from the tailings.

Upper-middle hydrostratigraphic unit

The depth to groundwater in the upper-middle unit beneath the present tailings surface is about 26 feet. The general direction of groundwater flow in this unit is west toward the Green River.

However, like the top hydrostratigraphic unit, the flow of groundwater in the upper-middle unit is also locally controlled by recharge from south of the tailings pile by flow from underlying units. Beneath the tailings pile the potentiometric surface of the upper-middle unit forms a "trough" or groundwater sink, indicating that the flow of groundwater along the sink is controlled by a zone of higher secondary permeability, likely from jointing, fracturing, or minor faulting of the bedrock. It is along this sink that the upper-middle unit is recharged by groundwater from the overlying Brown's Wash alluvium (top unit). Beneath the tailings, groundwater flows in the upper-middle hydrostratigraphic unit at a volume flow rate of about 4.9 gpm; the velocity of flow ranges from 0.01 to 0.71 ft/day.

Groundwater in the upper-middle unit beneath the proposed disposal site is first encountered at a depth of about 60 feet (groundwater is not present beneath the disposal site above this depth). Beneath the southern one-third to one-half of the proposed disposal area, the upper-middle unit is dry or is only saturated in the bottom one to two feet. North of the disposal site, the upper-middle unit becomes saturated as the bedrock units dip toward the north. Between the disposal site and the present tailings pile, the flow of groundwater in the upper-middle unit is controlled by connected fractures, recharge from south of the disposal area or from underlying aquifers, and by the dip of the bedrock units. The flow of groundwater in the upper-middle unit beneath the disposal site is about two gpm.

Lower-middle hydrostratigraphic unit

The depth to the top of the lower-middle unit beneath the tailings surface is 60 to 65 feet. However, the potentiometric surface of the lower-middle unit is two to three feet above the surface of the tailings. A strong, vertically upward hydrauliic gradient exists between the lower-middle unit, and the overlying top- and upper-middle hydrostratigraphic units, which has prevented seepage and contaminants from the tailings from entering the lower-middle unit. The general direction of groundwater flow in the lower-middle unit beneath the tailings pile is west toward the Green River. West and east of the tailings, the lower-middle unit intertongues with the upper-middle unit, and the lower-middle unit becomes thin and discontinuous or nonexistent in some places. The flow of groundwater in the lower-middle unit west and east of the tailings is undoubtedly controlled by the intertonguing. The volume flow rate of groundwater in the lower-middle unit beneath the present tailings pile was not calculated since this unit has not been affected by tailings seepage.

Groundwater in the lower-middle unit beneath the proposed disposal site is first encountered at a depth of about 60 feet. Groundwater flow in this unit between the disposal site and the present tailings pile is controlled by the same factors that control flow in the overlying upper-middle unit. The flow of groundwater in the lower-middle unit beneath the disposal site is about two gpm.

Bottom hydrostratigraphic unit

Confined groundwater is present in the bottom unit beneath the tailings site. The potentiometric surface in the bottom unit is five to 14 feet above the present tailings surface, and 56 to 71 feet below the surface of the proposed disposal site. The direction of groundwater flow is north-northwest in the bottom unit. Groundwater flow through the bottom unit beneath the present tailings pile was not calculated since the bottom unit has not been affected (and will not be affected) by tailings seepage.

3.5.3 Groundwater quality

Groundwater quality at the Green River tailings site was characterized and compared with the proposed EPA standards for remedial action at inactive uranium processing sites and state of Utah drinking water standards. Since the maximum concentration limits for the proposed EPA standards and the Utah Primary Drinking Water Standards are the same, the ensuing discussion will refer only to the EPA standards. A list of standards for purposes of site characterization is provided in Table D.5.1 of Appendix D.

Background groundwater quality in the four hydrostratigraphic units at the Green River site was determined for the following proposed EPA constituents: chromium; molybdenum; nitrate; selenium; radium-226 and 228; uranium; and gross alpha. The other proposed EPA constituents listed in Table D.5.1 of Appendix D were found at levels below or near detection for the first two rounds of sampling in June 1986 and September 1986; consequently, some of these remaining constituents were excluded from subsequent sampling rounds and are not considered to be present as contamination at the Green River tailings site. Background groundwater quality in all four units is characterized by total dissolved solids (TDS) and concentrations of sulfate and chloride that exceed EPA and State of Utah Secondary Drinking Water Standards. Based on production capacity and TDS, groundwater in all four units would be classified as Class II. However, it may be classified as Class III because of the presence of selenium, molybdenum, chromium, nitrate, and uranium in background samples that exceeds proposed EPA maximum concentration limits for those constituents. A Class III designation of the groundwater at the Green River site based upon these criteria is not pursued in this RAP, and is not a component of the water resource protection strategy for disposal of tailings at the Green River site. However, the poor background and baseline water quality of the uppermost aquifer will be reconsidered when Subpart C (groundwater restoration) of the standard is pursued in a separate process.

Background groundwater quality in the top hydrostratigraphic unit is characterized by maximum concentrations of chromium (0.14 milligrams per liter, or mg/l), molybdenum (0.20 mg/l), nitrate (140 mg/l), and selenium (0.38 mg/l), and gross alpha activity (41 pCi/l) that exceed proposed EPA maximum concentration limits for these constituents. In the upper-middle unit, maximum concentrations of nitrate (93 mg/l), selenium (2.50 mg/l), and gross alpha activity (21 pCi/l) exceed proposed EPA maximum concentration limits; uranium (0.038 mg/l) is very close to the proposed maximum concentration limit of 0.044 mg/l. Background groundwater quality in the lower-middle hydrostratigraphic unit is characterized by concentrations of chromium (0.09 mg/l), molybdenum (0.22 mg/l), nitrate (173 mg/l), selenium (0.32 mg/l), uranium (0.155 mg/l), and gross alpha activity (150 pCi/l) that exceeds the proposed EPA maximum concentration limits for these constituents. In the bottom hydrostratigraphic unit, background concentrations of chromium (0.07 mg/l), molybdenum (0.14 mg/l), selenium (0.106 mg/l), and gross alpha activity (30 pCi/l), exceed proposed EPA maximum concentration limits.

Contaminated groundwater upgradient of the present tailings pile was also detected in the shale and mudstone of the Cedar Mountain Formation beneath the lower-middle unit. This contaminated water was collected from a monitor well located south (upgradient) of the tailings and west of the proposed disposal site. Maximum concentrations of nitrate (1280 mg/l) and selenium (0.322 mg/l) are over one order of magnitude higher than the proposed EPA maximum concentration limits for these constituents; the boron concentration is 0.84 mg/l, which is slightly higher than the State of Utah Drinking Water Standards maximum concentration limit of 0.75 mg/l. Since this saturated zone within the Cedar Mountain Formation (78 to 98 feet below the surface) is isolated from any surface source of contamination by strong, vertically upward hydraulic gradients, the source for contaminants found within this unit is from somewhere off of the tailings site, and possibly from an elevation below (upgradient of) the contamination.

The percolation of tailings leachate into the groundwater system beneath the present tailings pile has adversely impacted the water quality in both the top and upper-middle hydrostratigraphic units. The vertical extent of the contamination is confined to these two units by strong, vertically upward hydraulic gradients between the upper-middle unit and the underlying units. The maximum depth of contamination beneath the surface of the tailings is about 65 feet. Groundwater within the top and upper-middle units beneath the tailings contains levels of gross alpha activity, molybdenum, nitrate, selenium, and uranium that exceed the proposed EPA standards and/or background levels for these constituents; ammonium levels also exceed background levels (ammonium has neither a proposed EPA standard nor a Utah drinking water standard). The maximum concentrations observed for these contaminants in the top unit are: gross alpha activity (950 pCi/l); molybdenum (0.27 mg/l); nitrate (440 mg/l); selenium (0.41 mg/l); uranium (2.23 mg/l); and ammonium (42 mg/l). In the upper-middle unit, the observed maximum concentrations are: gross alpha activity (980 pCi/l); molybdenum (0.20 mg/l); nitrate (2480 mg/l); selenium (0.37 mg/l); uranium (3.11 mg/l); and ammonium (47 mg/l).

The contamination resulting from the tailings seepage travels downgradient through the top unit (Brown's Wash alluvium) toward the northwest and the channel of Brown's Wash. Once in Brown's Wash the contaminants move west with groundwater flow in the shallow alluvium (as subflow in the channel) or on the surface.

Surface water sample analyses from Brown's Wash (DOE, 1988a) indicate contaminated groundwater discharges to Brown's Wash; however, flow in the channel is intermittent and the concentrations of the contaminants (as well as major cations and anions) are a function of the evaporation of water in the channel (i.e., evaporation causes a relative increase in concentration of the contaminants). The contaminated water travels downstream (west) in Brown's Wash and mixes with backwater from the Green River. Water quality analyses from samples of Green River water upstream and downstream from its confluence with Brown's Wash show that the discharge of contaminated water from Brown's Wash to the Green River has no adverse affect on the water quality of the Green River (DOE, 1988a). This is because the contaminants are diluted by a factor of 10^5 to 10^6 once they mix with the Green River.

Contamination from tailings leachate in the upper-middle hydrostratigraphic unit extends northwest from the tailings pile. Contaminant plumes of gross alpha, molybdenum, and nitrate extend 1000 to 1200 feet downgradient of the middle portion of the tailings pile. Selenium, which seems to be the most mobile of the contaminants, extends 1800 feet or more downgradient of the tailings. Uranium has probably moved only 300 to 600 feet downgradient of the middle portion of the tailings pile, and the plume probably does not extend past the west (downgradient) edge of the pile; this indicates that uranium is being geochemically attenuated in the upper-middle unit. Contamination is also present near Brown's Wash in the upper-middle unit 1500 to 1600 feet west of the tailings. The source of this contamination is likely seepage of contaminated water in Brown's Wash channel into the bedrock channel bottom, primarily through connected vertical fractures in the bedrock. Since the source concentrations of the contaminants at this location are far less than the concentrations at the tailings source, this "secondary" plume of contamination is very localized and probably does not extend very far beyond the channel of Brown's Wash.

3.5.4 Groundwater use, value, and alternative supplies

There are 15 registered wells in Township 21 South, Range 16 East in the Green River area. Only one of these wells is on the same side of the Green River as the tailings site, and none are within the potentially affected environment of the tailings site. The majority of the 15 registered wells are not being used becaus of poor quality of the water, disrepair of the wells, and the availability of better quality water from the city of Green River. The usage of groundwater in the vicinity of Green River is consistent with the usage of groundwater on a regional basis. It is difficult to assign a value to groundwater that has no use or only very limited use. Qualitatively, it can be stated that the shallow groundwater, either affected or unaffected by tailings seepage, has little or no value because of the naturally high concentrations of selenium, molybdenum, chromium, nitrate, and uranium found within it. For this reason, the shallow groundwater may be classified as Class III (i.e., the groundwater is contaminated naturally to the extent that it cannot be cleaned up using treatment methods reasonably employed in public water supply systems).

Future use of shallow groundwater for domestic consumption in the site area is not expected due to its poor natural quality and the availability of better quality water from the Green River. In spite of the poor natural quality of the groundwater within the Brown's Wash alluvium (top hydrostratigraphic unit) and the upper and lower portions of the Cedar Mountain Formation, water suitable for livestock and some crop irrigation was located in the Buckhorn Conglomerate Member of the Cedar Mountain Formation beneath the tailings site; this unit is protected from current and future contamination in the overlying aquifers by strong, vertically upward hydraulic gradients.

The seepage of tailings fluids from the Green River site has not adversely impacted any groundwater currently being used. Alternate water supplies to residents in the Green River area include Green River water as currently supplied by the city of Green River, and commercial (bottled) water.

3.6 SURFACE WATER

The tailings pile and mill site at the Green River site are on a slope between an upper abandoned river terrace and the southern edge of the present floodplains of the Green River and Brown's Wash.

Major tributaries of the Green River (which joins the Colorado River 100 miles downstream of the site) are the Yampa and White Rivers of Colorado and the Duchesne and Price Rivers of Utah, all of which flow into the Green River above the site, and the San Rafael River, which joins the Green River about 20 miles downstream of the site. Brown's Wash has a drainage area of approximately 85 square miles near the Green River tailings site. Approximately 750 feet northeast of the tailings pile an unnamed intermittent stream flows into Brown's Wash.

Surface runoff north of the site is diverted from Brown's Wash and the tailings site by a railroad embankment. Runoff from the mill site is directed northwest to Brown's Wash and eventually to the Green River. An area of approximately 110 acres drains to the disposal area southeast of the mill yard. This area is drained to the southwest and northeast by several small gullies.

The tailings pile is subject to erosion and inundation from flood events in Brown's Wash having a recurrence interval of approximately 500 years. Floods with lesser recurrence intervals could cause erosion of the tailings due to bank failure. The tailings pile would not be affected by flooding of the Green River because the overbank areas are broad and flat and flow could not reach the pile. The proposed disposal area is not susceptible to flooding of either the Green River or Brown's Wash.

There are no uses of water in Brown's Wash in the vicinity of the Green River site. The city of Green River presently takes water out of the Green River upstream of the confluence with Brown's Wash for municipal use. Withdrawal downstream of the site is minimal.

The quality of water in Brown's Wash is affected by the presence of the tailings. The effect is dependent on the quantity of flow in the wash. There are no measurable effects from the tailings on the quality of water in the Green River.

4.0 SITE DESIGN

4.1 INTRODUCTION

This section discusses the following design items for remedial action at the Green River, Utah, UMTRA site:

- Remedial action objectives.
- Permanent design features.
- Construction features.
- Construction activities and schedule.

Maps, drawings, and tables relevant to the design are provided in this section and the appendices of this RAP. The site design presented herein is described to demonstrate compliance with EPA standards.

The main objectives of the site design are to satisfy the UMTRCA and the EPA standards restricting the release of contaminated materials into the environment and limiting the release of radon gas and gamma radiation from tailings, contaminated soils, and other contaminated materials.

4.2 DESIGN OBJECTIVES

The major design objectives are as follows:

- Consolidate and stabilize contaminated materials in a disposal embankment above the elevation of the Probable Maximum Flood (PMF) in Brown's Wash.

- Reduce radon flux to the atmosphere from tailings and from other contaminated materials to levels not greater than 20 pCi/m^2s.

- Design permanent features for stabilization of tailings and other contaminated materials to be effective for at least 1000 years to the extent achievable, and in any event, for at least 200 years.

- Prevent human and animal disturbance of the disposal embankment.

- Minimize, to the extent achievable, the impact of materials in the disposal embankment on ground and surface water.

- In areas that will be released for unrestricted use, reduce Ra-226 contamination levels to less than five pCi/g above background levels in the top 15 cm of soil and to less than 15 pCi/g above background levels in any 15-cm-thick soil layer beneath the top 15 cm.

- Minimize the size of the restricted final disposal site.

- Minimize the release of contaminants from the site during construction.

- o Minimize the area disturbed during construction.
- o Minimize the exposure of workers and the general population to contaminated materials.

4.3 DESIGN SUMMARY

4.3.1 Remedial action summary

The main feature of the remedial action is relocation and stabilization of contaminated materials in a disposal embankment on a terrace located above Brown's Wash. Contaminated materials to be relocated will include:

- o Materials from the tailings pile.
- o Windblown contamination on the surface of the site and adjacent areas and contaminated materials from vicinity properties.
- o Debris resulting from demolition of contaminated buildings.
- o Contamination resulting from decontamination of buildings.

The disposal embankment will cover six acres and contain 339,377 in-place cubic yards of contaminated materials.

The mill site is located approximately one-half mile east of the Green River and one mile southeast of the city of Green River. The disposal embankment will be located southeast of the former mill site on a terrace 70 feet above the elevation of the floodplain of Brown's Wash. The location and design of the disposal embankment have been selected to protect against erosion from Brown's Wash and against undercutting of the embankment by gully formation.

The stabilized embankment will be constructed primarily below the existing ground surface. The excavation for the below-grade portion of the embankment will extend into bedrock of the Dakota and Cedar Mountain Formations. Excavation will be performed with conventional earth-moving equipment. Tailings and windblown contaminated material will be placed and compacted in horizontal layers starting on top of a six-foot-thick layer of compacted select soil fill placed at the bottom of the excavation.

An infiltration/radon barrier will be constructed of compacted uncontaminated materials. The infiltration/radon barrier is designed to protect groundwater by minimizing infiltration and to reduce radon flux from the embankment to less than 20 pCi/m^2s. The infiltration/radon barrier will consist of a 36-inch-thick layer of compacted silty clay imported from a source located 2.5

miles north of the site. Six percent bentonite by weight will be mixed into the radon barrier material to ensure a compacted infiltration/radon barrier saturated hydraulic conductivity of less than 2 x 10^{-8} cm/s.

An erosion protection layer will be constructed to protect the infiltration/radon barrier and embankment from runoff that would result from a Probable Maximum Precipitation (PMP) on the embankment and from runoff that would result from a PMF from the small watershed upslope of the embankment. The erosion protection layer is also designed to protect the embankment from the encroachment of gullies.

The uppermost portion of the erosion protection will be a layer of riprap. Above finished grade, the riprap will be 12 inches thick and have a minimum mean size of D_{50} = 2.6 inches. This riprap is referred to as Type A riprap. A six-inch-thick bedding layer will be placed above the select fill to prevent migration of the infiltration/radon barrier into the riprap. The lower 15 inches of the infiltration/radon barrier will be below the maximum projected frost depth at the toe of the sideslopes.

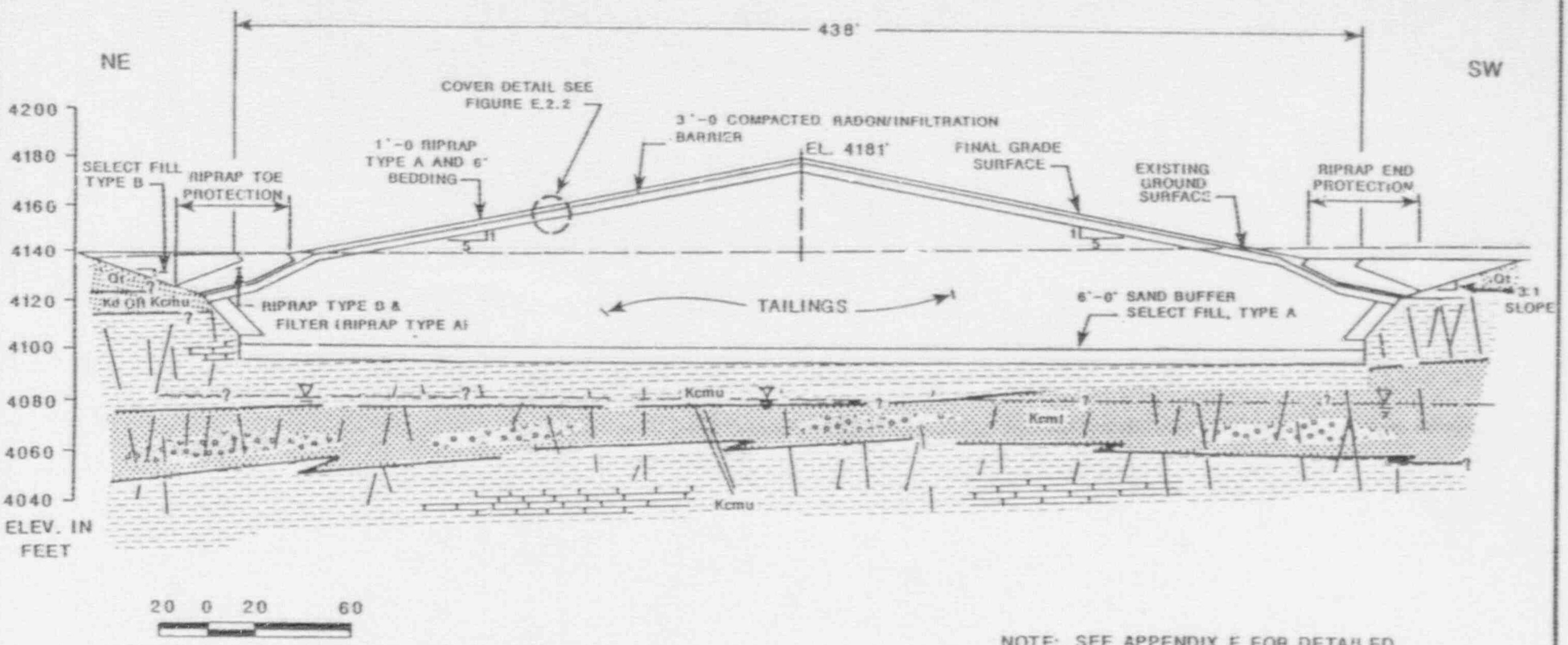
Below finished grade, the riprap will be a minimum of 36 inches thick and have a minimum D_{50} = 18 inches. This riprap is referred to as Type B riprap. A 12-inch-thick layer of Type A riprap and a six-inch layer of bedding material will be constructed between the infiltration/radon barrier and the Type B riprap. These intermediary layers will prevent migration of the infiltration/radon barrier into the Type B riprap.

The configuration of the infiltration/radon barrier, bedding, and Type A and B riprap layers are presented in Figures 4.1 and 4.2.

Slopes of the disposal embankment will be 5:1 and will be from the approximate bedrock surface elevation up to 4181 ft above mean sea level (MSL) at the top of the embankment.

Existing gullies near the disposal embankment will be regraded to minimize potential hazards of enlargement of the gullies and the formation of new gullies. Gravel fill materials will be placed and compacted in the bottom of each gully. The remainder of each gully will be filled with material from the disposal embankment excavation. About 69,900 cy of gravel will be used to fill gullies.

The mill building addition, the office building addition, and the roaster building will be demolished. Debris resulting from demolition will be buried in the disposal embankment. All demolition activities will be controlled to protect workers and to restrict release of airborne contamination. Contaminated material will not be removed from the site.



NOTE: SEE APPENDIX F FOR DETAILED PLANS AND SPECIFICATIONS

LEGEND

	FORMATION	MATERIAL	SYMBOL
Qt	TERRACE SEDIMENTS	SOILS	▨
Kd	DAKOTA SANDSTONE	BEDROCK	▨ SANDSTONE OR SILTSTONE
Kcmu	CEDAR MOUNTAIN FORMATION UPPER-MIDDLE UNIT		☐ SHALE OR MUDSTONE
Kcml	CEDAR MOUNTAIN FORMATION LOWER-MIDDLE UNIT		▦ LIMESTONE
			⁘ CONGLOMERATE

// FRACTURES

—▽— POTENTIOMETRIC SURFACE

FIGURE 4.1

DIAGRAMMATIC CROSS SECTION OF PROPOSED DISPOSAL CELL AND FOUNDATION
GREEN RIVER, UTAH, TAILINGS SITE

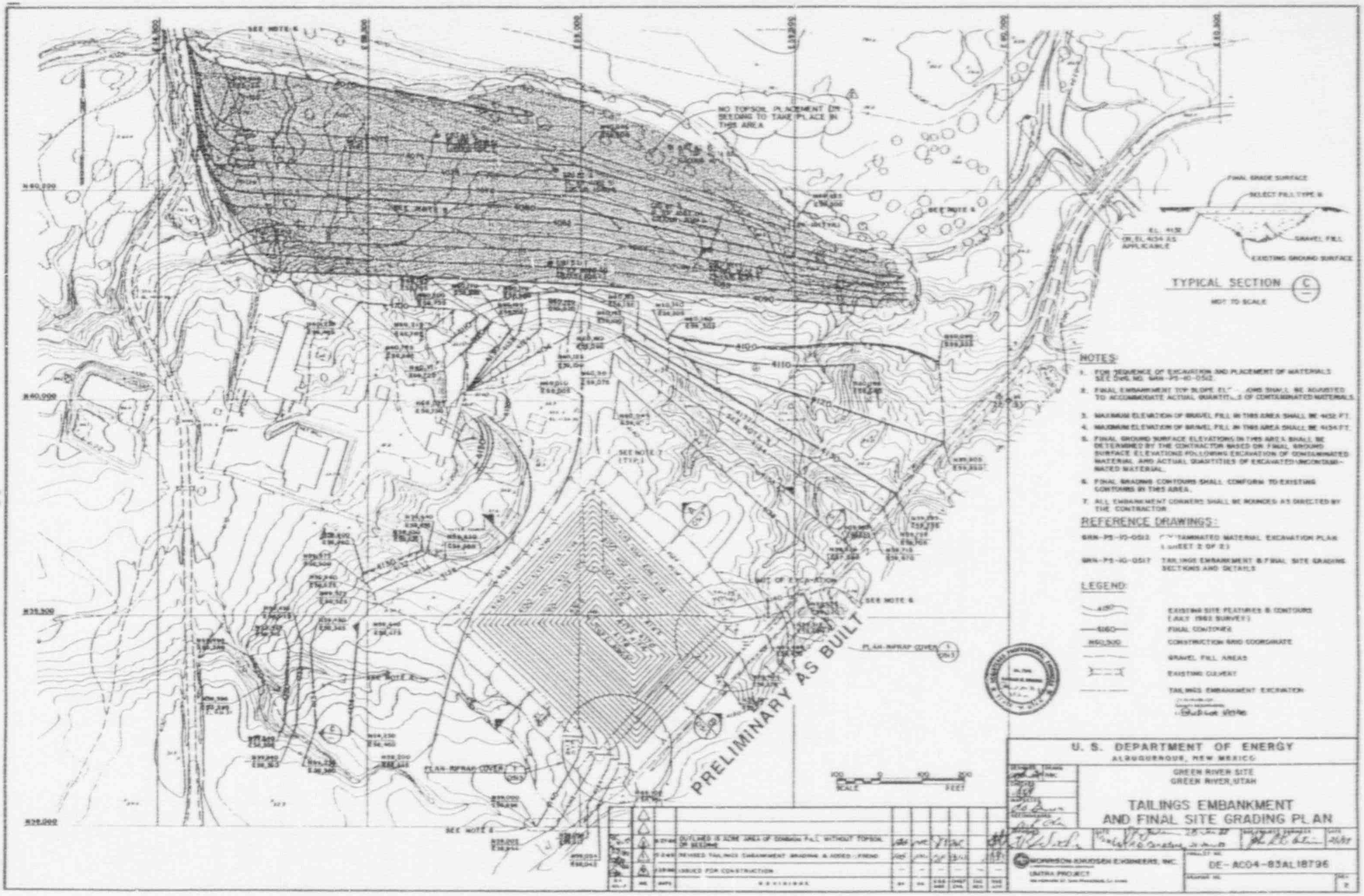


FIGURE 4.2
TAILINGS EMBANKMENT AND FINAL SITE GRADING PLAN

The mill building, crusher building, and office building will be decontaminated to make them suitable for reuse.

Excavated and disturbed disposal site and borrow site areas will be regraded (or backfilled) as required to promote drainage and subsequently revegetated. Areas outside the final disposal site boundary will be released for unrestricted use after completion of remedial action.

4.3.2 Control and monitoring of moisture in contaminated materials and tailings

The specifications for placement of disposal cell materials have been carefully prepared to minimize and control the use of water in order to meet MCLs or background concentrations at the point of compliance (POC) for the identified hazardous constituents. (See Section 2200 of Appendix F.) However, natural precipitation and dust control water could lead to an increase in the moisture content within the disposal cell. A monitoring system is proposed to measure the moisture within the disposal cell during and immediately following construction.

4.3.3 Reprocessing assessment

The cost-effectiveness of reprocessing the tailings to recover the residual uranium has been analyzed (FBDU, 1981). The analysis indicates that capital and operating costs for reprocessing the tailings would be approximately \$1600 (1981 dollars) per pound of uranium oxide produced. The present market value of uranium oxide is less than \$25 per pound. Reprocessing, therefore, is not economically feasible.

4.3.4 Site acquisition requirements

Legal access to the site will be through purchase of the site from UMETCO by the state of Utah. The site will remain in the ownership of the state during site construction. Following completion of the remedial action, ownership of the permanent diposal site will be transferred to the DOE.

4.3.5 Justification of the Green River design

The EPA standards in 40 CFR 192.02(a)(1) require that control of residual radioactive materials and listed constituents be designed to be effective for up to one thousand years, to the extent reasonably achievable, and, in any case, for at least 200 years. For those sites where the DOE is unable to demonstrate that control measures will clearly be effective for 1,000 years, the DOE must demonstrate that (1) the proposed design represents the best reasonably achievable design to control residual radioactive materials and listed constituents, and (2) control will be effective for some duration in excess of 200 years.

The DOE considers that the Green River disposal unit will control residual radioactive materials and listed constituents in compliance with the EPA standards for at least 1,000 years. The DOE's compliance demonstration with the groundwater protection standards relies on long groundwater travel times between the base of the contaminated materials and the point of compliance. Under expected conditions, the DOE estimates that the travel times will exceed 1,000 years. The travel times, however, may be somewhat less than 1,000 years, but greater than 200 years, considering the uncertainties and limitations of the analyses used to develop the estimates. Therefore, the DOE will herein demonstrate that the disposal unit design is the best reasonably achievable design and that the disposal unit will effectively control residual radioactive materials for at least 200 years to demonstrate compliance with groundwater protection aspects of the EPA standards in 40 CFR 192.02(a)(1).

The DOE has prepared a comparative analysis of alternative disposal designs and concluded that the Green River disposal unit is the best reasonably achievable design to comply with the EPA standards. The following discussion supports this conclusion.

Alternate sites

The DOE considered a representative set of alternative site locations for the disposal of residual radioactive materials from Green River. The set included stabilization in place, stabilization on site (the preferred alternative), and relocation at (1) the northeast Green River site, (2) the southeast Green River site, (3) the Thompson site, and (4) the Woodside site (DOE 1988a; DOE 1986a; and FBDU 1981). Stabilization in place would create a sufficient hazard from flooding by Brown's Wash that the disposal unit may not comply with the EPA standards with respect to long-term stability. Consequently, stabilization in place was rejected as a disposal option. The alternate sites considered did not provide significantly better conditions in terms of groundwater protection because the hydraulic properties and groundwater quality at these sites is similar in many ways to those at the Green River site. Further, relocation of the materials to the alternate sites would increase the cost of the remedial action by \$12 million to \$38 million because of the site preparation and transportation costs. Therefore, stabilization on site in the area formerly used for ore storage, well above the floodplain of Brown's Wash, is the preferred disposal site alternative.

Disposal cell configuration

The DOE selected partially below-grade disposal of the residual radioactive materials to enhance the long-term stability of the disposal cell. The DOE considered three variables in selecting the configuration of the disposal sell: shape, area, and depth. Assessments of a representative set of alternate shapes indicated that shape has minimal effect on compliance with the groundwater protection standards. The shapes that have the greatest potential to reduce groundwater impacts are difficult to construct and significantly increase the cost of the remedial action compared to the square shape of the preferred design. In addition, some shapes significantly increase the surface areas of the disposal unit; increases in surface area result in corresponding increases in the water flux, and conceivably the flux of listed constituents, through the disposal unit. The square shape is the preferred alternative design with minimum area that is readily constructible.

Given the square shape, the maximum excavation depth of 43 feet has been selected to minimize the surface area of the disposal unit. Greater depths of excavation would place the residual radioactive materials unacceptably close to the water table, which is located approximately ten feet below the preferred excavation depth. The separation distance was selected based on the highest measured water table elevation and the maximum recorded seasonal variation of the water table at the site. Deeper excavation would penetrate through the calcareous shale bedrock into the sandstone layer beneath the site. Deeper excavation could be detrimental by destroying the shale layer, which is a natural barrier to contaminant migration, and by directly connecting the base of the disposal cell with the sandstone unit, which has relatively high hydraulic conductivity. Therefore, the DOE selected the disposal cell configuration to minimize the flux of water and constituents through the cell, to protect against saturation within the cell, and to avoid compromising a natural barrier to contaminant migration.

Buffer layer

The DOE included a buffer layer at the base of the disposal unit to protect against rapid fingering and preferential flow of leachate through the unsaturated zone beneath the unit, to increase the groundwater travel time from the base of the contaminated material to the point of compliance, and to attenuate transport of some listed constituents by adsorption, ion exchange, and precipitation. The DOE considered a number of variables with respect to the design of the buffer layer, including hydraulic properties, sorption characteristics, and thickness.

The DOE considered buffer materials with both lower and higher saturated hydraulic conductivities, ranging from 1E-8 to 1E-3 cm/s, compared with the design saturated conductivity of the buffer layer of 5E-5 cm/s. Once the water flow through the disposal unit reaches steady state, the flux under a unit hydraulic gradient will be controlled by the lowest conductivity to minimize the flux through the disposal unit. Selection of a lower conductivity material for the buffer layer would not significantly improve performance of the disposal unit because the flux rate is governed by the flux through the cover. In addition, the selection of a buffer material with a conductivity equal to or less than the cover conductivity (2E-8 cm/s) could cause adverse accumulation of water above the buffer layer within the disposal (e.g., "bathtubbing"). Such accumulation could cause direct discharge of constituents from the disposal cell. Further, lower conductivity materials may not sufficiently mitigate against fingering and preferential flow of leachate through the unsaturated zone beneath the unit. Finally, because the buffer will operate in the unsaturated state, there is little difference between it and a lower permeability material that would have to be placed at, and thus operate in, a saturated condition.

The DOE proposes to construct the buffer layer out of the selected silty and clayey sand and gravel that overlies bedrock at the disposal site. Although this material does not possess strong sorptive characteristics for the listed constituents at Green River, locally available materials that are suitable for buffer layer construction are not expected to be significantly better than the Green River materials in terms of sorption capacity. The silty and clayey sands and gravels contain interstitial carbonate deposits that may be effective in buffering the pH of leachate from the Green River disposal cell and, thus, reduce the mobility of chromium, Ra-226, arsenic, nickel, lead, and other constituents via precipitation. In addition, oxiferric and alumniohydroxide coatings in the silty and clayey sands and gravels may be effective in sorbing listed constituents such as uranium, arsenic, and radium. Further, the constituents present in the Green River buffer material may not be effective in attenuating all listed constituents. Therefore, materials with better sorptive characteristics than the selected buffer material do not appear to be readily available without a comprehensive search and analysis of alternative materials and considerable expense.

Batch and column feed testing of the buffer material show that the buffer material is effective in reducing feed concentrations of arsenic, molybdenum, selenium, and vanadium (tailings extract solution) to significantly lower concentrations. This testing, with the results, is documented in calculation GRN-07-89-12-07-00 (see Appendix H).

The DOE also considered the thickness of the buffer layer. In general, the buffer layer must be thick enough to provide sufficient travel time between the residual radioactive material and bedrock and to mitigate fingering and yet be thin enough to avoid expanding the surface area of the disposal unit. If the buffer layer were much thinner than the preferred design (e.g., two feet compared with six feet), preferential flow through the buffer layer could become dominant and result in relatively rapid transport of constituents through the fractured bedrock to the water table. In addition, the travel time through the buffer layer would decrease linearly as a function of thickness.

On the other hand, increases in the thickness of the buffer layer (e.g., eight feet compared with six feet) would expand the layer into the volume available to dispose of residual radioactive materials.

Because the base of the excavation is already at a minimum elevation (as discussed above), expansion of the buffer layer would require horizontal expansion of the disposal unit. This expansion would cause a corresponding increase in the surface area of the disposal unit and place more of the residual radioactive materials above the existing ground surface. Such changes could reduce the inherent stability of the disposal cell and may allow the encroachment of nearby gullies and impair the cell's ability to protect groundwater in exchange for a slight gain in travel time and sorption. Further, significant increases in the thickness of the buffer layer would be required to increase travel time through the layer significantly because thickness varies linearly and travel time is directly proportional to thickness. For example, an increase in thickness from six feet to 50 feet would be required to increase the travel time through the buffer layer from 120 years to 1,000 years.

Therefore, the design of the buffer layer has been optimized with respect to groundwater protection by considering its hydraulic properties, sorptive characteristics, and thickness.

Windblown materials

A substantial volume (200,000 cubic yards) of windblown and vicinity property material was found at the Green River site. This material was characterized in terms of leachable hazardous constituents (calculation GRN-07-89-12-07-00 in Appendix H) to determine where within the disposal cell these materials should best be placed. The chemical characterization of the windblown material showed that, for all of the hazardous constituents identified at the Green River site except for uranium and vanadium, the extract concentrations from batch experiments using the windblown materials are below the interim concentration limits proposed by the NRC (and concurred in by the DOE). The column leach tests show, however, that uranium and vanadium feed concentrations are reduced when leached through a laboratory column of buffer material. For these reasons, the windblown materials were considered to be "clean" of leachable hazardous constituents that could impact groundwater quality beneath the disposal cell. The DOE, therefore, optimally placed the windblown and vicinity properties material within the disposal cell between the tailings (upper portion of the cell) and the buffer material (bottom of the cell). It is reasonable to assume, then, that the 25-foot-thick layer of windblown and vicinity property materials acts in a similar manner as the buffer materials and can be included in the calculation of travel times to the base of the disposal cell (calculation GRN-07-89-03-04) from the overlying tailings (see Section E.3 of Appendix E).

Moisture contents

The DOE will construct and maintain the materials comprising the disposal cell at moisture contents near that of the average steady state moisture contents. Moisture contents of the disposal unit materials must be minimized to avoid the drainage of water added during the construction. Such drainage could significantly reduce groundwater travel times to the point of compliance and temporarily increase the transport of listed constituents out of the unit. However, if moisture contents are too low, the DOE may have difficulty compacting materials to the densities required to ensure the long-term geotechnical stability of the disposal unit and maintain airborne particulate concentrations and releases below appropriate state and Federal regulatory limits. As an alternative, the DOE considered adding a surfactant or other chemical agent to suppress fugitive emissions of dust and contaminated materials. However, because surfactants only treat the surface, construction traffic would make them ineffective almost immediately following application. In addition, such treatments add organic chemicals to the residual radioactive materials that may increase the release of contaminants and reduce the effectiveness of the disposal unit in protecting groundwater. The DOE can achieve the density specifications and control airborne emissions at moisture contents down to the approximate steady state moisture contents reported in the RAP. Calculation GRN-07-89-03-04 supports the concept that some variation of placement moisture content can be tolerated without causing excessive impact on travel time.

The DOE has committed to maintain moisture contents as low as reasonably achievable in the buffer and residual radioactive materials layers and in accordance with the steady state moisture contents identified in the April 5, 1989, agreements between the DOE and the NRC. Although lower moisture contents could increase groundwater travel times and decrease constituent transport to the point of compliance, imposition of measures to attain these contents could result in violations of the fugitive emission requirements and decrease the stability of the disposal unit. Thus, the steady state moisture contents are the optimum moisture contents for groundwater protection.

Radon barrier

The DOE has proposed a radon barrier consisting of three feet of silty clay amended with six percent by weight sodium bentonite that is compacted to 100 percent of the standard Proctor density. The DOE is confident that the barrier will have a saturated hydraulic conductivity less than 2E-8 cm/s and agrees to test as-constructed samples of the barrier to ensure compliance with this design conductivity. The DOE considered alternative cover designs to reduce potential infiltration into the disposal unit further, including substitution of synthetic polymeric membranes, CLAYMAX^R, or other alternatives for the silty clay barrier; increased thicknesses of the barrier; and increased percentages of bentonite in the barrier.

The DOE assessed the viability of alternative barriers in generic special studies that were initiated in response to the EPA's proposed groundwater protection standards in 40 CFR 192. The results of these studies are documented in "Remedial Action Planning and Disposal Cell Design" (DOE, 1989b). Based on the studies, the DOE concluded that only conventional earthen covers and CLAYMAX could be relied upon for long-term (1,000 years) protection of groundwater at disposal sites because of the inherent stability of synthetic materials and the limited operational experience with such materials. The DOE considered installing a thin layer of CLAYMAX in the cover to attain a net flux density equal to or less than 1E-9 cm/s. Based on analyses of the Green River site, the DOE concluded that the minimal improvement in performance of the disposal unit associated with a composite cover that included CLAYMAX would not adequately justify the significant increase in cost. In addition, the DOE would have to resolve substantial issues about the long-term durability and performance of CLAYMAX prior to including it in the disposal unit cover. Thus, the DOE rejected CLAYMAX because it was not a reasonable alternative.

The DOE also considered increasing the thickness of the bentonite-amended radon barrier. Increases would not significantly improve the long-term performance of the barrier. At least one foot of the barrier is located below the frost penetration zone and, thus, would be expected to provide a barrier with sufficiently low permeabilty to infiltration to minimize release of listed constituents. The barrier would be effective in reducing infiltration of water into the disposal unit to below 2E-8 cm/s. Thus, increasing the thickness of the radon barrier would only increase the cost of the remedial action without significantly improving the performance of the barrier.

The DOE considered increasing the content of sodium bentonite above the six percent by weight in the current design. Based on laboratory testing data on file at the UMTRA Project Office, the DOE concluded that further amendment of the radon barrier with sodium bentonite would not significantly decrease the hydraulic conductivity of the barrier. The specified hydraulic conductivity for the radon barrier of 2E-8 cm/s is approximately one order of magnitude below the generally accepted design conductivity of 1E-7 cm/s for compacted clay liners and covers at municipal and hazardous waste landfills. Attainment of the 2E-8 cm/s conductivity is considered to be the best and most reasonably achievable in terms of construction of earthen barriers to water and contaminants. Consequently, a six percent sodium bentonite admixture represents the optimum modification of the radon barrier with respect to groundwater protection because further increases in bentonite content do not improve performance of the cell.

Filter layer

The DOE has selected a high permeability filter layer above the radon barrier to enhance lateral runoff of incident precipitation off the disposal unit to further minimize infiltration. The hydraulic conductivity of the filter layer has been optimized at a conductivity of four cm/s (Calculation GRN-07-89-03-04) using a relatively clean sand and gravel. Lateral diversion of runoff could be increased, thus decreasing infiltration, by increasing the hydraulic conductivity of the filter layer above four cm/s. However, the runoff may be so rapid under such conditions that the water would erode the radon barrier, which could potentially increase infiltration and radon emissions and decrease stability of the disposal unit. The DOE also considered decreasing the thickness of the filter layer to ensure that the carrying capacity of the layer is minimized to divert runoff from the pile through the riprap under the design storm events. Such a decrease in thickness could lessen infiltration into the radon barrier by decreasing the amount of time that water would be ponded above the radon barrier on the sideslopes of the disposal unit. However, literature supports the concept that a decrease in bedding layer thickness may result in reduced erosional stability (Anderson et al., 1970). Further, calculations (GRN-07-89-03-04) show that by increasing the bedding permeability, little additional effect is gained by further changes to the cover geometry. Therefore, the filter layer has been optimized with respect to groundwater protection by ensuring that the thickness and hydraulic conductivity of the layer are large enough to divert runoff laterally off the side slopes of the disposal unit, yet not so high that the runoff would significantly degrade the performance of the disposal unit by eroding the radon barrier.

Source modifications

The DOE considered the viability of source modifications such as geochemical amendments to the residual radioactive materials and thermal stabilization of the materials. Such modifications were assessed generically for the UMTRA Project in special studies (DOE, 1989b). The DOE used the special studies to identify alternatives that deserved additional investigation because they may be viable on a site-specific basis. The DOE considered a representative range of source control alternatives for the Green River site, including washing, thermal stabilization, the addition of peat to reduce uranium and nitrate releases, and the addition of calcium hydroxide. Washing and thermal stabilization were rejected as unreasonable because they would significantly increase (i.e, from two to five times) the costs of the remedial action without demonstrably improving the long-term performance of the disposal unit in terms of groundwater protection. In addition, the washing alternative would require extensive engineering development, permitting, and operation to reduce the volume of the waste but would not significantly reduce the hazards associated with the listed constituents.

The DOE considered adding peat to the contaminated materials and concluded that the peat would not be expected to reduce the release of all constituents, even though it may sorb uranium and several other metals and reduce nitrate to less mobile species. As discussed previously, listed constituents in the residual radioactive materials are mobile under a variety of geochemical conditions and no one environment is expected to attenuate all the constituents. In addition, geochemical amendments such as peat have been studied only in the laboratory; such amendments have not been attempted in either bench- or field-scale applications. The laboratory studies have not provided conclusive results regarding the effectiveness of such amendments in attenuating the release of listed constituents from uranium tailings. Thus, there is considerable uncertainty about whether such amendments would be effective in reducing the release of listed constituents from the Green River disposal cell. Further, the addition of peat would significantly increase the cost of remedial action at the site and could decrease the stability of the site as a result of the organic degradation of the peat (Thompson, 1988). Therefore, the DOE concluded that a peat amendment was not a reasonable alternative for the Green River site.

The DOE also considered adding calcium hydroxide or another alkaline chemical agent to increase the pH of the residual radioactive materials. The increase in pH would be expected to decrease the solubility and mobility of listed constituents that are less soluble under neutral to alkaline pHs. However, the residual radioactive materials already have pHs that are in the range of neutral (e.g., six to eight) and further increases in pH could significantly increase the mobility and solubility of listed constituents such as uranium, molybdenum, and selenium as a result of complexion with hydroxide, carbonate, and bicarbonate radicals. Such behavior has been observed at other uranium tailings sites where alkaline groundwaters have been contaminated with tailings seepage or alkaline solutions were used to leach the uranium. Thus, the addition of calcium hydroxide as an amendment in the disposal unit would be expected to have an adverse impact with respect to the protection of groundwater (NRC, 1985b; NRC, 1984; NRC, 1983). Therefore, the DOE determined that calcium hydroxide or other alkaline chemical amendments to the disposal unit are inappropriate because they could actually decrease the effectiveness of the unit in terms of groundwater protection.

Contaminated material testing

The NRC normally requires testing to verify the placement density and moisture content of contaminated materials (including tailings, windblown contaminated soil, and vicinity property material) placed in the disposal cell at a frequency of one test per 1,000 cubic yards of material placed. Specifications for UMTRA Project sites constructed prior to the Green River disposal cell generally required contaminated material to be placed at 90 percent of standard Proctor density. In evaluating this practice the DOE was concerned that the remedial action subcontractor would not be restricted in the amount of water that could be added for compaction. Realizing that the moisture content at placement would be very important to attaining the groundwater protection strategy, the DOE proposed a contaminated material placement specification that would minimize the amount of water that could be added. The specification (see section 2200, 3.5, C. of Appendix F) states that contaminated materials would be compacted to 90 percent of standard Proctor by a minimum number of passes of a tamping foot or vibratory roller to be determined during initial placement of the first 1,000 cubic yards of windblown materials and tailings. This approach is appropriate because the materials were determined to be homogeneous within types (tailings and other contaminated material) and compaction for soils with similar particle gradations could be predicted from a review of literature and laboratory test data.

Considering the homogeneous nature of the contaminated materials (see Section D.4 of Appendix D), testing to verify placement density, and moisture content, a testing frequency of one test per lift was proposed by the DOE. Approximately 6,000 cubic yards or less of contaminated material would be included in each nine-inch-thick lift.

Further explanation of the testing of contaminated materials and the results of the tests are included in the calculation volume with the title "Green River, Utah, Contaminated Material Moisture Content, Density, and Compaction Data" accompanying this RAP and available through UMTRA Project Document Control, Albuquerque, New Mexico.

Conclusion

The DOE has considered a representative range of alternate disposal actions for the residual radioactive materials at the Green River site. Based on this assessment, the DOE concludes that the present disposal unit design represents the best design that is reasonably achievable to comply with the proposed EPA standards.

4.4 PERMANENT DESIGN FEATURES

4.4.1 Introduction

Permanent design features are described in more detail below for the cleanup of the mill site and adjacent areas and for stabilization of the disposal embankment. Factors considered in the design, including subsurface conditions, engineering properties of the tailings, groundwater protection, and requirements for erosion and radon control, are described and their effect on layout and construction of the disposal embankment are discussed.

4.4.2 Contaminated material excavation

Contaminated materials will be excavated and stockpiled. Areas that will be excavated and the corresponding excavation depths are shown on Figures 4.3 and 4.4. After these materials are excavated, the contractor will determine if these areas or other areas require additional excavation.

Stockpiled contaminated materials will be placed in the disposal embankment once the embankment excavation is completed.

4.4.3 Demolition of existing buildings

Six buildings are present on the former mill site. The location of these buildings are shown on Figure 4.5.

The roaster building, the office building addition, and the mill building addition will be demolished because it is not practical to decontaminate them. Debris that results from demolition will be placed in the disposal embankment. Demolition will be conducted in a manner that will protect workers and that will minimize release of airborne contamination.

4.4.4 Decontamination of existing buildings

The crusher building, the mill building, and the office building will be decontaminated in order to make them suitable for future use. Decontamination will include:

- o Washing building walls, ceilings, and floors.
- o Excavating contaminated soil and utilities that are located beneath the buildings.

4.4.5 Disposal embankment location

Stabilization on site of the tailings and other contaminated materials is the preferred disposal option. The Environmental Assessment (DOE, 1988a) concludes that stabilization on site is preferred because it is an economic solution that has equivalent or lesser environmental impacts than the other disposal options that were considered.

4.4.6 Disposal embankment layout

A description of the disposal embankment at the completion of remedial action work is provided in Section 4.3.1. The final embankment layout is shown on Figure 4.2. All contaminated materials will be buried in the disposal embankment. The surface area of the embankment has been reduced to the smallest practicable size

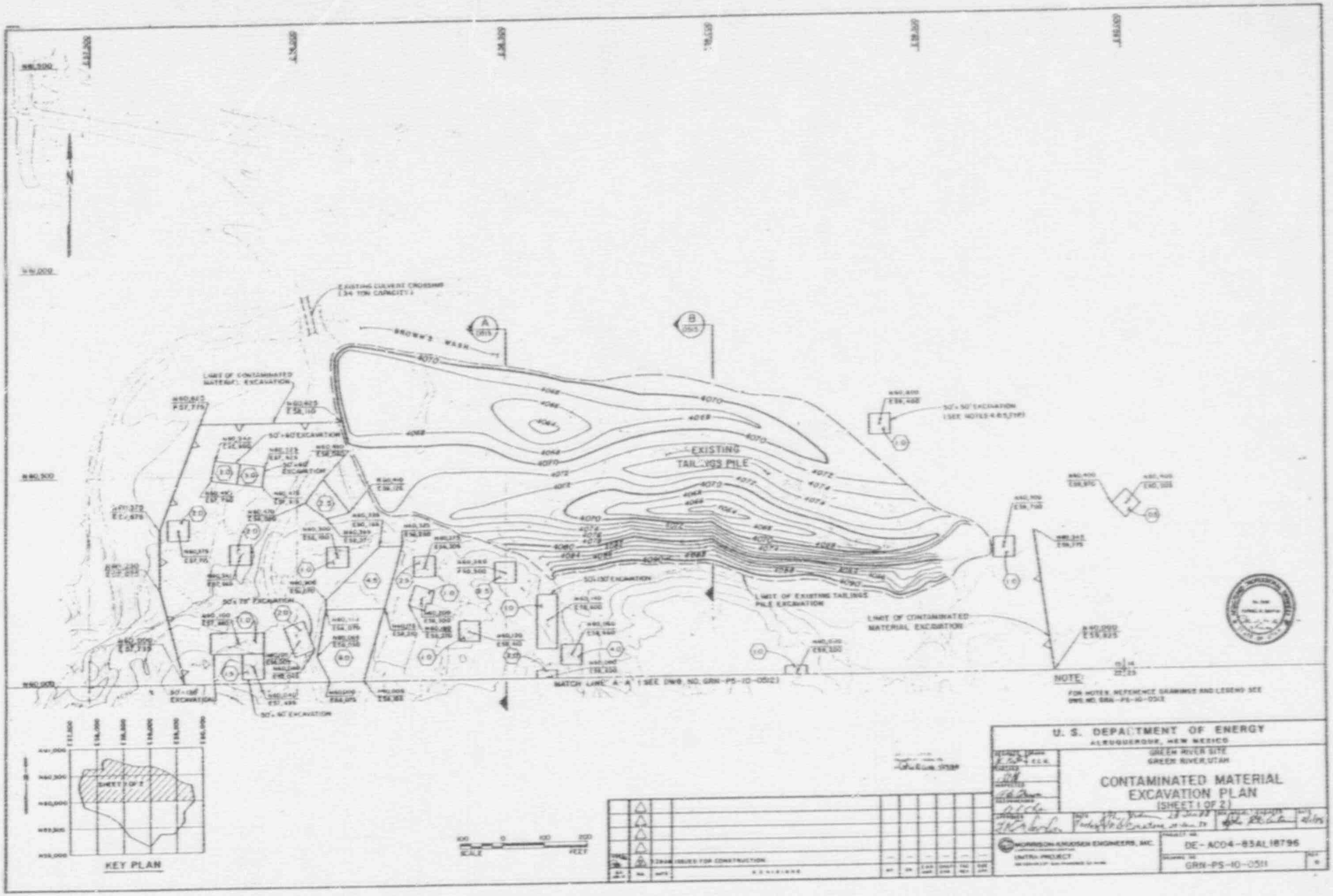
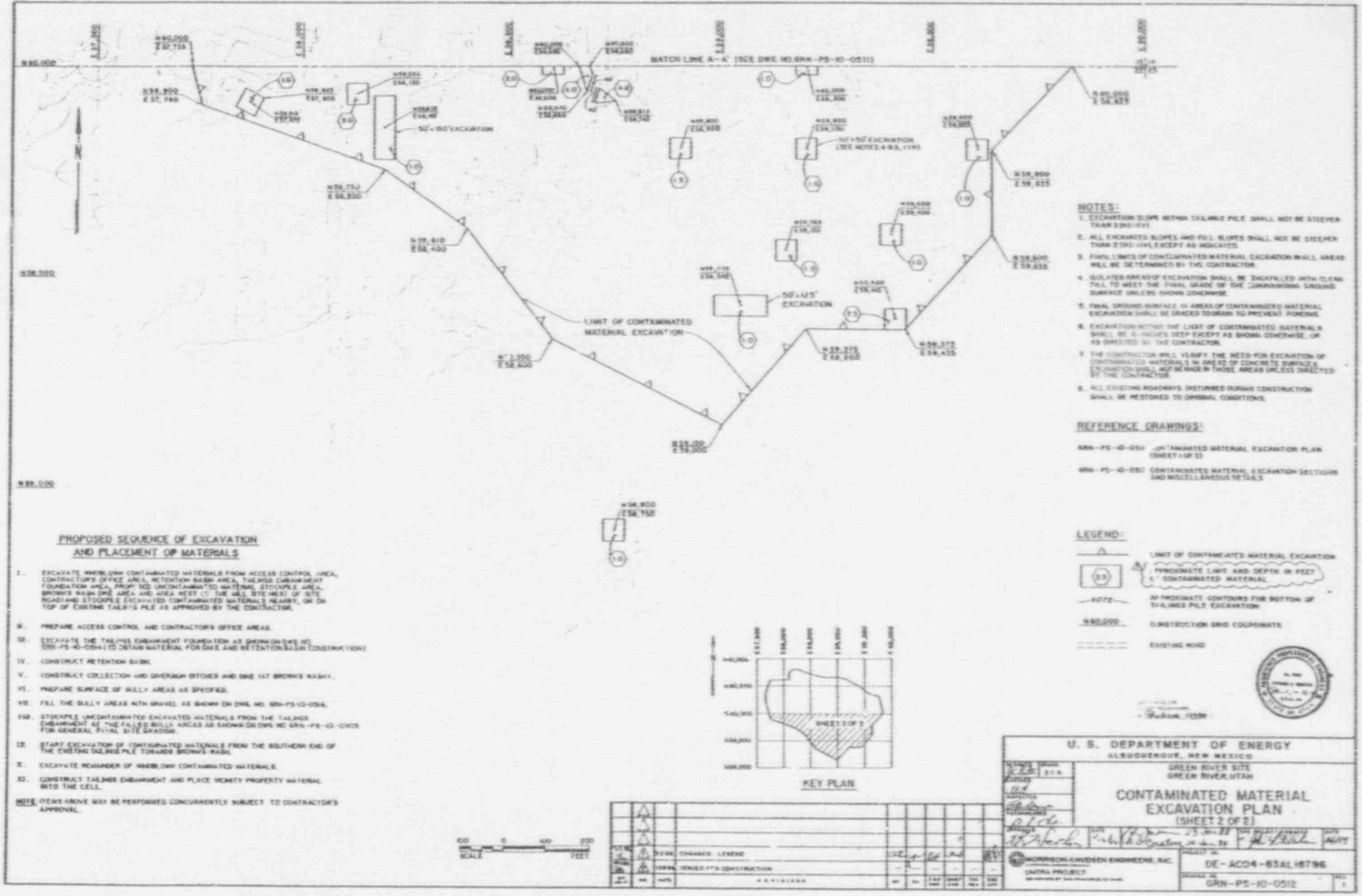


FIGURE 4.3

CONTAMINATED MATERIAL EXCAVATION PLAN



PROPOSED SEQUENCE OF EXCAVATION AND PLACEMENT OF MATERIALS

I. EXCAVATE WINDBLOWN CONTAMINATED MATERIALS FROM ACCESS CONTROL AREA, CONTRACTOR'S OFFICE AREA, RETENTION BASIN AREA, TAILINGS EMBANKMENT FOUNDATION AREA, PROPOSED UNCONTAMINATED MATERIAL STOCKPILE AREA, BROWN'S WASH DIKE AREA AND AREA WEST OF THE MILL SITE WEST OF SITE ROAD AND STOCKPILE EXCAVATED CONTAMINATED MATERIALS NEARBY, OR ON TOP OF EXISTING TAILINGS PILE AS APPROVED BY THE CONTRACTOR.

II. PREPARE ACCESS CONTROL AND CONTRACTOR'S OFFICE AREAS.

III. EXCAVATE THE TAILINGS EMBANKMENT FOUNDATION AS SHOWN ON DWG NO. GRN-PS-10-0514 (TO OBTAIN MATERIAL FOR DIKE AND RETENTION BASIN CONSTRUCTION).

IV. CONSTRUCT RETENTION BASIN.

V. CONSTRUCT COLLECTION AND DIVERSION DITCHES AND DIKE (AT BROWN'S WASH).

VI. PREPARE SURFACE OF GULLY AREAS AS SPECIFIED.

VII. FILL THE GULLY AREAS WITH GRAVEL AS SHOWN ON DWG. NO. GRN-PS-10-0516.

VIII. STOCKPILE UNCONTAMINATED EXCAVATED MATERIALS FROM THE TAILINGS EMBANKMENT AT THE FILLED GULLY AREAS AS SHOWN ON DWG NO. GRN-PS-10-0505 FOR GENERAL FINAL SITE GRADING.

IX. START EXCAVATION OF CONTAMINATED MATERIALS FROM THE SOUTHERN END OF THE EXISTING TAILINGS PILE TOWARDS BROWN'S WASH.

X. EXCAVATE REMAINDER OF WINDBLOWN CONTAMINATED MATERIALS.

XI. CONSTRUCT TAILINGS EMBANKMENT AND PLACE VICINITY PROPERTY MATERIAL INTO THE CELL.

NOTE: ITEMS ABOVE MAY BE PERFORMED CONCURRENTLY SUBJECT TO CONTRACTOR'S APPROVAL.

NOTES:

1. EXCAVATION SLOPE WITHIN TAILINGS PILE SHALL NOT BE STEEPER THAN 3(H):1(V).
2. ALL EXCAVATED SLOPES AND FILL SLOPES SHALL NOT BE STEEPER THAN 2(H):1(V), EXCEPT AS INDICATED.
3. FINAL LIMITS OF CONTAMINATED MATERIAL EXCAVATION IN ALL AREAS WILL BE DETERMINED BY THE CONTRACTOR.
4. ISOLATED AREAS OF EXCAVATION SHALL BE BACKFILLED WITH CLEAN FILL TO MEET THE FINAL GRADE OF THE SURROUNDING GROUND SURFACE UNLESS SHOWN OTHERWISE.
5. FINAL GROUND SURFACE IN AREAS OF CONTAMINATED MATERIAL EXCAVATION SHALL BE GRADED TO DRAIN TO PREVENT PONDING.
6. EXCAVATION WITHIN THE LIMIT OF CONTAMINATED MATERIALS SHALL BE 6-INCHES DEEP EXCEPT AS SHOWN OTHERWISE, OR AS DIRECTED BY THE CONTRACTOR.
7. THE CONTRACTOR WILL VERIFY THE NEED FOR EXCAVATION OF CONTAMINATED MATERIALS IN AREAS OF CONCRETE SURFACES. EXCAVATION SHALL NOT BE MADE IN THOSE AREAS UNLESS DIRECTED BY THE CONTRACTOR.
8. ALL EXISTING ROADWAYS DISTURBED DURING CONSTRUCTION SHALL BE RESTORED TO ORIGINAL CONDITIONS.

REFERENCE DRAWINGS:

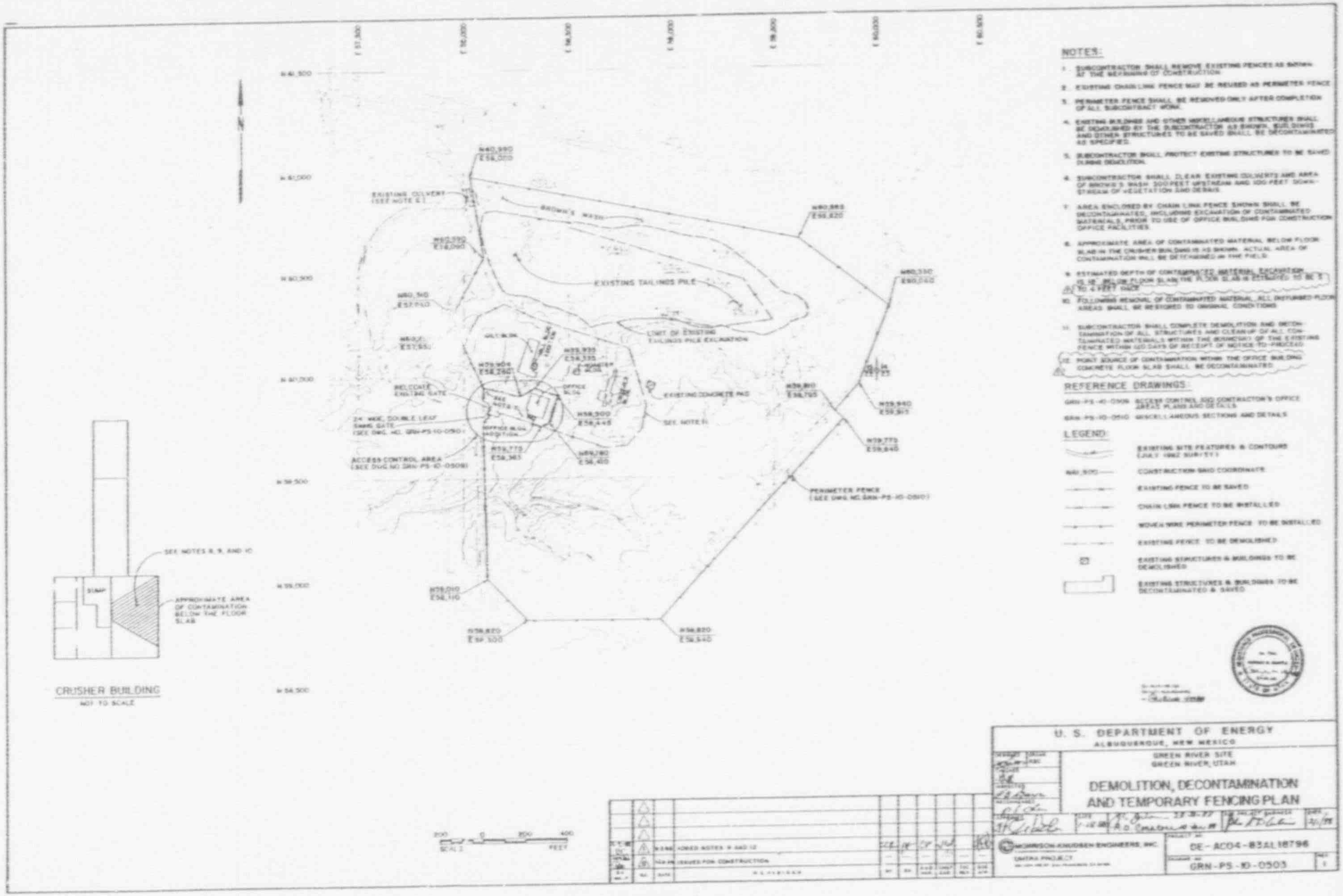
GRN-PS-10-0511 CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 1 OF 2)
GRN-PS-10-0513 CONTAMINATED MATERIAL EXCAVATION SECTIONS AND MISCELLANEOUS DETAILS

LEGEND:

LIMIT OF CONTAMINATED MATERIAL EXCAVATION
APPROXIMATE LIMIT AND DEPTH IN FEET OF CONTAMINATED MATERIAL
APPROXIMATE CONTOURS FOR BOTTOM OF TAILINGS PILE EXCAVATION
N40,000 CONSTRUCTION GRID COORDINATE
EXISTING ROAD

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
GREEN RIVER SITE
GREEN RIVER, UTAH
CONTAMINATED MATERIAL
EXCAVATION PLAN
(SHEET 2 OF 2)
DE-AC04-83AL18796
GRN-PS-10-0512

FIGURE 4.4
CONTAMINATED MATERIAL EXCAVATION PLAN



NOTES:

1. SUBCONTRACTOR SHALL REMOVE EXISTING FENCES AS SHOWN AT THE BEGINNING OF CONSTRUCTION.
2. EXISTING CHAIN LINK FENCE MAY BE REUSED AS PERIMETER FENCE.
3. PERIMETER FENCE SHALL BE REMOVED ONLY AFTER COMPLETION OF ALL SUBCONTRACT WORK.
4. EXISTING BUILDINGS AND OTHER MISCELLANEOUS STRUCTURES SHALL BE DEMOLISHED BY THE SUBCONTRACTOR AS SHOWN. BUILDINGS AND OTHER STRUCTURES TO BE SAVED SHALL BE DECONTAMINATED AS SPECIFIED.
5. SUBCONTRACTOR SHALL PROTECT EXISTING STRUCTURES TO BE SAVED DURING DEMOLITION.
6. SUBCONTRACTOR SHALL CLEAR EXISTING CULVERTS AND AREA OF BROWN'S WASH 200 FEET UPSTREAM AND 100 FEET DOWNSTREAM OF VEGETATION AND DEBRIS.
7. AREA ENCLOSED BY CHAIN LINK FENCE SHOWN SHALL BE DECONTAMINATED, INCLUDING EXCAVATION OF CONTAMINATED MATERIALS, PRIOR TO USE OF OFFICE BUILDING FOR CONSTRUCTION OFFICE FACILITIES.
8. APPROXIMATE AREA OF CONTAMINATED MATERIAL BELOW FLOOR SLAB IN THE CRUSHER BUILDING IS AS SHOWN. ACTUAL AREA OF CONTAMINATION WILL BE DETERMINED IN THE FIELD.
9. ESTIMATED DEPTH OF CONTAMINATED MATERIAL EXCAVATION IS 18" BELOW FLOOR SLAB. THE FLOOR SLAB IS ESTIMATED TO BE 3 TO 4 FEET THICK.
10. FOLLOWING REMOVAL OF CONTAMINATED MATERIAL, ALL DISTURBED FLOOR AREAS SHALL BE RESTORED TO ORIGINAL CONDITIONS.
11. SUBCONTRACTOR SHALL COMPLETE DEMOLITION AND DECONTAMINATION OF ALL STRUCTURES AND CLEAN-UP OF ALL CONTAMINATED MATERIALS WITHIN THE BOUNDARY OF THE EXISTING FENCE WITHIN 120 DAYS OF RECEIPT OF NOTICE-TO-PROCEED.
12. POINT SOURCE OF CONTAMINATION WITHIN THE OFFICE BUILDING CONCRETE FLOOR SLAB SHALL BE DECONTAMINATED.

REFERENCE DRAWINGS:

GRN-PS-10-0509 ACCESS CONTROL AND CONTRACTOR'S OFFICE AREAS PLANS AND DETAILS
GRN-PS-10-0510 MISCELLANEOUS SECTIONS AND DETAILS

LEGEND:

EXISTING SITE FEATURES & CONTOURS (JULY 1982 SURVEY)
N41,500 —— CONSTRUCTION GRID COORDINATE
EXISTING FENCE TO BE SAVED
CHAIN LINK FENCE TO BE INSTALLED
WOVEN WIRE PERIMETER FENCE TO BE INSTALLED
EXISTING FENCE TO BE DEMOLISHED
EXISTING STRUCTURES & BUILDINGS TO BE DEMOLISHED
EXISTING STRUCTURES & BUILDINGS TO BE DECONTAMINATED & SAVED

ADDED NOTES 9 AND 12
ISSUED FOR CONSTRUCTION

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
GREEN RIVER SITE
GREEN RIVER, UTAH
DEMOLITION, DECONTAMINATION AND TEMPORARY FENCING PLAN
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
DE-AC04-83AL18796
GRN-PS-10-0503

FIGURE 4.5

DEMOLITION, DECONTAMINATION AND TEMPORARY FENCING PLAN to minimize quantities of erosion protection materials and the amount of future infiltration into the tailings, and to provide the maximum buffer zone from Brown's Wash.

4.4.7 Geotechnical considerations

The principal geotechnical considerations used to design the disposal embankment are slope stability, liquefaction, settlement, and gully formation.

Analysis of slope stability was made for static and dynamic (earthquake) conditions. Earthquake conditions were simulated using a pseudo-static approach. The pseudo-static coefficient, or horizontal acceleration, was set equal to two-thirds of the maximum site horizontal acceleration given in Appendix D. Strength values for tailings, select fill, and infiltration/radon barrier materials were based on laboratory tests. Conservative strength values were used for bedding and riprap materials. The slope stability analysis concluded that slopes will remain stable under static and dynamic conditions.

Materials in the disposal embankment will be compacted to increase strength and reduce compressibility. Tailings and contaminated materials will remain unsaturated, based on assessment of site climate, surface grading, subsurface conditions, and reduced infiltration due to the relatively impermeable infiltration/radon barrier. Thus, there is no potential for strength loss and settlement that could be caused by liquefaction or by dynamic densification.

The total long-term settlement of material in the disposal embankment will be very small due to compaction of the embankment materials. Settlement of the bedrock foundation will be negligible. Therefore, the potential hazards of settlement, including differential settlement-induced cracking of the infiltration/radon barrier, are considered to be acceptably small.

4.4.8 Surface hydrology

The disposal embankment site is above the elevation of the PMF elevation in Brown's Wash. The only off-site water that could affect the integrity of the embankment, therefore, would come from the watershed located between the disposal site and I-70. Erosion protection on the southeast side of the embankment will protect against such runoff. For additional protection, this water will be diverted from the disposal embankment by ditches constructed along the southeast side of the disposal embankment. The ditches are designed to carry runoff from ordinary storms away from the embankment perimeter and to reduce runoff velocities below erosive velocities. Only runoff from large precipitation events would flow against the embankment.

4.4.9 Erosion protection

Rock layers placed on the embankment will protect against erosion. Rock sizes are designed to resist erosive forces of runoff from precipitation that will fall directly on the embankment and runoff from the watershed located southeast of the embankment. Riprap toe protection will extend about 20 feet on the surface from the embankment toe to reduce erosion of the ground surface adjacent to the embankment.

Migration of infiltration/radon barrier material or select fill cover materials will be prevented by an overlying layer of bedding. A layer of Type A riprap will be placed between Type B riprap and bedding to prevent the migration of bedding into Type B riprap.

The Utah Department of Transportation quarry at Fremont Junction, Utah, will be the source of Type B riprap and Type A riprap. The durability of rock from this source was determined to be satisfactory to meet the requirements of NUREG/CR-4620 to resist long-term weathering based on the results of tests performed on rock samples obtained from the quarry. The test results are presented in Appendix D of the February 1988 RAP. The subcontractor will be allowed to use rock from another source if it can be demonstrated that the alternate rock source is equivalent to the Fremont Junction rocks. Bedding will be obtained from the same borrow site as used for the infiltration/radon barrier material.

Table 4.1 summarizes the requirements for riprap and bedding materials.

The remedial action plan includes the following measures to reduce the hazard of the undermining of the disposal embankment by long-term erosion, including enlargement of existing gullies and formation of new gullies:

o Filling the gullies.

o Constructing riprap protection along the disposal embankment toe that will protect the embankment against erosion in the event that gullies form adjacent to the disposal embankment. Details of the riprap toe protection are presented in Section 4.3.1.

o Grading the site to promote sheet flow and reduce flow concentrations that might cause gully formation.

4.4.10 Infiltration/radon control

An infiltration/radon barrier consisting of uncontaminated soil mixed with six percent bentonite by weight will be constructed over the tailings to limit emanation of radon to the levels set by

Table 4.1 Erosion protection requirements for disposal embankment

Location	Particle size requirements (inches)	Volume (cy)
Bedding	$0.04 \leq D_{50} \leq 0.2$ $0.75 \leq D_{100} \leq 3.0$	4,800
Type A Riprap	$2.6 \leq D_{50} \leq 3.5$ $3.2 \leq D_{100} \leq 4.4$	10,100
Type B Riprap	$18.0 \leq D_{50} \leq 23.5$ $22.5 \leq D_{100} \leq 30.5$	16,000

EPA standards and to inhibit infiltration into underlying tailings. The three-foot-thick infiltration/radon barrier will be placed at sufficient depth to ensure that at least 12 inches of infiltration/radon barrier are below the frost depth.

Based on measurements of current contamination levels, a 12-inch-thick infiltration/radon barrier is satisfactory to reduce radon flux beneath 20 pCi/m^{2}s. The thickness of the infiltration/radon barrier will be verified during construction based on radiation data from in-place contaminated materials, but would not be less than three feet.

Silty clay obtained from the designated borrow site located three miles north of the project site will be used to construct the infiltration/radon barrier. Geotechnical tests, including compaction, shear strength, and permeability tests, were performed on soil samples obtained from this source. Results of the test program are included in Appendix D.4 of Volume IIA of the January 1989 RAP and in the Information to Bidders volume. Based on these results, it is concluded that the infiltration/radon borrow material, when mixed with six percent of bentonite by weight and compacted to 100 percent of maximum dry density based on ASTM D-698, will produce an average saturated hydraulic conductivity of 2×10^{-8} cm/s, or less. Construction features that will be used to protect against defects in the infiltration/radon barrier that might increase permeability include:

- o Provide a minimum three-foot-thick barrier to reduce the potential for localized flow paths due to construction irregularities.
- o Provide a rough surface between lifts by scarifying prior to placement of overlying lift.

- o Provide uniform moisture distribution by "moisture-curing" infiltration/radon barrier materials before compaction.
- o Facilitate uniform layer properties by restricting clod sizes to one inch or smaller.
- o Control water used for compaction and dust control.

4.4.11 Economic considerations

To the extent practical, the remedial action plan is designed to result in the minimum construction cost that is consistent with design standards, safe construction practices, and other applicable criteria. The EPA standards will be met by stabilizing contaminated material on the site as described above. Stabilization of contaminated materials on the site is less expensive and creates fewer environmental impacts than moving them to a new disposal site. Minimizing the surface area of the embankment reduces the cost of surface and perimeter erosion protection. The use of on-site excavated soils for site grading and cover is made to the maximum extent practicable to reduce costs.

4.5 CONSTRUCTION FEATURES

4.5.1 Overview

Construction features are described below to provide an overview of implementation of remedial action. Construction features include staging areas, decontamination facilities, temporary drainage ditches, wastewater collection and retention systems, a dike to protect the existing tailings pile, and construction offices. Locations and sizes of construction features may be changed to facilitate construction activities.

The office building will be decontaminated at the beginning of construction to allow it to be used as an office by the DOE, the contractor, and the radiological subcontractor.

A woven wire perimeter fence will be constructed around the site to control traffic in and out of the site and to prevent unauthorized entry to the site. Access to the site will be by means of a gate on the site road located about 200 feet west of the decontamination pad. The decontamination pad will be constructed immediately south of the existing mill site buildings (see Figure 4.6). Vehicles leaving contaminated areas will be monitored and washed, if necessary, to prevent the spread of contamination.

Temporary diversion ditches will prevent surface water runoff from entering the site during remedial action operations. Collection ditches on the site will channel on-site contaminated runoff water to the wastewater retention basin or to low areas where runoff can be pumped to the retention basin.

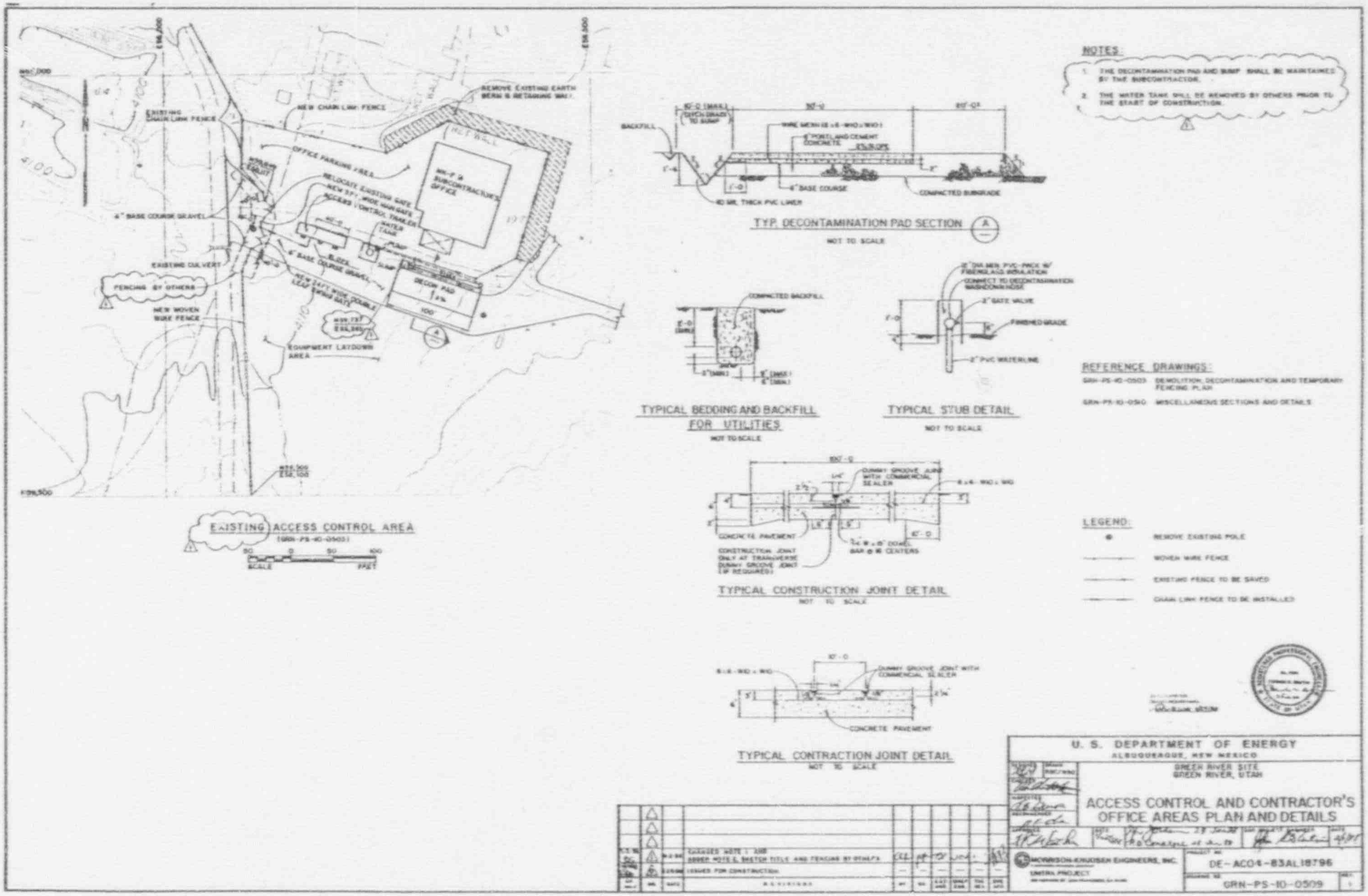


FIGURE 4.6
ACCESS CONTROL AND CONTRACTOR'S OFFICE AREAS PLAN AND DETAILS

Uncontaminated material from the disposal embankment excavation will be stockpiled along the south bank of Brown's Wash to protect the retention basin and tailings pile from a 100-year flood on Brown's Wash. (This design feature is included at the request of the state of Utah.)

Contaminated materials will be transported on temporary haul roads and on existing permanent roads.

The following utilities are available at the site:

- Electricity (Utah Power and Light).
- Telephone (Mountain Bell).
- Water and sewer (city of Green River).

Locations of these utilities are presented on Figure 4.7.

4.5.2 Drainage, erosion control, and wastewater retention basin

Surface water runoff from uncontaminated areas will be diverted to off-site areas. Surface water runoff from contaminated areas will be collected and drained to a retention basin.

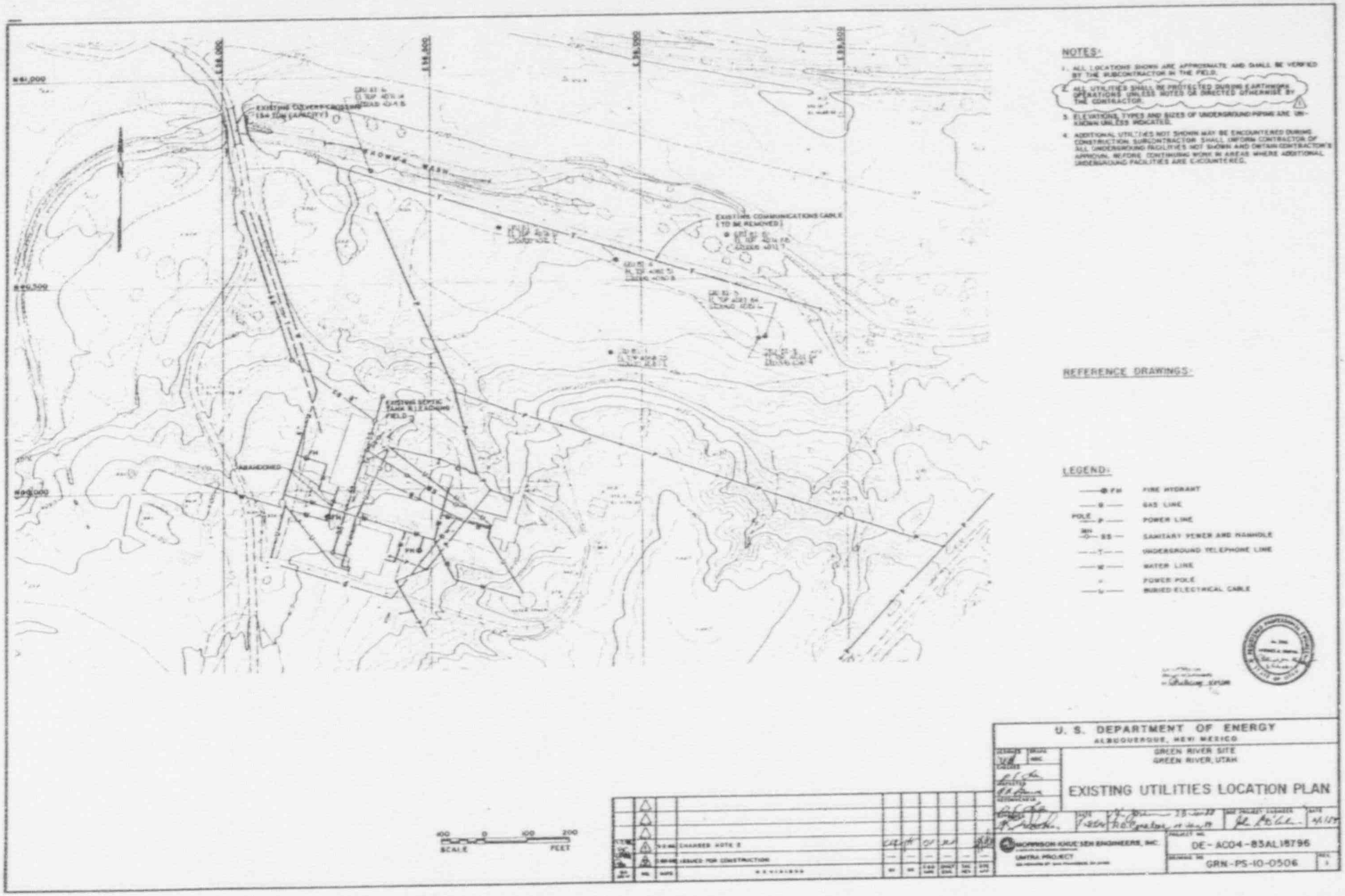
Contaminated runoff will either be retained in the retention basin and evaporated or treated as necessary and discharged. To the extent practical, contaminated water will be evaporated or used for compaction water to moisture-condition tailings and other contaminated materials. Treatment and discharge may be necessary if runoff during the construction period exceeds the basin capacity, or if the water in the retention basin does not evaporate before completion of construction. Controlled discharges from the retention basin would meet effluent limits established by a National Pollutant Discharge Elimination System (NPDES) permit. Emergency uncontrolled discharge would be used only if necessary to prevent failure of the retention basin.

Diversion ditches are designed to carry runoff resulting from a PMP event. This will prevent uncontaminated runoff from entering the site. Wastewater collection ditches are designed to carry peak flow from a 10-year storm to the retention basin.

The wastewater retention basin will receive discharge from:

- Runoff from contaminated areas.
- Dewatering of the existing tailings area, if required.
- Decontamination of trucks and other equipment.
- Washbasin and shower facilities.

The retention basin at the site is sized to retain runoff resulting from a 10-year, 24-hour storm in addition to the maximum storage required for normal storm water runoff and wastewater generated from remedial action activities. The retention basin



NOTES:

1. ALL LOCATIONS SHOWN ARE APPROXIMATE AND SHALL BE VERIFIED BY THE SUBCONTRACTOR IN THE FIELD.
2. ALL UTILITIES SHALL BE PROTECTED DURING EARTHWORK OPERATIONS UNLESS NOTED OR DIRECTED OTHERWISE BY THE CONTRACTOR. △
3. ELEVATIONS, TYPES AND SIZES OF UNDERGROUND PIPING ARE UNKNOWN UNLESS INDICATED.
4. ADDITIONAL UTILITIES NOT SHOWN MAY BE ENCOUNTERED DURING CONSTRUCTION. SUBCONTRACTOR SHALL INFORM CONTRACTOR OF ALL UNDERGROUND FACILITIES NOT SHOWN AND OBTAIN CONTRACTOR'S APPROVAL BEFORE CONTINUING WORK IN AREAS WHERE ADDITIONAL UNDERGROUND FACILITIES ARE ENCOUNTERED.

REFERENCE DRAWINGS:

LEGEND:

—⊕ FH	FIRE HYDRANT
— G —	GAS LINE
POLE — P —	POWER LINE
MH —○— SS —	SANITARY SEWER AND MANHOLE
— — T — —	UNDERGROUND TELEPHONE LINE
— W —	WATER LINE
○	POWER POLE
— U —	BURIED ELECTRICAL CABLE

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
GREEN RIVER SITE
GREEN RIVER, UTAH

EXISTING UTILITIES LOCATION PLAN

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRN-PS-10-0506

FIGURE 4.7

EXISTING UTILITIES LOCATION PLAN

will also have sufficient capacity to hold the total estimated sediment inflow during construction operations. The basin spillway will safely discharge peak runoff from a 25-year storm and maintain one foot of freeboard between the top of the embankment and the water surface at a time when the spillway is flowing at design elevation.

4.5.3 Existing buildings

The mill building addition, the office building addition, the roaster building, and all other abandoned equipment at the mill site will be demolished. Debris resulting from the demolition will be buried in the disposal embankment. All demolition activities will be controlled to protect workers and to restrict release of airborne contamination. Contaminated material will not be removed from the site.

The mill building, crusher building, and office building will be decontaminated to make them suitable for reuse.

4.5.4 Dewatering

If water is encountered during excavation of the existing tailings pile, dewatering may be performed to facilitate excavation. Water resulting from dewatering operations will be pumped into the retention basin.

4.5.5 Equipment decontamination pad

Equipment leaving contaminated areas will be monitored for contamination. To prevent contaminated materials from being carried out of areas, a decontamination pad with a holding tank and pump will be provided to wash contaminated equipment.

4.5.6 Dust control

Dust generated by excavation, earth movement, vehicle use, temporary stockpiling of materials, and similar activities will be controlled by spraying water and/or water-based surfactants. Special care will be taken to control dust created by the decontamination and demolition of buildings and by temporary stockpiling or mixing of contaminated materials.

Schedules for spraying the roads and embankment areas will vary daily and will be adjusted as required. The frequency of spraying will increase when combinations of low soil moisture and high wind speed are encountered.

4.5.7 Borrow areas

The approximate location of the radon barrier and bedding material borrow area is shown on Figure 4.8. Type B riprap and Type A riprap will be obtained from a boulder, cobble, and gravel deposit at Fremont Junction, approximately 75 miles west of the site.

4.5.8 Archaeological sites

No historic or cultural resources have been identified at the tailings or at the radon barrier borrow site. Cultural resource clearance will be obtained for all areas to be disturbed during construction, including the riprap and bedding borrow sources.

4.5.9 Construction sequence

The following construction sequence is planned for the remedial action. However, the construction subcontractor will be allowed to execute the work within the constraints of project specifications. The actual construction sequence, therefore, may differ from the planned sequence.

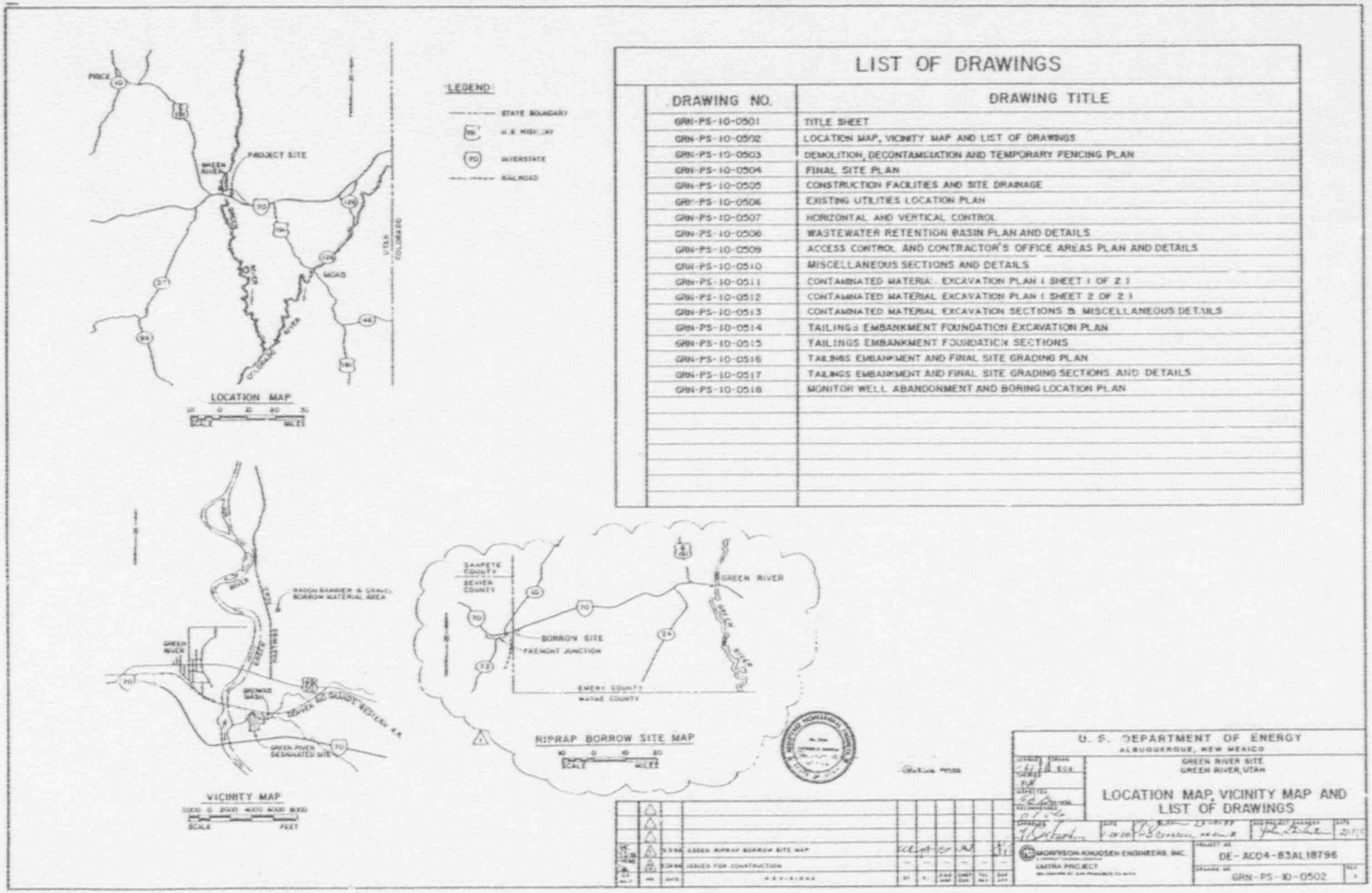
The first item of construction will be the establishment of a site security system including erection of the perimeter fence. This will provide a means for control of traffic entering and leaving the site. Immediately thereafter, contaminated materials in the decontamination pad and staging areas will be excavated and stockpiled. The decontamination pad slab will then be constructed.

The next major item of site preparation will be construction of the retention basin and drainage ditches. Materials excavated during these operations will be stockpiled for subsequent use as fill. Site drainage will be improved by clearing the floodplain of Brown's Wash where it flows under the site road and clearing the clogged culverts that drain the small drainage immediately east of the site.

Concurrent with these activities, any necessary construction and/or upgrading of access roads and haul roads will be performed.

After the initial site preparation is completed, earthwork at the disposal area will begin. This will involve excavation and stockpiling of materials to allow for below-grade disposal of contaminated materials. Some excavated materials will be stockpiled near Brown's Wash in the form of a dike to provide flood protection as discussed in Section 4.5.1.

Concurrently, demolition of the mill building addition, the office building addition, and the roaster building and decontamination of the crusher, mill, and office buildings will proceed.



LIST OF DRAWINGS

DRAWING NO.	DRAWING TITLE
GRN-PS-10-0501	TITLE SHEET
GRN-PS-10-0502	LOCATION MAP, VICINITY MAP AND LIST OF DRAWINGS
GRN-PS-10-0503	DEMOLITION, DECONTAMINATION AND TEMPORARY FENCING PLAN
GRN-PS-10-0504	FINAL SITE PLAN
GRN-PS-10-0505	CONSTRUCTION FACILITIES AND SITE DRAINAGE
GRN-PS-10-0506	EXISTING UTILITIES LOCATION PLAN
GRN-PS-10-0507	HORIZONTAL AND VERTICAL CONTROL
GRN-PS-10-0508	WASTEWATER RETENTION BASIN PLAN AND DETAILS
GRN-PS-10-0509	ACCESS CONTROL AND CONTRACTOR'S OFFICE AREAS PLAN AND DETAILS
GRN-PS-10-0510	MISCELLANEOUS SECTIONS AND DETAILS
GRN-PS-10-0511	CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 1 OF 2)
GRN-PS-10-0512	CONTAMINATED MATERIAL EXCAVATION PLAN (SHEET 2 OF 2)
GRN-PS-10-0513	CONTAMINATED MATERIAL EXCAVATION SECTIONS & MISCELLANEOUS DETAILS
GRN-PS-10-0514	TAILINGS EMBANKMENT FOUNDATION EXCAVATION PLAN
GRN-PS-10-0515	TAILINGS EMBANKMENT FOUNDATION SECTIONS
GRN-PS-10-0516	TAILINGS EMBANKMENT AND FINAL SITE GRADING PLAN
GRN-PS-10-0517	TAILINGS EMBANKMENT AND FINAL SITE GRADING SECTIONS AND DETAILS
GRN-PS-10-0518	MONITOR WELL ABANDONMENT AND BORING LOCATION PLAN

ADDED RIPRAP BORROW SITE MAP
ISSUED FOR CONSTRUCTION
REVISIONS

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO
GREEN RIVER SITE
GREEN RIVER, UTAH
LOCATION MAP, VICINITY MAP AND LIST OF DRAWINGS
MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT
PROJECT NO. DE-AC04-83AL18796
DRAWING NO. GRN-PS-10-0502

FIGURE 4.8
LOCATION MAP, VICINTY MAP, AND LIST OF DRAWINGS

The tailings pile, windblown tailings, and other contaminated materials will be excavated and placed on a six-foot-thick layer of select fill in the disposal cell. The movement of contaminated materials will not begin until upgrading of the haul and access roads has been completed and until a sufficient area has been opened and approved at the disposal area. After the contaminated materials are in place, the infiltration/radon barrier will be constructed over the disposal embankment. Appropriate measures will be taken during the winter shutdown to ensure that tailings or contaminated material in the disposal cell are not unnecessarily exposed to erosional forces or precipitation and runoff.

The final construction phase will consist of grading operations designed to improve overall site drainage. Grading operations will include filling of gullies and filling and revegetating areas disturbed by construction operations. An extensive fill will be constructed on the floodplain on the south bank of Brown's Wash using excess materials excavated for the disposal embankment.

Demobilization will primarily consist of removal and regrading of the wastewater retention basin and temporary drainage ditches. Contaminated water will be treated and discharged. Sediment and dike materials will be excavated and placed in the disposal embankment. The decontamination pad will be removed and placed in the disposal embankment. Associated equipment will be cleaned for salvage. The staging area will be dismantled. Associated contaminated items will be either buried or cleaned and salvaged. All contractor equipment will be decontaminated and inspected prior to release from contaminated areas.

4.6 CONSTRUCTION SCHEDULE

The remedial action includes the following tasks:

- Mobilization.
- Site preparation.
- Placement of tailings.
- Construction of embankment cover.
- Construction of embankment erosion protection.
- Site restoration.

Mobilization consists of bringing all required people and equipment to the site.

Site preparation includes establishing the site security system and construction office; the construction of the decontamination pad, retention basin, drainage ditches, and wastewater treatment facility; upgrading of haul and access roads; decontamination and demolition of existing mill buildings; and excavation and stockpiling of windblown contaminated soils.

Placement of tailings includes excavation of the below-grade portion of the disposal embankment, placement of the select fill layer, excavation and stockpiling of material from the tailings pile, and placement and compaction of the tailings and other contaminated materials in the disposal embankment.

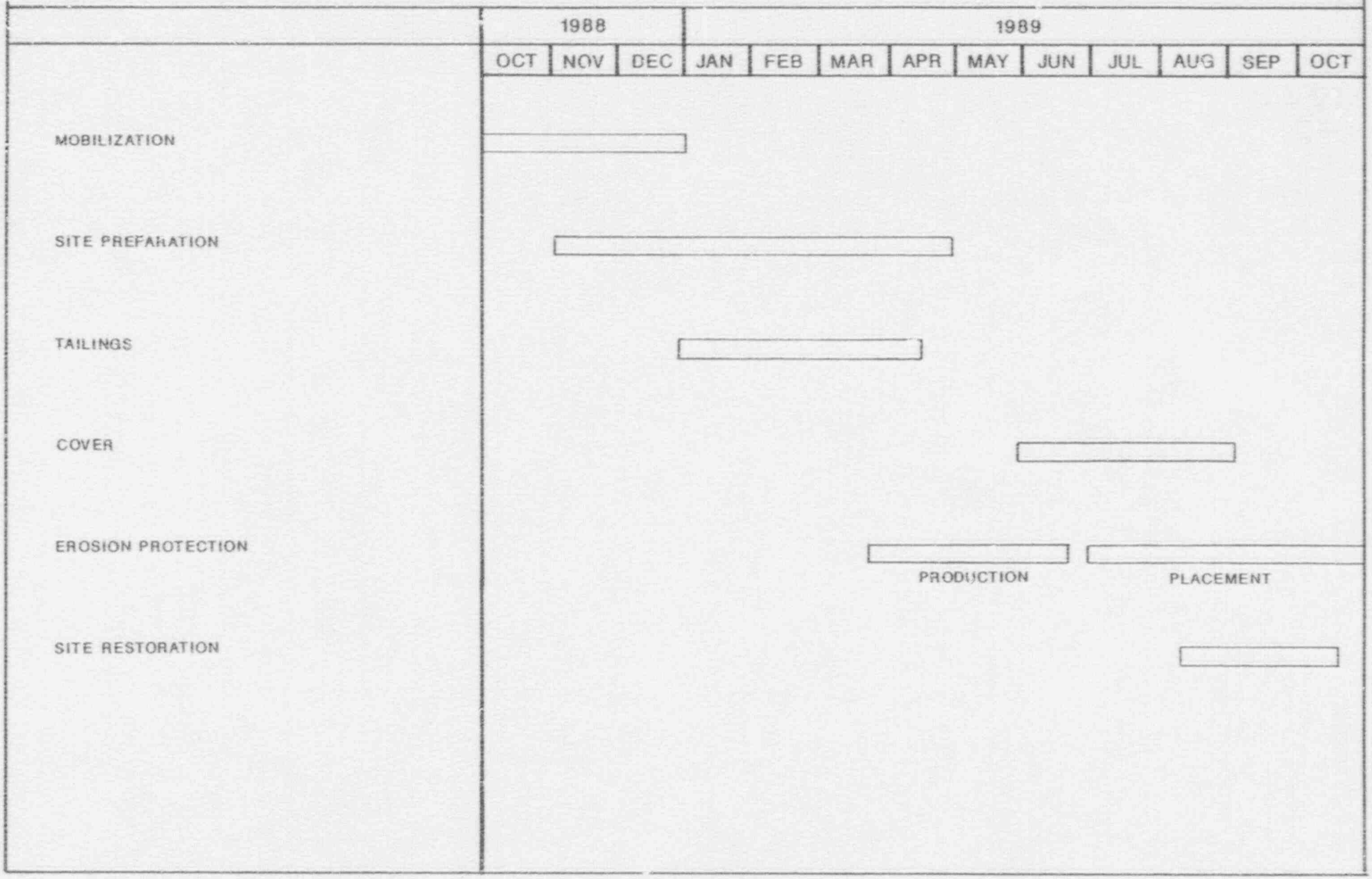
Construction of the embankment cover includes delivery to the site, placement in the embankment, and compaction of the infiltration/radon barrier and filter materials.

Construction of embankment erosion protection includes quarrying, delivery to the site, and placement of riprap materials.

Site restoration includes filling of existing gullies, removal of the retention basin and decontamination pad, regrading the floodplain of Brown's Wash, and reseeding of areas disturbed by construction, including borrow sites.

The timetable for performance of these tasks is presented on Figure 4.9. Construction operations are scheduled to start in September 1988, and are scheduled for completion in December 1989. A winter shutdown is optional, depending on weather conditions.

FIGURE 4.9 GREEN RIVER REMEDIAL ACTION SCHEDULE



5.0 WATER RESOURCES PROTECTION STRATEGY SUMMARY

The DOE must demonstrate compliance with the EPA standards for groundwater protection at inactive uranium mill tailings sites. These standards are contained in proposed revisions to Subparts A through C of 40 CFR 192 under Title I of the UMTRCA, as amended. Remedial action taken by the DOE must comply with the proposed standards until EPA promulgates them in final form (UMTRCA, Section 108). This section summarizes the water resources protection strategy for the Green River UMTRA Project site in Utah, and the elements of the strategy which demonstrate compliance with the proposed groundwater standards. Details of the water resources protection strategy are presented in Sections E.2 and E.3 of Appendix E. Characterization of groundwater and hydrogeology at the Green River site is presented in detail in Section D.5 of Appendix D, and is summarized in Section 3.5 of the text.

The DOE will comply with the disposal standard (40 CFR 192.02(a)(3)) by constructing a disposal cell that will prevent any tailings leachate from mixing with groundwater within the required 1000-year design life of the cell. Specifically, either designated MCLs or background concentrations (whichever is greater) will not be exceeded in the uppermost aquifer (the uppermost and lower-middle hydrostratigraphic units of the Cedar Mountain Formation) at the POC. The POC is the downgradient edges of the engineered disposal unit.

The following sections summarize the major elements of the protection strategy.

5.1 DESIGN CONSIDERATIONS

The tailings will be placed in a mostly below-grade cell. The base of the excavation will be at an elevation of about 4098 feet, which is nearly 40 feet below existing grade. Groundwater is 10 to 12 feet below the base of the excavation. The bottom six feet of the cell will be filled with a compacted, select clean fill soil to retard the movement of contaminants to groundwater from the overlying contaminated materials. Above the buffer will be a layer of compacted windblown tailings (mixed with clean soils) and a layer of compacted tailings.

A cover system will be constructed over the tailings. From bottom to top the cover system will consist of three feet of compacted radon barrier, six inches of clean, compacted bedding material, and one foot of rock for erosion protection. Collectively, the cover layers will limit infiltration of precipitation to less than 2×10^{-8} cubic centimeters per square centimeters per second (cm^3/cm^2s), will protect from catastrophic erosion by the PMF, and will control the release of radon from the cell. Degradation of the infiltration/radon barrier from freezing (via reduced density) will not occur because it is expected never to be saturated. Nevertheless, 15 inches of the infiltration radon barrier will lie beneath the calculated frost depth of 39 inches.

The disposal cell components (buffer, windblown materials, and tailings) will be placed at as low a moisture content as practicable, resulting in a flux rate of less than 2×10^{-8} cm^3/cm^2s, which is the saturated hydraulic conductivity of the infiltration/radon barrier multiplied by a unit gradient. By minimizing the amount of water used for compaction and dust control during construction, drainage of excess water from the cell is not a concern (see Section E.2.1.2).

In terms of groundwater protection, the proposed disposal cell and protection strategy at the Green River site make maximum use of the following favorable natural conditions:

- An arid climate (average annual precipitation is six inches per year; estimated ratio of yearly precipitation to actual evapotranspiration is one).
- Consistent, uniform fracturing of the foundation bedrock to prevent any perching of water in the cell and to promote drainage of runoff from the toe of the cell.
- Abundant, desirable secondary minerals on the fracture faces to attenuate any tailings seepage (although tailings seepage into the bedrock is not expected).
- Strong, upward vertical hydraulic gradients in the saturated bedrock downgradient of the disposal site to minimize the downward migration of contamination (although contamination of the groundwater by tailings seepage is not expected).
- Flow direction of groundwater beneath the disposal site toward the existing contamination from the old tailings pile.

In addition, the mostly below-grade disposal will maximize runoff and minimize infiltration into the disposal cell.

5.2 GROUNDWATER PROTECTION STANDARDS FOR DISPOSAL

There are three basic requirements for complying with the groundwater protection standard (40 CFR 192.02): (1) identification of the hazardous constituents within the disposal cell; (2) proposal of a concentration limit for each hazardous constituent; and (3) specification of the point of compliance.

Ten hazardous constituents (from Appendix IX of 40 CFR 264) within the tailings at the Green River site were identified from analyses of tailings pore water. These are cadmium, chromium, molybdenum, nickel, nitrate, selenium, uranium, vanadium, radium-226 and -228, and gross alpha activity. The proposed concentration limits for the ten hazardous constituents are listed in Table 5.1 along with the NRC's proposed interim concentration limits for hazardous constituents at the disposal site. Also, three additional hazardous constituents were included in DOE's and NRC's list of constituents for the disposal unit. These constituents are arsenic, lead, and methylene chloride.

Table 5.1 Hazardous constituents and concentration limits for disposal at the Green River UMTRA Project site[a]

Constituent	DOE proposed limits	Interim concentration limits
Arsenic	-	0.05 (MCL)
Cadmium	0.01 (MCL)	0.01 (MCL)
Chromium	0 09 (Background)	0.05 (MCL)
Lead	-	0.05 (MCL)
Methylene chloride	-	0.005 (Background)
Molybdenum	0.24 (Background)	0.1 (MCL)
Nickel	0.09 (Background)	0.06 (Background)
Nitrate	180 (Background)	60 (Background)
Selenium	2.50 (Background)	0.66 (Background)
Uranium-234/238	0.146 (Background)	0.044 (MCL)
Vanadium pentoxide	0.38 (Background)	0.09 (Background)
Radium-226/228	5.0 pCi/l (MCL)	5.0 pCi (MCL)
Gross alpha (excluding uranium and radon)	195 pCi/l (Background)	24.5 pCi/l (Background)

[a] All concentrations are milligrams per liter (mg/l) unless noted otherwise; pCi/l = picocuries per liter.

The proposed concentration limits have associated with them a natural variability. This natural variability must be accounted for when sampling and analyzing for construction and performance monitoring and in an assessment of what threshold concentration constitutes an excursion and warrants subsequent corrective action. The details of such an analysis will be presented in a separate document (Surveillance and Maintenance (S&M) Plan) for the Green River site.

The point of compliance at the Green River site will be the entire northwest and northeast edges of the engineered cell. Approximately 60 feet of rock riprap and select fill material lie between the compacted tailings and the point of compliance.

5.3 PERFORMANCE ASSESSMENT

The proposed disposal cell design is intended to prevent the introduction of contaminants into groundwater by providing for leachate travel times from the base of the contaminated soil to groundwater in excess of the design life (1000 years) of the cell.

The NRC UNSAT2 computer model (NRC, 1983) was used to estimate the redistribution of moisture within the disposal cell with time. Examination of the moisture distribution with time allows conclusions to be drawn regarding the steady state moisture conditions within the disposal cell, the travel time of contaminants through the disposal cell, and the flux at the bottom of the disposal cell. Based on the modeling, the travel time for contaminants exiting the bottom of the disposal cell is over 1100 years. (A more detailed discussion of the disposal cell performance is presented in Section E.3.2.) Because leachate percolating from the disposal cell is not expected to reach groundwater within the design life of the cell, no degradation of groundwater quality as a result of the remedial action is anticipated.

5.4 CLOSURE PERFORMANCE ASSESSMENT

The DOE must demonstrate compliance with the closure performance standard (40 CFR 192.02(a)(4)) by showing that the need for further maintenance of the disposal site and cell has been minimized and that the disposal unit minimizes or eliminates releases of hazardous constituents to groundwater.

Natural, durable materials will be used to construct the cell so that long-term performance is assured. Safety factors have been considered in the design so that the cell should operate for longer than the required 1000-year design life.

The previous section (5.3) discussed how the disposal cell will eliminate the release of hazardous constituents to groundwater at the Green River site.

5.5 GROUNDWATER PERFORMANCE MONITORING PROGRAM

The DOE is required to describe an integrated monitoring program to be conducted before, during, and after completion of the remedial action to demonstrate that the initial performance of the cell complies with the groundwater protection standard and the closure performance standards.

The DOE will present a detailed groundwater monitoring program in the S&M Plan for the Green River site. The main features of the monitoring program will include moisture monitoring in the tailings, windblown material and buffer layers, and saturated zone monitoring at the point of compliance. There is nothing that would physically preclude this program from being implemented.

Four neutron access holes for neutron logging will be used to monitor moisture within the tailings, vicinity property materials, other contaminated material, and buffer materials at different depths. The time-integrated moisture versus depth data will be used to estimate the unsaturated hydraulic conductivity of the tailings and the operative flux of moisture through the cell.

The compliance monitor wells will be sampled quarterly during the first year following completion of the remedial action, semi-annually for years two through six, and annually thereafter until the end of the performance monitoring period. Monitoring during the remedial action will take place semi-annually using wells placed during site characterization. The constituents to be analyzed from monitor well samples shall include all of the hazardous constituents presented in Section E.1.2 plus major anions and cations together with the standard suite of field parameters (alkalinity, pH, temperature, and specific conductance).

5.6 CORRECTIVE ACTION PLAN

The DOE is required to evaluate alternative corrective actions that could be implemented if the disposal monitoring program indicates that the disposal cell is not performing adequately (40 CFR 192.02(c)). The DOE should consider reasonable failure scenarios of the disposal cell and demonstrate that corrective actions could be implemented no later than 18 months after finding an exceedance of the groundwater protection standards.

The DOE has demonstrated that the disposal cell at Green River has been designed (and will be constructed) to perform for the mandated design life of 1000 years (see Section E.2.2.2). The design has incorporated standard safety factors and should therefore perform for at least 1000 years with minimal maintenance. There is therefore no "reasonable" failure scenario which would be related to catastrophic structural failure.

A potential "failure" of the cover system, in terms of groundwater protection, would be if the infiltration/radon barrier was not limiting infiltration to the design flux rate of 2×10^{-8} cm^3/cm^2s. The best-case corrective action for this condition at Green River would be first to assess the potential impacts to groundwater at the higher flux rate, and then to assess the risks to human health and the environment should there be a potential impact. A preliminary risk assessment conducted for the Green River site (DOE, 1988c) indicated minimal pathways for exposure for the potentially affected aquifers because of already poor quality groundwater within the aquifers. It is unlikely that any corrective action would be required at the Green River site such as reconstructing the cover system or active restoration of the affected aquifer(s) because of minimal risk to human health or the environment. To finalize the preliminary risk assessment to include a specific failure scenario would take only a few months; this plus any other necessary corrective action (applying for ACLs for any hazardous constituents predicted to exceed the proposed concentrations limits) could easily be done within the 18-month action time frame. The worst-case corrective action scenario would require removal and replacement of the cover and possible groundwater cleanup.

An exceedance of the proposed concentration limit for any hazardous constituent at the point of compliance (as determined from saturated zone monitoring during the early stages of performance monitoring) would likely be a result of drainage of construction water. This would be verified by examining the moisture monitoring system to be sure that excess moisture is not passing through the cell. Since every effort will be made during construction of the cell to limit the amount of water added for compaction (per specific construction specifications) and dust suppression, an excursion at the point of compliance is considered highly unlikely, particularly when travel time of any contaminants through the bottom six feet of buffer (and foundation bedrock) is considered. Any excursion at the point of compliance detected by saturated zone monitoring would include resampling and analysis at least once to verify the excursion. Details of these procedures will be presented in the S&M Plan for the Green River site.

5.7 CLEANUP AND CONTROL OF EXISTING CONTAMINATION

The DOE and NRC consider that evaluation of cleanup of existing groundwater contamination (Subpart B of 40 CFR 192) at the Green River processing site should be deferred until after the EPA promulgates final groundwater protection standards, provided the DOE demonstrates that disposal may proceed independently of cleanup (Subpart B of the standards can be "decoupled" from Subpart A).

By defining existing and background water quality at both the processing and disposal sites, the DOE has demonstrated that the present water quality is distinguishable from any adverse impacts that may result from the remedial action. In addition, construction of the disposal cell will in no way preclude any future aquifer restoration activities from taking place, should active restoration be deemed necessary. Finally, because the period of construction is relatively short at Green River and the extent of existing contamination is almost entirely within the site boundaries, there is very little or no risk that human health or the environment could be impacted by leaving the contamination in place during the interim period between remedial action and evaluation of groundwater cleanup.

There are several methods of restoring the affected aquifers at the Green River processing site if it ever becomes necessary to do so. Because the source of contamination will be removed when the tailings are placed and stabilized at the disposal site, and background quality of groundwater in the affected aquifers is poor, the most appropriate method of restoring the aquifers is probably to allow the contamination to flush naturally and disperse downgradient from the site. Natural flushing may be used as the sole method for restoration, or it may be used in conjunction with any of a number of active restoration methods.

6.0 ENVIRONMENTAL, HEALTH, AND SAFETY

6.1 POLICY

It is the policy of the UMTRA Project that the DOE and its contractors take all reasonable precautions in the performance of the remedial action work to protect the environment, ensure the health and safety of employees and the public, and provide protection of the U.S. Government. 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 required by the Occupational Safety and Health Administration (OSHA).

The RAC 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. The surrounding community and the on-site workers must be protected to prevent avoidable accidents and radiation exposure. The RAC will follow the "UMTRA Project Environmental, Health, and Safety Plan" (DOE, 1985) and additional site-specific guidance, such as that in the Special Conditions of the subcontract documents.

6.2 SITE CONDITIONS AFFECTING HEALTH AND SAFETY PLANNING

Health and safety considerations at the Green River site will require special attention by the RAC because of the physical, radiological, and industrial hygiene hazards that may exist there. This section describes the specific conditions that represent potential hazards that are known or suspected to exist. The following text is not intended to provide a comprehensive list of potential hazards, but rather describes conditions that have been noted during prior work activities at the Green River site.

Appendix D, Site Characterization, contains a description and map of the existing utilities at the Green River site. Buried gas, water and sewer lines, and above-ground electric lines exist on and around the processing site. In addition, there is a propane tank buried near the mill yard, and unmarked lines that were part of the original mill operations may be buried around the site and near the mill buildings.

Four main buildings, several small buildings, and a water tower remain at the site. The buildings are abandoned, and all structures are considered structurally sound but in a state of disrepair. Processing chemicals have not been observed during previous site visits, but may still be stored in some of the abandoned buildings. Radiological contamination and external exposure rates have been measured in the buildings and the results are reported in Addendum D1 to Appendix D, Site Characterization.

The processing site is located approximately one mile southeast of the city of Green River, Utah. Highway traffic may be heavy along I-70, south of the site, and along the main line track of the Denver and Rio Grande Western Railroad, which runs to the north. Both represent potential vehicle hazards and should be considered in planning the remedial actions, and in developing employee orientation and safety training programs.

The Green River runs near the western site boundary, and an intermittent tributary to Green River, Brown's Wash, runs north of the site. In the past, floodwaters have carried an estimated 14,000 tons of tailings downstream (FBDU, 1981). Potential hazards due to flooding should be considered and appropriate contingency plans should be prepared.

Some emergency response facilities exist in the city of Green River, and may be easily accessed by telephone. Emergency phone numbers are:

Fire/Ambulance/Medical Clinic	8111
Police/Sheriff	8111 or 564-3431

The Green River Medical Clinic is located at 110 South Medical St., and has no full-time doctor. The nearest hospital with an emergency room is 60 miles away in Moab, Utah. Helicopter ambulance service is available by calling the 8111 emergency number.

7.0 RESPONSIBILITIES OF PROJECT PARTICIPANTS

7.1 INTRODUCTION

The following defines the various responsibilities of the DOE UMTRA Project Office, the NRC, and the state of Utah during design, remedial action, and through the initiation of custodial surveillance and maintenance. The DOE will be assisted by its Technical Assistance Contractor (TAC), the Jacobs-Weston Team and its RAC, M-K Ferguson Company, Inc.; however, all assigned responsibilities will remain the ultimate responsibility of the DOE. In general, the TAC will assist the DOE in the preparation of conceptual designs and remedial action plans and will provide quality assurance, audits, and recommendations for final certification. The RAC will prepare detailed designs and manage field construction activities. The state of Utah's 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:

o <u>DOE (including TAC, RAC)</u>:

Prepare the RAP.
Manage and coordinate project.
Obtain permits and approvals.
Prepare detailed designs and specifications.
Prepare quality assurance plan.
Prepare and implement public participation and information plan.
Provide funds.
Conduct remedial action.
Audit remedial action.
Prepare surveillance and maintenance plan.
Certify remedial action.
Obtain license.
Conduct surveillance and maintenance.

o <u>State of Utah</u>:

Review and concur in the RAP.
Assist DOE in acquiring or extinguishing the interests of land owners or others with property interests at the designated processing site and disposal site.
Assist in obtaining local government approvals.
Issue state permits or approvals.
Assist in public participation and information.
Convey to the Federal government title to residual radioactive materials stabilized at the site.
Provide funds.

o <u>NRC</u>:

Review and concur in the RAP.
Review and concur in the Remedial Action Inspection Plan (RAIP).
Review and concur in surveillance and maintenance plan.
Review and concur in final certification report.
Issue license for long-term surveillance and maintenance of the disposal site.

7.2 DETAILED RESPONSIBILITIES

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

7.2.1 <u>Regulatory compliance</u>

Requirements for regulatory compliance, previously identified by Federal and state agencies, will be incorporated into the final design specifications, as needed, by the DOE. Revisions to the design and specifications resulting from internal DOE reviews will be incorporated prior to the agencies' review for permits.

The RAC will submit permit applications and supporting details to the agencies for permit issuance.

During the remedial action, the DOE will audit construction activities for compliance with provisions in the permits and approvals. (Permitting agencies may independently audit relevant activities consistent with normal practice.) Summary audit reports will be prepared by the DOE and submitted to the appropriate agencies as required. Depending upon agency comments, revisions to construction compliance activities will be made.

Upon completion of the permitted action, the DOE will conduct a final review and will prepare a close-out report for submittal to the agencies as required. Permits will then be terminated.

7.2.2 <u>Licensing</u>

The NRC will issue a general license for post-remedial maintenance of Title I sites by amendment to 10 CFR 40. The NRC's concurrence in the site-specific S&M Plan will render the site licensed. A draft site S&M Plan will be submitted to the NRC prior to certification. Based on the NRC comments, a final S&M Plan will be prepared and submitted to the NRC. The final plan will contain the site-specific surveillance and maintenance program, legal description of the site, site ownership, subsurface mineral ownership, and reporting and record keeping requirements.

7.2.3 Land acquisition

The state of Utah will assist the DOE in acquiring or extinguishing the interests of landowners, permittees, lessees, and sublessees of, or other individuals with property interests in the processing and disposal sites. Upon completion of the remedial action, legal title to the disposal site and attendant residual radioactive materials will be conveyed to the Federal government.

7.2.4 Detailed design

The RAC will prepare preliminary engineering drawings for review by the DOE. Based upon this review, the RAC will prepare final design drawings, specifications, and bid packages. Once finalized and approved by the DOE, the bid packages will be issued to prospective bidders pursuant to Federal regulations and a construction subcontractor(s) will be selected.

Final design and specifications will be available to the NRC and the state upon request, and will be included in the final RAP.

7.2.5 Construction

The DOE will prepare guideline documents to comply with health and safety, security, quality assurance, public information, and other regulatory requirements. The RAC will acquire the necessary permits and approvals from the appropriate agencies. Site mobilization and initiation of construction activities will occur in accordance with the DOE-approved construction schedule.

Construction activity will be audited by the DOE. These audits will be provided to the NRC and the state of Utah, and to other regulatory agencies upon request to the DOE. The state, NRC, and other regulatory agencies may also perform independent audits of the remedial action. Revisions to the remedial action resulting from site audits will be incorporated into the as-built design and the RAP by the DOE as necessary.

Upon completion of the remedial action, the site will be certified by the DOE. The NRC will review and concur in the final site certification report.

7.2.6 Health and safety

The DOE has prepared the "UMTRA Project Environmental, Health, and Safety Plan" (DOE, 1985). Based upon this guidance, site-specific implementation procedures will be developed by the RAC.

As part of the implementation procedures, the RAC will institute radiation control and environmental monitoring and will develop response procedures for severe weather and medical emergencies.

Construction contractors will comply with approved procedures and file reports with the DOE that record the results of monitoring, and report accidents and illnesses. Records will be maintained by the DOE following remedial action construction. Employee and public complaints will be investigated by the DOE.

7.2.7 Public information

The DOE will establish a local site manager who will provide information to the public and local media. Prior to and during construction, the DOE, with assistance from the state of Utah officials and local citizens, will conduct public information meetings to inform the interested public of key aspects and current progress of the remedial action. Concurrent with the public meetings, the DOE will provide status and progress reports for the state of Utah and other agencies (e.g., the NRC and EPA).

7.2.8 Radiological support

The DOE will prepare and implement a Radiological Support Plan (Appendix C) and will take measures to independently assure the quality of the analyses and compliance with the procedures.

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

7.2.9 Quality assurance

The DOE will prepare the Quality Assurance (QA) plan in conformance with guidelines established in the UMTRA Project QA plan (DOE, 1986b). The DOE will audit the construction activities and will submit audit reports as appropriate.

7.2.10 Surveillance and maintenance

The DOE will prepare and submit to the NRC the S&M Plan as part of the site license application. The NRC will review and concur with the plan, and the DOE (or responsible Federal agency designated) will ensure that the plan is implemented.

8.0 SURVEILLANCE AND MAINTENANCE

8.1 INTRODUCTION

The objectives of the custodial surveillance and maintenance program are to assure that, upon completion of remedial action, the stabilized embankment remains undisturbed, the tailings continue to be non-hazardous to the public and the local environment, and all site conditions comply with the EPA, NRC, and state of Utah standards.

The custodial surveillance and maintenance program will be defined jointly by the DOE and the NRC during the creation of the proposed S&M Plan and concurrence. Following are the basic elements that may be included in this program.

8.2 SURVEILLANCE

8.2.1 Site inspections

Site inspections constitute visual and definitive verification that the disposal site continues to function as designed and assures continued compliance with regulatory standards. Inspections will consist of two phases: Phase I, a systematic walk-over designed to evaluate the condition of the disposal site qualitatively; and, if needed, Phase II investigations to assess quantitatively 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 as-built 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 evaluations may be conducted to determine the magnitude and rate of changes in the above factors quantitatively. From these studies, the need for corrective action (i.e., custodial maintenance) would be ascertained.

8.2.2 Aerial photographs

Aerial photographs will 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 identify activities (e.g., road conditions, storm drainage construction) adjacent to the site that may affect its function.

Aerial photographs may also be taken on a periodic schedule. Photographs will be taken at both low (i.e., high resolution) and high (i.e., for adjacent activities) altitudes and at oblique and vertical angles. The type of film, ground control, camera specifications, amount of overlap, interpretative keys, and other requirements will be established as part of the custodial surveillance and maintenance program.

8.2.3 Groundwater monitoring

Long-term, post-remedial-action monitoring of the uppermost downgradient aquifer will be conducted at the disposal site. Monitoring is outlined in Section E.3.4 of Appendix E and will be described in detail in the site S&M Plan.

8.2.4 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 the DOE, NRC, and the state.

8.3 CUSTODIAL MAINTENANCE

The need for custodial maintenance can only be determined following site inspection. However, it is anticipated that custodial maintenance will consist primarily of the following:

- Limited soil/rock replacement due to unanticipated erosion, human or animal intrusion, or cover disturbance--these activities are expected to be required infrequently.
- Control of deep-rooted plants by infrequent application of herbicides or physical removal as required.
- 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 maintenance, as required, 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 QUALITY ASSURANCE

9.1 GENERAL

The RAC shall provide and maintain an effective QA program and procedural system which will assure that all work, materials, supplies, and services required under the contract conform to contract requirements, whether constructed or processed by the RAC or its subcontractors or procured by subcontractors or vendors. The RAC shall perform or have performed adequate inspections and tests as will ensure and substantiate that all work, materials, supplies, and services conform to contract requirements.

The RAC shall furnish a QA test and inspection plan that will define the health, safety, and environmental activities to be incorporated into the design and/or performed during construction to ensure contract compliance and site certification. Test and inspection requirements shall be approved by the DOE prior to the start of any job site construction work under this contract. If the RAC revises the plan, the RAC shall concurrently furnish a copy of the revision to the DOE for approval prior to implementing the revision on work under the contract.

9.2 QUALITY ASSURANCE PLAN

Before construction operations are started, the RAC shall meet with the authorized DOE QA representative to review and discuss the RAC's proposed project QA plan. The meeting shall clarify details of the individual site plan requirements including the formats to be used for recording and reporting tests and inspections, administration of the plan, personnel assignments, and the interrelationship between the RAC and the DOE QA representative. The RAC shall furnish a list of the procedures required to implement the project plan. This list shall include, at a minimum, procedures for data collection, analyzing samples, inspection and testing, and formats of reports to be used.

9.3 DAILY INSPECTION REPORT

The RAC shall prepare a daily report for every day worked, and a weekly summary report covering the RAC and subcontractor's operations in an appropriate format. The daily reports shall provide complete and factual evidence that continuous, effective quality control inspections and tests have been performed, including but not limited to: (1) the type and number of inspections and tests involved; (2) results of inspections and tests; (3) nature of deficiencies requiring corrections; and (4) corrective actions taken or to be taken.

The RAC shall maintain current records of all inspections and shall furnish, as part of the files at the end of the project, copies of the inspection reports and all other files appropriate to each subcontract. The reports of inspection shall cover all work placement subsequent to the previous report and shall be verified by the RAC's designated QA representative.

9.4 MEASURING AND TEST EQUIPMENT CALIBRATION AND CONTROL

The RAC shall provide measuring and test equipment having the precision and accuracy needed to establish conformance with specified quality requirements. Calibrations shall be in accordance with nationally recognized standards. The RAC shall identify procedural systems for test equipment calibration and recall.

9.5 NONCONFORMANCE

A nonconformance and change procedural system shall be developed by the RAC and approved by the DOE.

9.6 RECORDS CONTROL

The RAC shall be responsible for generation, retention, and retrieval of legible records that provide objective evidence of conformance to the specified quality requirements. These records shall be considered valid only if they are completed and signed or otherwise authenticated and dated by authorized personnel. These records shall include, but are not limited to:

- Radionuclides in soil data.
- Air monitoring data.
- Design review files.
- Water contaminant analysis.
- Personnel radiation exposure data.
- As-built drawings.
- Test and inspection reports.
- Engineering specifications.
- Material certifications.
- Certificates of compliance.
- Non-conformance reports and corrective action requests.
- Operating procedures.
- Change orders.
- Unusual occurrence reports.

All records shall be available to the DOE for review upon request. All personnel radiation exposure records shall be turned over to DOE upon completion of the site remedial action.

9.7 CODES AND STANDARDS

The RAC shall have on the job site, no later than three weeks after site mobilization, the applicable quality assurance codes and standards available for ready reference by all personnel. The RAC shall maintain at the job site copies of all approved-for-construction drawings, specifications, and other documents which describe the remedial action.

9.8 RECORD DRAWINGS

The RAC shall develop QA procedural systems to ensure the use of approved-for-construction drawings and updating of record drawings. Two full-sized sets of contract drawings shall be used by the RAC for this purpose. All variations from the contract drawings shall be depicted. Generally, the drawings shall reflect only changes and corrections to data and dimensions shown on contract drawings. Where the contract specifications or drawings permit optional use of more than one type of material or equipment, the type of material or equipment installed shall be shown on the drawings. The drawings shall be maintained in a current condition at all times, and shall be made available for review by the DOE at all times. Variations from the contract drawings shall be shown in the contract working drawings and shall be incorporated into the record drawings. Upon physical completion of the contract work, two reproducible copies of these drawings shall be furnished to the DOE.

9.9 MATERIAL CERTIFICATION

The technical specifications may require that certain materials be certified. Two types of certifications that may be specified are:

- Certificate of compliance.
- Certified material test report (CMTR). When a CMTR is requested from the RAC or its subcontractors, it shall be accompanied by a certificate of compliance certifying that the tested material is actually the material incorporated in the work.

9.10 QUALITY ASSURANCE PROGRAM VERIFICATION

Verification of the QA program implementation by DOE may be accomplished by:

- Review of daily or weekly summary reports.
- On-site inspections and surveillance.
- Periodic audits.
- Acceptance of DOE QA recommendations based on DOE QA audits of RAC activities.
- Any combination of the above.

9.11 REMEDIAL ACTION FIELD CHANGES

During the course of remedial action, design changes are expected to occur. Some of these changes may impact compliance with EPA standards, but most changes are expected to be unrelated to critical design elements of the stabilized tailings pile. The following sections define three classes of changes and establish guidelines to be used when implementing changes.

9.11.1 Class 1 changes

A Class 1 change is a change that may affect compliance with the EPA standards (40 CFR 192). Class 1 changes shall be reflected in a modification to the RAP, which will ultimately result in a change to the State Cooperative Agreement. The NRC and the state of Utah will be required to concur on all Class 1 changes.

Class 1 changes include, but are not limited to, the following:

- Discovery of unusually high levels of residual radioactive materials which will change the radon emission concentrations after remedial action as they are specified in the final RAP.
- Disposal of hazardous or mixed wastes within the disposal cell.
- Changes in the radon barrier thickness or permanent erosion protection.

9.11.2 Class 2 changes

A Class 2 change is a change to any permanent construction feature that does not clearly affect compliance with the EPA standards. Class 2 changes will be forwarded to the NRC and the state of Utah for informative purposes. At any time that the NRC and/or state feel a change has been incorrectly designated as Class 2, the change may be redesignated as Class 1 upon verification of error. By handling Class 2 changes in such a manner, construction delays will be avoided, and the NRC and state will consistently be aware of all changes affecting the RAP. Class 2 changes will not require formal NRC or state concurrence, and will not require a modification to the RAP or Cooperative Agreement.

Class 2 changes include, but are not limited to, the following:

- Adjustments to specifications that will not affect the major aspects of design, such as permeability, infiltration, radon flux, or groundwater contamination.
- Requests for additional well sealing for newly discovered wells.
- Changes in location of permanent fencing.

9.11.3 Class 3 changes

A Class 3 change is a change to temporary features that have no impact on the design for the stabilization of the stabilized embankment. Class 3 changes will not require NRC or state concurrence and may be approved by a representative of the Remedial Action Contractor of appropriate supervisory position.

Class 3 changes include, but are not limited to, the following:

- Changes in location or use of construction/excavation materials.
- Change in location of temporary fencing.
- Alteration of temporary drainage facilities, roads, or site office facilities.

9.11.4 General requirements

The general requirements which are to be fully understood and commonly interpreted by all parties (DOE, NRC, state) when using the above classification of changes are as follows:

- All changes will be logged on a Project Interface Document (PID), which will be initiated by the RAC and forwarded to the DOE Project Office (PO). The DOE PO will then forward copies of the PID and supporting data, if required, to the NRC and the affected state as outlined below.
- Each change will be classified promptly by the RAC and concurred upon by the DOE Project Office, with input from the TAC if needed, immediately following notification from the field. The contact for DOE concurrence shall be documented in the space provided on the PID.
- For all Class 1 changes, the DOE will notify the NRC and state no later than one working day after notification by the RAC. The NRC and the state will then be given copies of all pertinent data necessary for review and concurrence or comment within one working day after receipt of same by the DOE PO. This may be transmitted verbally or telefaxed prior to formal issuance.
- RAP modifications may be handled as a group as opposed to separate issuance each Class 1 change.
- For all Class 2 changes, appropriate justification data will be forwarded to the NRC and state as submitted to the DOE PO by the RAC. This may be transmitted following verbal or telefaxed notification as noted under the third

general requirement above. Written justification will be forwarded by the PO within five working days after receipt.

- For all Class 3 changes, the PID will be forwarded to the NRC and the affected state within a reasonable time.
- The RAC will maintain an up-to-date record of all changes for all sites. In addition, the DOE PO will maintain an up-to-date file of all PIDs.

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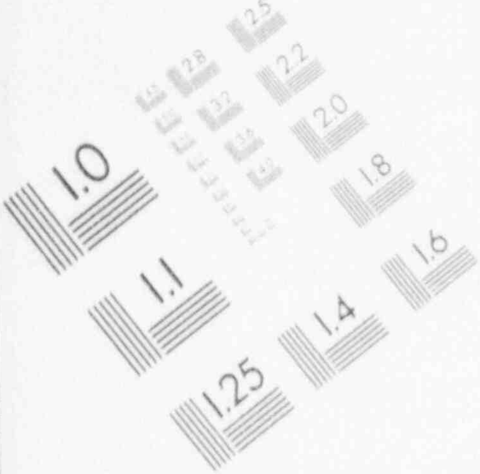

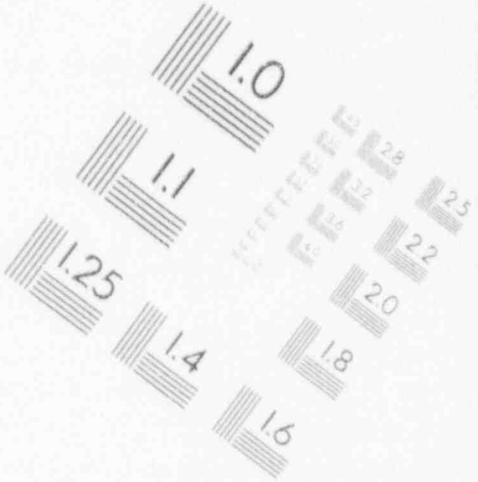

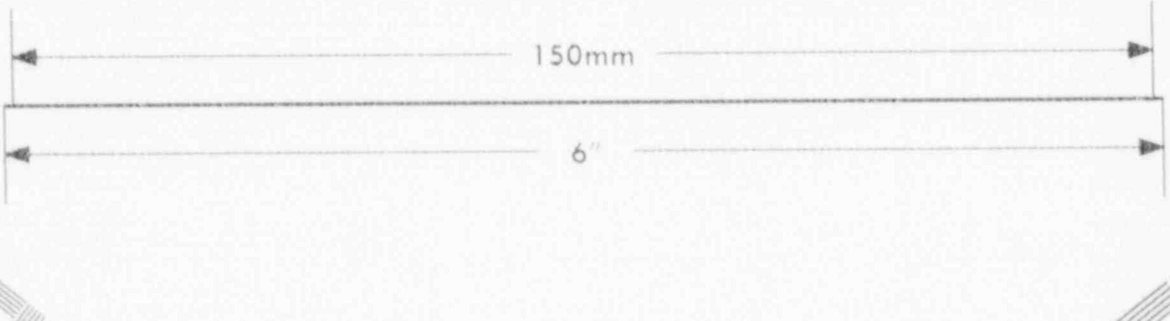

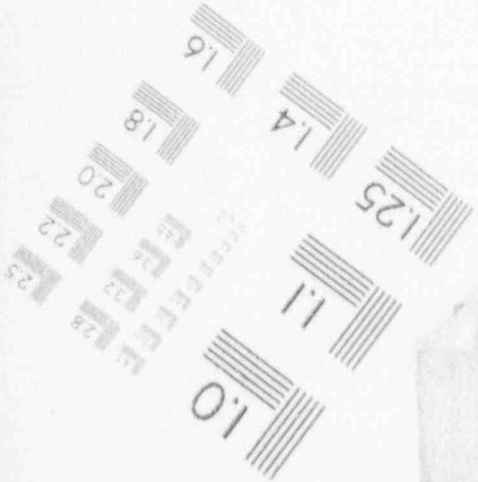

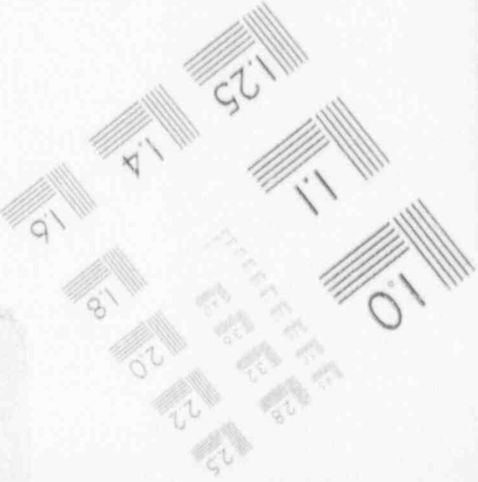

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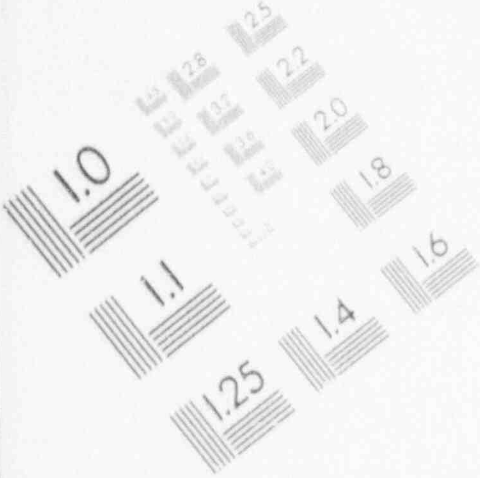

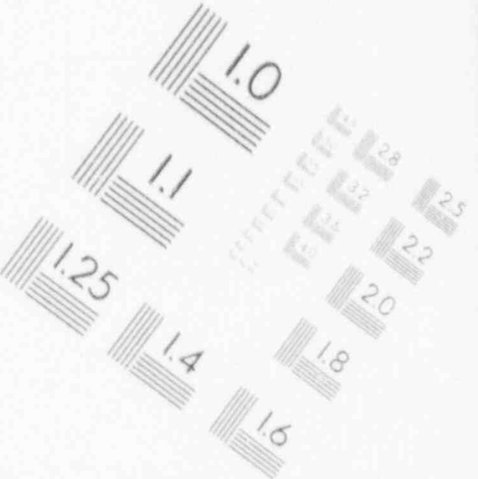

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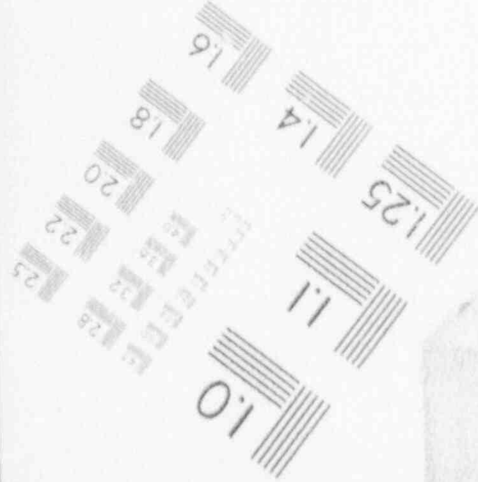

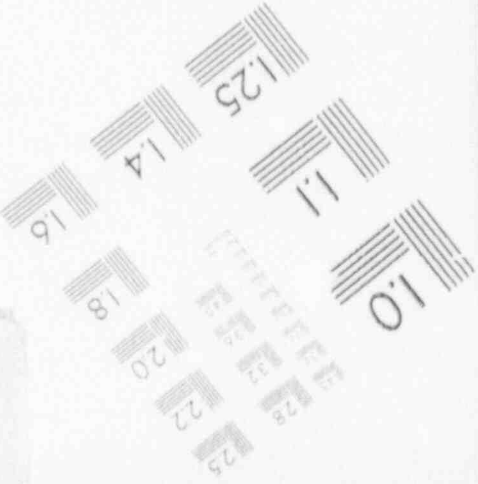

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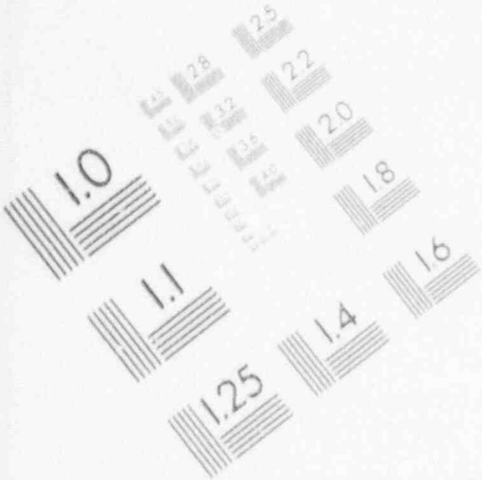

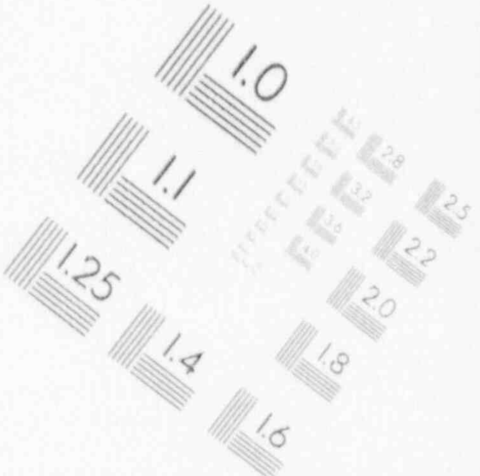

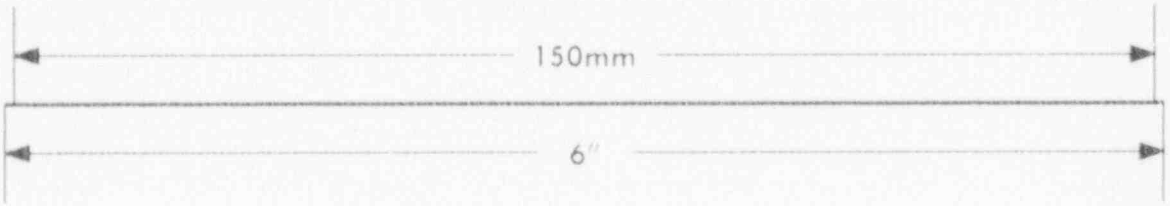

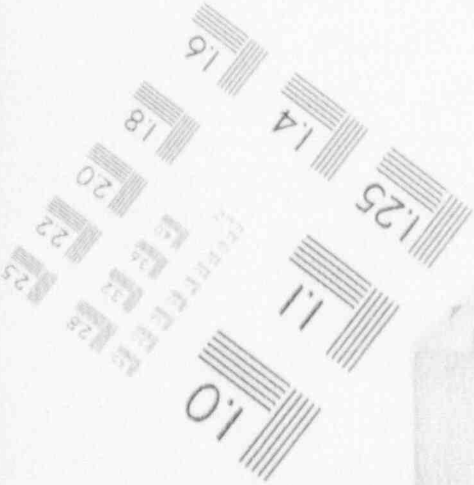

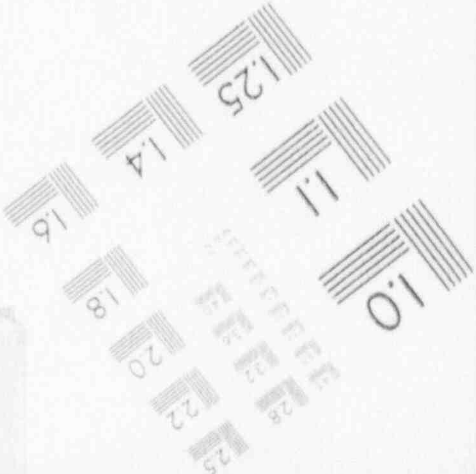

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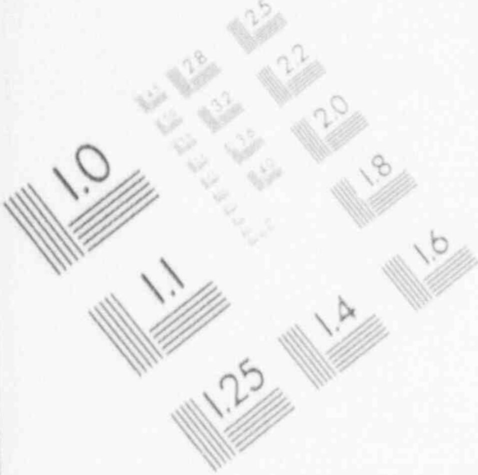

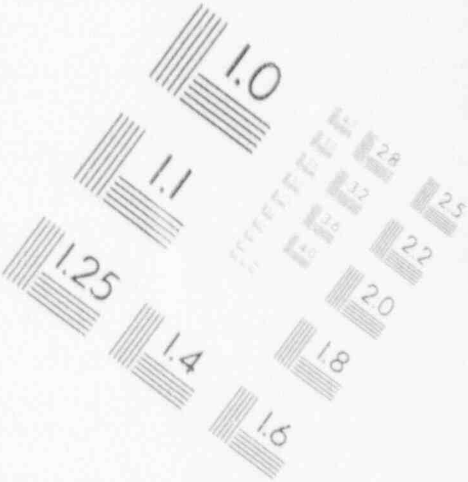

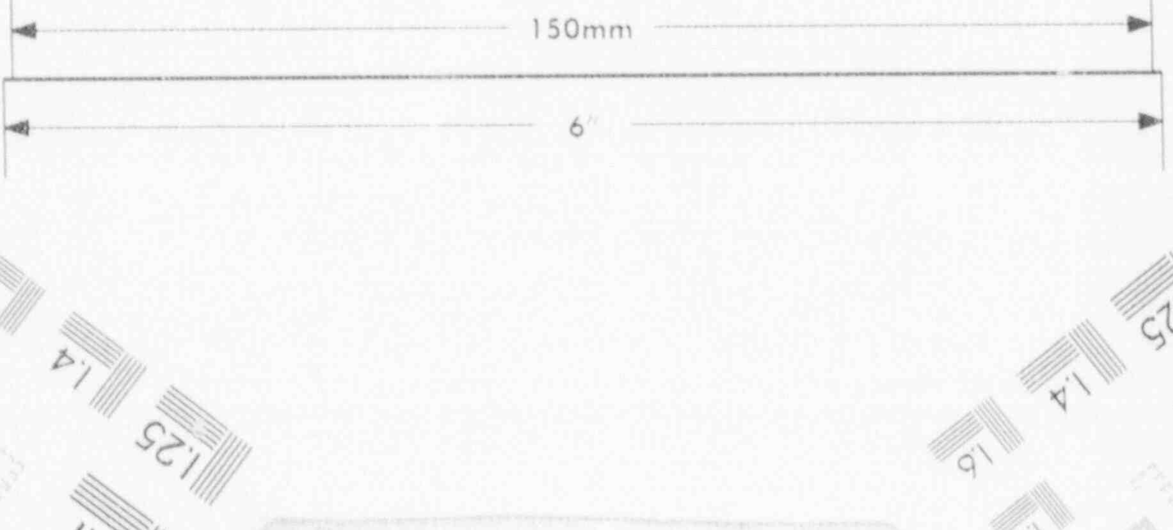

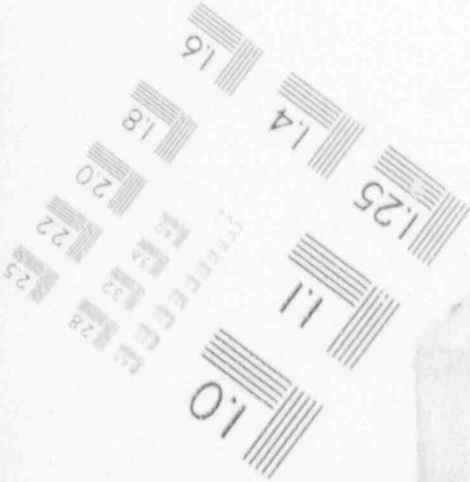

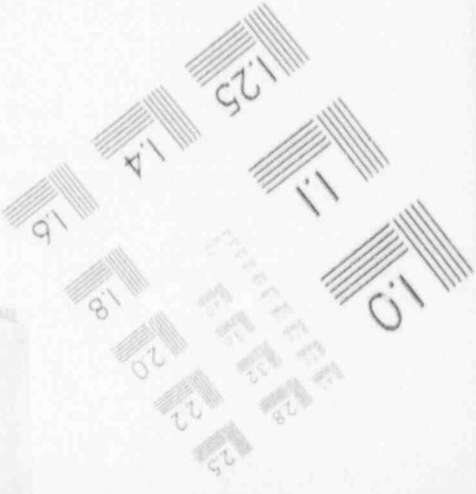

10.0 PUBLIC INFORMATION AND PUBLIC PARTICIPATION

10.1 INTRODUCTION

Section III of the UMTRCA states,

> "In carrying out the provisions of this title, including the designation of processing sites, establishing priorities for such sites, the selection of remedial action 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."

The following sections describe the actions the DOE and state have taken and will take to encourage the participation of an informed public in this project.

10.2 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 Environmental Assessment (EA) will be completed for the Green River site. Public participation is an important part of the preparation of the EA; the participation requirements are detailed in the Council on Environmental Quality Regulations (effective July 1979) for implementing the provisions of NEPA, and in the DOE guidelines of 1980 for NEPA compliance.

In preparing the EA, the DOE has conducted individual meetings with community officials and private citizens to discuss the purpose of the proposed remedial action and ascertain the extent of public interest in this project. At these meetings the public is given an opportunity to express their concerns and identify what they believe to be significant issues.

The identified issues are documented in the EA and incorporated into the decision-making process. The DOE accepts written comments for a 30-day period after publication of the EA. Interested parties are given the opportunity to comment on the EA after the EA is published.

In addition to meetings on the EA, the DOE will continue to hold public information meetings in Green River to describe the remedial action plan for the project and receive comments which may be used in the design for remedial action.

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

Frequent meetings and briefings will be held to provide information and project status updates, and to solicit public participation in the project activities. The DOE, state and local officials, and interested citizens are involved in discussions regarding remedial action construction schedules, radiation monitoring reports, groundwater protection plans, and other project activities.

10.3 PUBLIC INFORMATION

In order for public participation to be effective, the public must be informed concerning the remedial action project in Green River. Several methods of information dissemination are used by the DOE. Press releases and press packets are prepared for project status updates, including report summaries, texts of presentations, and graphics.

The names and addresses of individuals, media representatives, and Federal, state, and local officials are computerized for information dissemination purposes. Information is provided to interested persons in the Federal government, state administration, and private citizens in Grand County.

A public preconstruction meeting will be conducted by the DOE. Principal topics of discussion include the remedial action design and construction schedules.

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

A variety of printed materials will be prepared concerning the UMTRA Project and the Green River site. These include project fact sheets, a site fact sheet, and the EA. As they are printed, these materials and other fact sheets and documents have been and will continue to be sent to interested individuals and are available in the public libraries, county offices, and the Utah Department of Health. The same materials are also available at DOE-designated libraries nationwide.

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GLOSSARY

absorbed dose, radiation	The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest; usually given in units of "rads."
alluvium	Sediment deposited by a flowing river.
ambient	Surrounding on all sides, encompassing.
anticline	A fold in rocks that is convex upward or had such an attitude at some stage of development.
aquifer	A subsurface formation containing sufficiently saturated permeable material to yield usable quantities of water.
aquitard	A saturated geologic unit that does not transmit usable quantities of water.
attenuate	To reduce in strength, force, value, or amount.
background radiation	Background radiation due to cosmic rays and natural radioactivity is always present. Background radiation may also be present due to the presence of radioactive substances in building materials, and the like.
bioassay	A method for quantitatively determining the concentration tion of radionuclides in a body by measuring the quantities of those radionuclides that are eliminated from the body, usually in the urine or the feces.
Class III archaeological surveys	Relates to an archaeological investigation of probable occurrence of cultural resources within a given locale. A Class III survey is an in-depth inspection of an area to determine the presence of archaeological materials where the likelihood of their occurrence is high, based on the history of the area.
concentration, maximum permissible	The maximum concentration of radionuclide that a remedial action worker may be exposed to which, if accumulated during a set time interval, would be within Federal safety standards.
confined aquifer	An aquifer bounded above and possibly below, by continuous beds or strata of much lower permeability. In general, a confined aquifer contains water under pressure that is significantly greater, or less than, the normal hydrostatic pressure gradient of water created by the force of gravity.
contamination	In this report, the presence of radioactive material in concentrations above natural levels.
cosmic rays, radiation	High energy particulate and electromagnetic radiations that originate outside the earth's atmosphere.

curie (Ci)	The unit of radioactivity of any nuclide, defined as precisely equal to 3.7×10^{10} disintegrations per second.
daughter product(s)	A nuclide resulting from radioactive disintegration of a radionuclide, formed either directly or as a result of successive transformations in a radioactive series; it may be either radioactive or stable.
decay chain, radioactive	A succession of nuclides, each of which transforms by radioactive disintegration into the next until a stable nuclide results.
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.
disposal	The planned, safe, permanent placement of radioactive waste.
dose	A general term denoting the quantity of radiation or energy absorbed, usually by a person; for special purposes, it must be qualified; if unqualified, it refers to absorbed dose.
dose, absorbed	The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material at the point of interest; given in units of rads.
dose equivalent	The quantity that expresses all kinds of radiation on a common scale for calculating the effective absorbed dose and defined as the product of the absorbed dose in rads and modifying factors, especially the quality factor, usually given in units of rems; often abbreviated "dose."
dose equivalent, committed	The dose equivalent to organs or other tissues that will be received following an intake of radioactive material during the 50-year period following that intake.
dose equivalent, committed effective	The weighted sum of committed dose equivalents to organs using weighting factors based on the susceptibility of each organ to certain health factors.
dosimetry	The determination of radiation doses, by measurement or calculation.
effective porosity	The percent of a total volume of a given mass of soil or rock that consists of interconnecting interstices.
eolian	Deposited after transport by wind.

equilibrium (radioactive)	In a radioactive decay chain, the state when the ratios between activities of successive members of the decay chain remain constant.
exposure	A measurement of the amount of gamma radiation that may deposit energy in an individual; given in units of roentgens. Also used to refer to an individual being subjected to the presence of radiation.
external dose	The absorbed dose that is due to a radioactive source external to the individual as opposed to the absorbed dose from inhaled or ingested sources.
floodplain	Lowland or relatively flat areas that are subject to flooding. A 100-year floodplain has a one percent or greater probability of flooding in any given year.
flux, radon	The emission of radon gas from the earth or other material, usually measured in units of picocuries per square meter per second.
fugitive dust	Dust particles which are dispersed from a construction site or from trucks during hauling.
gamma dose	Radiation dose caused by gamma radiation.
groundwater	Subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated.
half-life	The time required for 50 percent of the quantity of a radionuclide to decay into its daughters.
hydraulic conductivity	Ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium.
hydraulic gradient	Pressure gradient; rate of change of pressure head per unit of distance of flow at a given point
inert gas	One of the chemically unreactive gases: helium, neon, argon, krypton, xenon, and radon.
interbedded	Occurring between beds, or lying in a bed parallel to other beds of a different material.
internal dose	The absorbed dose or dose commitment resulting from inhaled or ingested radioactivity.
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. It will include a finding that the site does not and will not constitute a danger to the public health and safety.
maintenance, custodial (passive)	The repair of fencing, the repair or replacement of monitoring equipment, revegetation, minor additions to soil cover, and general disposal site upkeep.
micro	A prefix meaning one millionth (x 1/1,000,000 or 10^{-6}).
milli	A prefix meaning one thousandth (x 1/1000 or 10^{-3}).
Modified Mercalli (scale)	A standard scale for the evaluation of the local intensity of earthquakes based on observed phenomena such as the resulting level of damage. Not to be confused with magnitude, such as measured by the Richter scale, which is a measure of the comparative strength of earthquakes at their sources.
monitor	To observe and make measurements to provide data for evaluating the performance and characteristics of the stabilized tailings pile.
National Register of Historic Places	Established by the Historic Preservation Act of 1966. The Register is a listing of archaeological, historical, and architectural sites nominated for their local, state, or national significance by state and Federal agencies and approved by the Register staff.
nuclide	A general term applicable to all atomic forms of the elements; nuclides comprise all the isotopic forms of all the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state.
permeability	A measure of the relative ease with which a porous medium can transmit a liquid under a potential gradient.
permissible dose	That does of ionizing radiation that is considered acceptable by standards-setting bodies such as the EPA.
person-rem	Unit of population exposure obtained by summing individual dose-equivalent values for all people in the population; thus, the number of person-rems attributed to one person exposed to 100 rems is equal to that attributed to 100 persons each exposed to one rem.
physiographic province	A region of similar structure and climate that has a common geomorphic history.
pico	A prefix meaning one trillionth (1 x 1/1,000,000,000,000 or 10^{-12}).

picocurie	A measure of radioactivity defined as one trillionth curie; defined as equivalent to 0.037 disintegrations per second.
plastic limit	The water-content boundary of a sediment, e.g., a soil, between the plastic and semisolid states.
radioactivity (radioactive decay)	The property of some nuclides to spontaneously emit radiation in the form of gamma rays or charged particles.
radioisotope	A radioactive isotope of an element with which it shares almost identical chemical properties.
radionuclide	A radioactive nuclide with a specific number of neutrons and protons.
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 (Rn-222)	The gaseous radioactive daughter product of radium-226; it has a half-life of 3.8 days. It is an inert gas and may escape from the material containing the radium-226.
radon-daughter product	One of several short-lived radioactive products of radon-222. All are solids.
recharge	The entry into the saturated zone of water made available at the water-table surface, together with the associated flow away from the water table within the saturated zone.
rem	A special unit of dose equivalent which expresses the effective absorbed dose calculated for all radiations on a common scale. It is defined as the product of the absorbed dose in rads and certain modifying factors, e.g., the quality factor.
Richter scale	A logarithmic scale ranging from one to 10 used to express the magnitude or total energy of an earthquake.
roentgen	A unit of exposure of ionizing electromagnetic radiation (gamma or x-ray) in air; for gamma radiation, one roentgen in air is approximately equal to one rad and one rem in tissue.
sedimentary	Descriptive term for rock formed of sediment, especially: (1) clastic rocks (e.g., conglomerate, sandstone, shale) formed of fragments of other rock transported from their sources and deposited by water or wind, and (2) rocks formed by precipitation from solution (e.g., gypsum) or from secretions of organisms (e.g., limestone).
seismic	Pertaining to an earthquake or earth vibration.

stabilization	The reduction of radioactive contamination in an area to a predetermined level by a standards-setting board such as the EPA, by encapsulating or covering the contaminated material.
surveillance	The observation of the stabilized tailings pile for purposes of visual detection of need for custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.
syncline	A fold in rocks in which the strata dip inward from both sides toward the axis.
tailings, uranium-mill	The wastes remaining after most of the uranium has been extracted from uranium ore.
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. The value of transmissivity is equal to the product of the hydraulic conductivity and the thickness of the aquifer.
UMTRA Project	Uranium Mill Tailings Remedial Action Project of the U.S. Department of Energy.
unconfined aquifer	An aquifer in which the water table forms the upper boundary.
upgradient	Toward a higher hydraulic gradient; the direction from which groundwater flows.
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 Green River site that is determined by the DOE, in consultation with the NRC, to be contaminated with residual radioactive material derived from the Green River site, and which is determined by the DOE to require remedial action.
water table	The surface of a body of unconfined groundwater on which the fluid pressure in the pores of a porous medium is exactly atmospheric.
windblown	Off-pile tailings transported by wind or water erosion.
working level (WL)	A measure of radon-daughter product concentration; technically, it is any combination of short-lived radon daughter products in one liter of air that will result in the ultimate emission of alpha particles with a total energy of 130,000 MeV.

working level-month (WLM)	The exposure resulting from inhalation of air with a concentration of one WL for 170 working hours. Continuous exposure of a member of the general public to one WL for one year results in approximately 52 WLM.
zone, unsaturated	The unsaturated zone is the zone between the land surface and the uppermost saturated zone.

APPENDIX A
REGULATORY COMPLIANCE

TABLE OF CONTENTS

LIST OF FIGURES

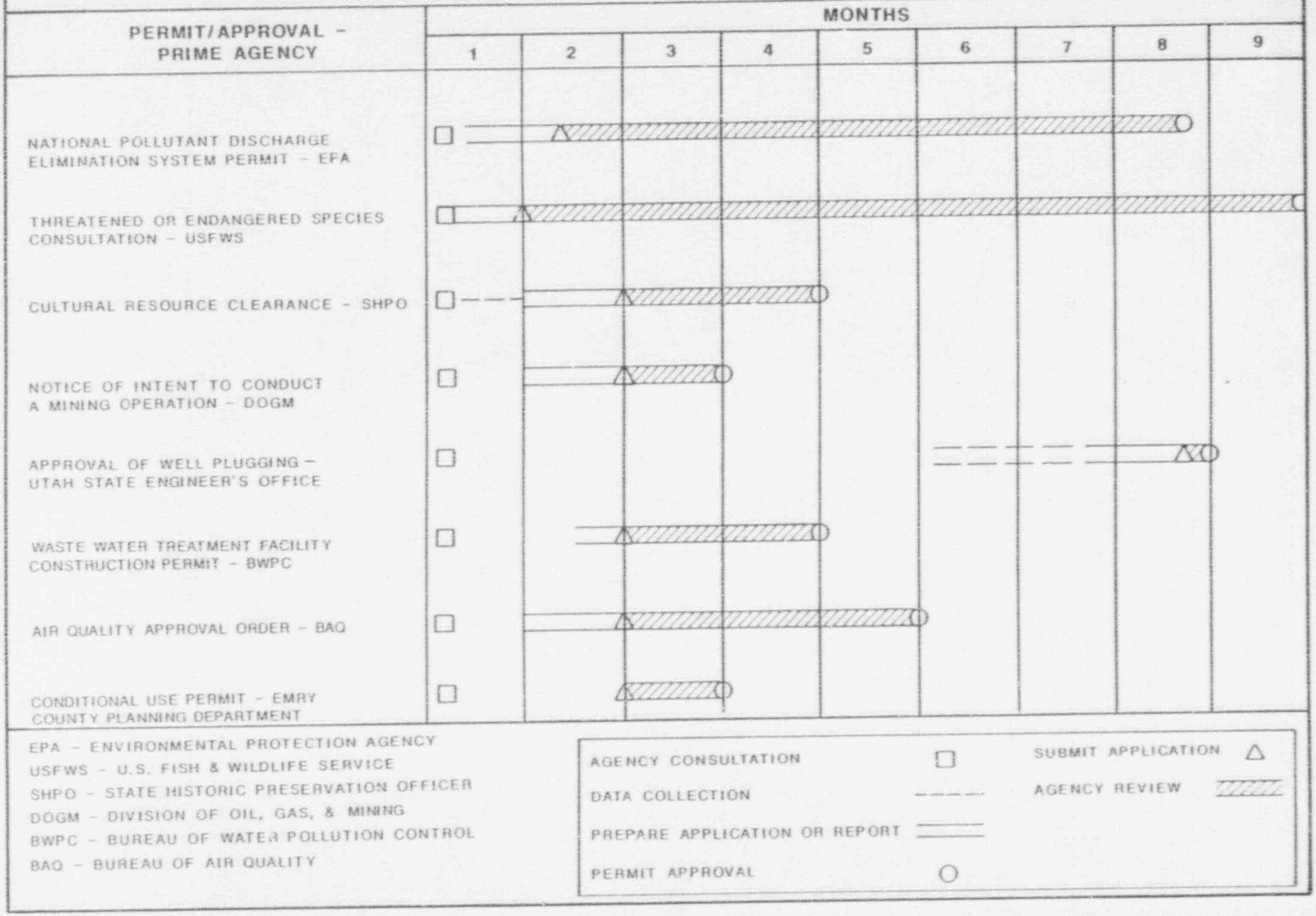
A.1 INTRODUCTION

This 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 site design (see Section 4.0 of the text). Other permits, licenses, and approvals may be required for activities beyond the scope of the Remedial Action Plan (RAP) or due to modification of the conceptual design.

Procedures for preparing permit, license, or approval applications and agency review processes are outlined in the following sections. The principal technical and supervisory personnel at the regulatory agencies are listed as well. The Remedial Action Contractor (RAC) should consider this appendix to be an introduction to the permitting process while details must be obtained from the regulatory agencies. Applications must be submitted to Federal, state, and local agencies depending on the type of permit, license, or approval sought.

A tentative schedule for regulatory compliance activities (Figure A.1.1) is included for initial planning purposes. Figure A.1.2 illustrates the regulatory compliance matrix. The RAC should sequence the preparation and filing of applications so that approvals will be received in a timely manner without causing delay to construction activities. Environmental Services personnel from the Technical Assistance Contractor (TAC) will provide additional assistance as needed.

FIGURE A.1.1 REGULATORY COMPLIANCE SCHEDULE, GREEN RIVER, UTAH



EPA – ENVIRONMENTAL PROTECTION AGENCY
USFWS – U.S. FISH & WILDLIFE SERVICE
SHPO – STATE HISTORIC PRESERVATION OFFICER
DOGM – DIVISION OF OIL, GAS, & MINING
BWPC – BUREAU OF WATER POLLUTION CONTROL
BAQ – BUREAU OF AIR QUALITY

FIGURE A.1.2

REGULATORY COMPLIANCE COORDINATION

GREEN RIVER
UTAH

REGULATORY AGENCY

PERMIT OR APPROVAL	UTAH DEPARTMENT OF HEALTH	U.S. F & WS	UTAH SHPO	UTAH STATE ENGINEER'S OFFICE	UTAH DIV. OF OIL, GAS & MINING	EMRY CO. PLANNING DEPT.
NPDES PERMIT	L					
THREATENED & ENDANGERED SPECIES CONSULTATION		L				
CULTURAL RESOURCES CLEARANCE			L			
APPROVAL OF WELL PLUGGING				L		
NOTICE OF INTENT TO MINE					L	
WASTE WATER TREATMENT CONSTRUCTION PERMIT		L				
AIR QUALITY APPROVAL ORDER		L				
CONDITIONAL USE PERMIT						L

L - LEAD AGENCY

PERMIT: NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT

LEGAL CITATION: Clean Water Act of 1977; 40 CFR 125

AGENCY/CONTACT: Utah State Department of Health
Division of Environmental Health
Bureau of Water Pollution Control
P.O. Box 16690
Salt Lake, UT 84116-0690
ATTN: Calvin Sedweks, Executive Secretary (801) 538-6146
Steven McNeal, Environmental Engineer

PROCEDURE: This permit applies to all operations discharging to waters of the United States from a point source. Application is made by filing completed U.S. Environmental Protection Agency (EPA) Forms 1 and 2C under the EPA Consolidated Permits Program. 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) Existing Federal, state, or local permits.

(5) Map covering an area extending at least one mile beyond the facility property boundaries. The map should be based on a 7.5-minute U.S. Geological Survey quadrangle map.

(6) Description of the nature of the facility.

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) Schematic flow diagram indicating sources of water, operations contributing wastewater for the effluent water balance, and treatment processes for each waste stream.

(4) 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 wastewater treatment or other environmental programs.

NPDES PERMIT (Concluded)

(7) Influent and effluent characteristics:
- o Pollutants present.
- o Source of pollutants.
- o Concentration of pollutants.
- o Temperature of effluent.
- o Flow of effluent.
- o pH of effluent.
- o Total mass of pollutants discharged in a specified time interval.

SPECIAL CONSIDERATIONS: Form C may be used as an alternative to Form 2C in the application. The conceptual design specifies that a zero discharge retention pond will be used to receive contaminated water. For this type of facility, the main purpose in obtaining an NPDES permit is to limit the liability of the operator for discharges that may result from a very large precipitation event or other unanticipated event. The EPA and state officials encourage operators to obtain a permit for a zero discharge facility. 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) 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 discharge permit contains limitations and a schedule of compliance approved by the EPA.

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

SCHEDULE: The State of Utah will assume NPDES primary from the EPA in Febuary, 1987. 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, the state may determine that a site visit or additional information are necessary. In such a case, the applicant has 60 days to reply.

PERMIT: THREATENED OR ENDANGERED SPECIES CONSULTATION PROCESS

LEGAL CITATION: Endangered Species Act of 1973, Section 7,
16 USC 1531, et seq.

AGENCY/CONTACT: U.S. Fish and Wildlife Service
Endangered Species Office
2078 Administration Building
1745 West 1700 South
Salt Lake City, Utah 84138
ATTN: Robert Ruesink, Field Supervisor (801) 524-4430

PROCEDURE: A Federal agency must ensure that any action authorized, funded, or implemented by the agency is not likely to jeopardize the continued existence of any threatened or endangered (T&E) species or its critical habitat. The responsible Federal agency must consult with the U.S. Fish and Wildlife Service (USFWS) to determine what effect, if any, the proposed action might have on any T&E species.

In most cases, a letter is sent by the Federal agency to the USFWS outlining the proposed action. If the USFWS determines that no T&E species would be adversely affected by the action, the USFWS responds stating their finding and that no further compliance measures are necessary. If the USFWS identifies any T&E species that may be affected, the Federal agency is required to prepare a biological assessment considering the species identified by the USFWS, determine any impacts, and recommend appropriate mitigation measures. The Federal agency will issue a formal opinion of "may effect" or "no effect."

SPECIAL CONSIDERATIONS: No listed or proposed threatened or endangered plant or wildlife species are known to occur at the Green River tailings and borrow sites. However, the bald eagle, peregrine falcon, and Colorado squawfish may occur near the sites. The remedial action activities are not expected to affect these species. The Environmental Assessment will serve as the biological assessment for consultation with the USFWS.

SCHEDULE: After obtaining the list of T&E species from the USFWS, the Federal agency has 180 days or another mutually agreeable time period to complete a biological assessment. The Federal agency requests a Section 7 consultation, and the USFWS is required to issue a biological opinion within 90 days.

PERMIT: CULTURAL RESOURCE CLEARANCE

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

AGENCY/CONTACT:
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 to protect and, when necessary, recover significant resources. Prior to initiating surface disturbing activities, cultural resource clearance should be obtained from 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 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 area around the processing site revealed two historic trash dumps and no archaeological sites. The two historic sites are ineligible to the National Register of Historic Places. The borrow sites have not been surveyed; undisturbed areas should be surveyed prior to surface disturbance.

SCHEDULE: The SHPO review of archaeological reports involves one to three months.

ACTIVITY: NOTICE OF INTENT TO CONDUCT A MINING OPERATION

LEGAL CITATION: Utah Code Annotated; Mined Land Reclamation Act of 1975, Ammended 1982

AGENCY/CONTACT: Utah State Division of Oil, Gas, and Mining
No. 3 Triad Center
Suite 350
Salt Lake City, Utah 84180
ATTN: Lowell Brakston, Administrator, (801) 538-5340
Mined Land Reclamation Program
Frank Files, Reclamation Engineer

PROCEDURE: The mining of the borrow sources will require approval by the State of Utah. Application is made by providing information on form MR-1. Information to be provided consists of the following:

(1) Mine name and operator.
(2) Name and address of applicant.
(3) Location of mine.
(4) Name and address of surface owner.
(5) Name and address of mineral owner.
(6) Mine plans and maps including contour features, locations of disposal and stockpile areas, drainage patterns of land affected, highways and facilities near site, and known drill holes.
(7) Amount of acreage to be disturbed - including access and haul routes.
(8) Description of mining sequence.
(9) Estimated duration of mining operation.
(10) Construction and maintenance of access roads.
(11) Prior land use.
(12) Description of soils and their stockpiling.
(13) Description of methods to minimize hazards to public safety.
(14) Grading and revegetation.
(15) Description of impoundments.
(16) Reclamation schedule.

SPECIAL CONSIDERATIONS: The state will simplify the process in this case. No bonding would be required and there is no application fee. They will place a few stipulations on the permit, such as leaving 2:1 slopes and revegetation of the mined areas.

SCHEDULE: 30 days.

ACTIVITY: WASTEWATER TREATMENT FACILITY CONSTRUCTION PERMIT

LEGAL CITATION: Utah Code Annotated 26-15-45 and 73-14-1 through 13. Wastewater 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 16690
Salt Lake City, UT 84116-0690
ATTN: Steven McNeal (801) 538-6146
Environmental Engineer

PROCEDURE: The Construction Permit is required prior to construction of wastewater treatment works, or the discharge of wastewater. 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 wastewater 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 deveopment areas.
- Topography and layout of proposed facilities.
- Flood potential.

(6) Location of wells and surface waters within one-half mile. Results of soil boring 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 wastewater treatment. Part II of the regulations contains "Standards of Quality for Waters of the State" and Part III contains specifications for "Sewers and Waste-Water Treatment Works."

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: 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 16690
Salt Lake City, UT 84116-0690
ATTN: Brent Bradford, Director (801) 538-6108
Montie Keller, Chief
Compliance Division

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 throughout 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: 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.

PERMIT: APPROVAL OF WELL PLUGGING

LEGAL CITATION: Water Laws of Utah, UCA 73-5-9; Administrative Rules for Water Well Drillers, Utah Division of Water Rights, July 1, 1985

AGENCY/CONTACT:
Utah State Engineer's Office
Utah Division of Water Rights
1636 West North Temple
Salt Lake City, Utah 84116
ATTN: Robert Morgan, State Engineer (801) 533-6071
Kent Jones, Distribution Engineer

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

SPECIAL CONSIDERATIONS: The following procedures shall be implemented 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 the Regulations for Water Well Drillers.

(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 groundwater 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.

APPROVAL OF WELL PLUGGING (Concluded)

Failure to diligently comply with the plugging requirements of the State Engineer constitutes a separate misdemeanor offense for each day of violation.

SCHEDULE: None specified.

PERMIT: CONDITIONAL USE PERMIT

LEGAL CITATION: Emery County Zoning Ordinances

AGENCY/CONTACT: Emery County Attorney's Office
P.O. Box 1099
Castle Dale, UT 84513
ATTN: Mark Tanner, Planner (801) 381-2543

PROCEDURE: The County will issue a Conditional Use Permit for the use of Borrow Site 2. A Conditional Use Permit application is submitted with the following information:

(1) Legal description.
(2) Purpose.
(3) Size of project (acres).
(4) Existing and intended use of property.
(5) Volume of material to be removed.

The County will issue requirements of reclamation and quantity limits when the permit is approved.

SPECIAL CONSIDERATIONS: None. An application fee of $100 is required.

SCHEDULE: Approximately 30 days.

A.2 CONCLUDING REMARKS

The preceding list of permits is considered to be comprehensive. No other issues or permit requirements have been identified which are considered relevant to the current remedial action plan for the Green River tailings site.

The activities discussed below do not require specific regulatory compliance or additional permits if the remedial action plan is modified significantly.

SPILL PREVENTION CONTROL AND COUNTERMEASURES PLAN (SPCC)

If on-site fuel and oil storage facilities exceed 1320 gallons, or any single on-site fuel or oil tank exceeds 660 gallons capacity, the EPA requires the operator to prepare an SPCC plan meeting the specifications cited in 40 CFR 112 and certified by a professional engineer. No permit is required, but a copy of the plan must be kept at the fuel storage site and be available for review by the EPA in the event of a spill or general inspection.

MONITOR WELL DRILLING

No formal permits are required from the Utah State Engineer's Office (SEO). The wells should be drilled by a Utah licensed well driller. In addition, location and depth information should be provided to the SEO upon completion of drilling.

OPEN BURNING PERMIT

Burning between October 31 and May 1 is allowed without a permit. Burning during the remaining months requires a permit to be issued by the Grand County Planning Commission.

APPENDIX B
RADON BARRIER DESIGN

APPENDIX B

RADON BARRIER DESIGN

The infiltration/radon barrier design will be confirmed or revised during construction of the disposal cell after the source term for all of the layers of contaminated materials have been positively identified. Specifications for the current infiltration/radon barrier design are found in section 2200 and the related drawings in Appendix F, Final Design. The original calculations determined that a 12-inch-thick minimum required radon barrier would be adequate to control radon flux to meet the U.S. Environmental Protection Agency standards (40 CFR 192). The current radon barrier of 36 inches is conservative because the final source term and quantities are not expected to increase to the extent that more than 36 inches of radon barrier would be needed.

APPENDIX C
RADIOLOGICAL SUPPORT PLAN

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C.1 INTRODUCTION

The Uranium Mill Tailings Radiation Control Act of 1978 (PL95-604) gave the responsibility of developing standards for remedial action to the U.S. Environmental Protection Agency (EPA). Section 108 of PL95-604 states that the U.S. Department of Energy (DOE) shall "select and perform remedial actions at the designated processing sites and disposal sites in accordance with the general standards" prescribed by the EPA. The EPA standards state:

> "Section 108 of the Act requires the Secretary of Energy to select and perform remedial actions with the concurrence of the Nuclear Regulatory Commission and the full participation of any State that pays part of the cost, and in consultation, as appropriate, with affected Indian Tribes and the Secretary of the Interior. These parties, in their respective roles under Section 108, are referred to hereafter as 'the implementing agencies.'
>
> The implementing agencies shall establish methods and procedures to provide 'reasonable assurance' that the provisions of Subparts A and B are satisfied. This should be done primarily through use of analytical models, in the case of Subpart A, and for Subpart B through measurements performed within the accuracy of currently available types of field and sampling procedures. These methods and procedures may be varied to suit conditions at specific sites."

Subpart B consists of standards for cleanup of land and buildings. The standards applicable to the project are:

> "Remedial actions shall be conducted so as to provide reasonable assurance that, <u>as a result of residual radioactive materials from any designated processing site</u>:
>
> A. the concentration of Radium-226 in land averaged over an 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 microR/h."

In addition to the EPA standards for buildings, removable surface alpha contamination shall not exceed those limits stated in the current Uranium Mill Tailings Remedial Action (UMTRA) Project Environmental, Health, and Safety Plan. These limits will ensure that potential airborne radionuclide concentrations will not exceed 10 CFR 20 Appendix B standards and that physical contact with the surfaces by occupants of the structures will not result in a measurable radiation exposure.

As indicated earlier, the standards suggest that the implementing agencies determine what method and procedures will be used to provide "reasonable assurance" that the standards are met. Reasonable assurance implies that a site-specific analysis is appropriate where the cost of demonstrating compliance with the standards is to be weighed against the health risks or other impacts associated with leaving areas which slightly exceed the standards.

The sections which follow provide the procedures proposed for use at the Green River site. Consideration was given to the time required to collect samples and perform the analyses.

C.2 BASIS FOR RADIOLOGICAL SURVEY STRATEGY

The Green River site consists of a tailings pile, mill and ore storage areas, and some areas contaminated by windblown/waterborne tailings. Excavation to remove the tailings and off-pile contaminated material to the stabilization area will require removal of soil to a depth of several feet below grade. The disturbed areas will be restored to a grade that will control the drainage. The fill material will be uncontaminated and will minimize the potential health effects due to slight residual contamination.

Clean fill may not be required in some of the excavated areas, and residual contamination may remain exposed at the surface. In those areas where backfill after excavation is not required, residual contamination will be removed to the 5 pCi/g limit.

C.3 REMEDIAL ACTION RADIOLOGICAL SURVEY PLAN

Radiological surveys are performed for three purposes: site characterization, excavation control, and final radiological verification. Site characterization surveys or pre-remedial action surveys are performed to identify volumes of material which exceed the standard. The results are used for planning and engineering design. Excavation control monitoring is performed as the work is being done to guide and control the amount of contaminated material removed. Finally, when excavation control monitoring results indicate that there is a high probability that the area meets the standards, a final radiological survey is carefully performed and the results documented.

C.3.1 SITE CHARACTERIZATION SURVEYS

Field sampling programs conducted by Bendix Field Engineering Corporation (BFEC) have been used to identify the subsurface boundary of the tailings pile, as well as the depth and area of the former mill yards, ore storage, and windblown contaminated areas. Subsurface evaluations were performed using gamma well logging techniques and by analyzing cores from boreholes. In general, boreholes and surface measurements and samples were made on grids ranging from 100 by 100 feet to 200 by 200 feet. Additional measurements were performed in areas of radiological interest. The grid points have been identified by a land survey tied to a state plane survey point and all recordable data were located by these coordinates.

Radiometric surveys and sampling were conducted in the buildings at the site. Survey grids of 10 feet were established in each building. Additional points were added to ensure that a minimum of four samples were taken in each room. Exposure rate and removable and nonremovable alpha measurements were made at each grid point. Samples of the building foundations and associated subsurface soils were analyzed for Ra-226.

C.3.2 EXCAVATION CONTROL MONITORING

The purpose of excavation control monitoring is to guide the contractor's work through the use of real-time radiological measurements. It is designed to ensure that the 5 pCi/g (surface) and 15 pCi/g (subsurface) standards are met. In addition, it minimizes the possibility that material meeting the standards is also excavated. Properly performed excavation control monitoring simultaneously ensures that neither under-excavation nor over-excavation occurs.

Excavation will be monitored by qualified technicians relying principally on gamma field measurements employing hand-held instruments such as gamma-scintillation detectors. This technique will only be used where measurements are not seriously impaired by interference from nearby tailings deposits. In areas where significant interference exists, alternate monitoring techniques will be used. These techniques may include use of a shielded probe gamma-scintillation instrument (operated in a gross count mode or in a delta mode) or the immediate counting of soil samples. In all cases, these techniques will be routinely calibrated by comparison of the field measurements to soil samples analyzed in the laboratory and reported on a fully equilibrated dry-weight basis. Because the standards are based upon average areas of 100 m^2, the excavation control monitoring will be performed on areas of this characteristic size as well.

Elevated gamma-ray radiation fields preclude exclusive use of in-situ monitoring devices to estimate the surface radionuclide concentrations in soil on or immediately adjacent to the tailings pile. When in-situ measurements cannot be performed, the suggested method for analysis is to take individual or composite samples of soil, seal by canning, and immediately count the sample by gamma-ray spectrometry. Errors associated with this approach will be reduced by taking several samples 30 days prior to starting work to determine calibration factors. These samples will be counted, then held for subsequent analysis. They will be counted later after the Ra-226 daughters reach equilibrium. Analyses of these prepared samples can then be compared to standards. Several samples will be collected weekly during the remedial action and analyzed to provide a measure of the variation of the calibration factor.

C.3.3 BUILDING DECONTAMINATION CONTROL MONITORING

Four on-site buildings will require decontamination. The typical plan requires that in areas of known contamination, as determined by the site characterization surveys, measurements will be performed after each decontamination effort to assess the effectiveness of the effort. For potentially contaminated areas, measurements will be made at a minimum of either 100 percent of the area or at approximately 30 locations for surface areas of less than 500 square feet. In addition, measurements will be made in previously contaminated areas or other areas having a high probability of being contaminated.

C.3.4 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR LAND

The final radiological survey will be based on 100 m^2 areas, with a composite sample used to obtain a measure of the average Ra-226 concentration in an area. The radium measurement will be reported on a dry-weight basis. For measurements based on gamma spectrometry of radium daughters, full equilibrium will be assured. It is expected that at least preliminary measurement results will be obtained prior to backfilling. The error limits for Ra-226 verification measurement techniques must be better than plus or minus 30 percent, at the 95 percent confidence level.

The average Ra-226 concentration on each 100 m^2 area which is surveyed will be determined by a composite sample composed of nine 15-cm-deep samples of approximately equal mass taken on a uniform spacing over the survey area. Other sampling protocols may be used if shown to adequately characterize the mean concentration and if approved in advance by the UMTRA Project Office.

C.3.5 FINAL RADIOLOGICAL VERIFICATION SURVEY FOR BUILDINGS

Four on-site buildings at Green River will require radiological verification. The typical plan requires that gamma surveys will be conducted using an instrument capable of detecting two microR/h above background. Buildings will be scanned while holding the instrument at three feet above the floor. Maximum, minimum, and average exposure rates will be recorded for each room of the buildings. All areas where the exposure rates exceed 20 microR/h above background will be noted.

Alpha detection instruments will be used to monitor surface contamination. A grid system will be constructed for each room of a structure which has been decontaminated. The grid size will be adjusted so that a minimum of 30 grid points will be defined by using grid lines not more than 30 feet nor less than three feet apart. Measurements will be made at each grid point and other areas of special radiological interest such as floor drains or areas that were the most highly contaminated. Contamination may be averaged over a 10-square-foot area and compared with the allowable limits, as provided in Section C.1. In cases where the total contamination is greater than the limits for removable contamination, measurements for assessing the removable contamination levels will be made.

Radon daughter concentration (RDC) measurements will be conducted in areas of the building where previous data indicated elevated radon progeny concentrations. An annual average radon daughter concentration will be determined for all structures to assure that they meet the standard.

C.4 DATA AND SAMPLE MANAGEMENT

During the cleanup operations, the Remedial Action Contractor will collect data to support excavation control. Data used in declaring an area adequately decontaminated will be documented in a format approved by the UMTRA Project Office.

Site characterization survey data, excavation control data, and the final radiological survey data will be collected using procedures and analytical methods meeting the requirements of the UMTRA Project Quality Assurance Program Plan (UMTRA-DOE/AL-400325). All data used in describing the final radiological condition of the site, as well as other data as specified by the UMTRA Project Office, will be provided in a convenient format. Data generated in the remedial action will be presented in a report documenting the final radiological condition of the property. Verification samples will be archived pending orders for transfer or disposal from the UMTRA Project Office.

C.5 CERTIFICATION

Certification is a professional judgement by an independent party that the remedial action has been completed according to the site-specific Remedial Action Plan and meets the applicable standards.

During the remedial action operations, the Remedial Action Contractor will make available to appropriate state agencies, Federal agencies, or UMTRA Project-designated contractors data related to the cleanup. In addition, samples collected during the cleanup operations may be split for analyses by these agencies to allow comparison of analytical results. These data, along with any additional data collected at the discretion of the certifying agent, will be used in the final certification report.

UMTRA-DOE/AL 050510
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United States Department of Energy

Remedial Action Plan and Final Design for Stabilization of the Inactive Uranium Mill Tailings At Green River, Utah

Final

Volume IIA – Appendix D: Supplement,
Site Characterization
Appendix E: Groundwater Protection
Strategy

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

March 1991

Uranium Mill Tailings Remedial Action Project UMTRAP

APPENDIX D
SUPPLEMENT, SITE CHARACTERIZATION

NOTE: This volume incorporates by reference Sections D.1., D.2, D.3, D.6, and D.7 of the February 1988 RAP. It also incorporates by reference the revised portions of Section D.4, which were presented in the January 1989 Supplement to Appendix D.

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D.5 GROUNDWATER HYDROLOGY

D.5.1 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has established health and environmental protection regulations to correct and prevent groundwater contamination resulting from processing activities at inactive uranium mill tailings sites (40 CFR 192). The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 designated responsibility to the U.S. Department of Energy (DOE) for assessing the tailings sites. This assessment includes the following:

- o Definition of hydrogeologic characteristics of the environment, including the hydrostratigraphy, aquifer hydraulic parameters, areas of aquifer recharge and discharge, potentiometric surface, and groundwater velocity.
- o Comparison of existing water quality with background water quality and applicable EPA standards. Some discussion of EPA secondary drinking water quality parameters is included to define the general quality of the groundwater.
- o Definition of physical and chemical characteristics of the potential contaminant source, including concentration and leachability in relation to migration of contaminants in groundwater and hydraulically connected surface water.
- o Description of water resource use, including availability, current and future use, value, and alternative supplies.
- o Evaluation of current impacts to the groundwater system resulting from uranium processing activities.

On January 5, 1983, the EPA promulgated final standards for the disposal and cleanup of the inactive uranium processing sites under the UMTRCA (48 FR 590). On September 3, 1985, the groundwater provisions of the regulations (40 CFR 192.20(a)(2)-(3)) were remanded to the EPA by the U.S. Tenth Circuit Court of Appeals. On September 24, 1987, the EPA issued proposed groundwater regulations to replace those set aside (52 FR 36000). The DOE has commented on the proposed standards.

Water quality at the Green River tailings site was characterized and compared with the EPA's proposed groundwater standards for inactive uranium processing sites (Table D.5.1). The constituents listed in Table D.5.1 are most commonly associated with uranium mill tailings. The numerical concentration limits associated with the constituents reflect safe levels for public drinking water and are therefore the same as maximum concentration limits (MCLs) for EPA primary drinking water standards. Appendix VIII of the EPA's proposed standards includes a complete list of hazardous constituents that should be evaluated on a site-specific basis. These constituents include both organic and inorganic compounds and elements. Section E.3.1.1 of Appendix E contains a complete discussion of hazardous constituents that are associated with the uranium mill tailings at the Green River site.

The DOE has characterized conditions at the Green River processing site and does not anticipate that any changes to the remedial action will be required when the final EPA standards are issued. Upon issuance of these standards, the DOE will reevaluate the groundwater protection plan and determine the need for institutional controls on the public use of groundwater at the site, aquifer restoration, or other measures, and take appropriate action to comply with the final standards.

The following sections present details of the hydrogeologic characterization at the Green River site. Appendix E presents an assessment of future impacts to the groundwater system resulting from the proposed remedial actions, and a strategy for protecting water resources at the Green River site. Figures and tables are presented at the end of the text for ease in reading.

D.5.2 SITE CHARACTERIZATION SUMMARY

D.5.2.1 Summary

To comply with EPA standards for remedial actions at inactive uranium processing sites (40 CFR 192), the DOE has characterized the hydrogeology, water quality, and water resources at the Green River, Utah, designated site. Major points are summarized below, followed by a detailed discussion of the site characterization.

- o Four distinct hydrostratigraphic units occur within the upper 200 feet of Quaternary and Cretaceous sediments beneath the site. In decending order these are: (1) Brown's Wash alluvium (top hydrostratigraphic unit); (2) shale and limestone of the Cedar Mountain Formation (upper-middle hydrostratigraphic unit); (3) sandstone, siltstone, and conglomerate of the Cedar Mountain Formation (lower-middle hydrostratigraphic unit); and (4) Buckhorn Conglomerate Member of the Cedar Mountain Formation. The Dakota Sandstone is present in some areas beneath the proposed disposal site. These units are underlain by the Jurassic-aged Morrison Formation.

- o Average hydraulic conductivities of aquifer materials range from a low of 1.6 feet per day (ft/day) in the upper-middle shale unit to a high of 25.0 ft/day in the Brown's Wash alluvium. Average linear groundwater velocities range from 0.08 ft/day to 1.14 ft/day in the two units, respectively.

- o Groundwater flow in the upper- and lower-middle hydrostratigraphic units is controlled by connected fractures and joints; strong, upward, vertical hydraulic gradients; and the attitude (dip) and lateral extent of the hydrostratigraphic units. Groundwater flow in the Brown's Wash alluvium and the upper-middle shale unit, where it lies beneath the alluvium, is also controlled by paleo-erosion of the upper-middle unit near the present tailings pile by a meandering Brown's Wash channel, and by the subsequent deposition of the Brown's Wash alluvium.

- Background groundwater quality in all four hydrostratigraphic units is characterized by concentrations of total dissolved solids (TDS), sulfate, and chloride that exceed EPA and state of Utah secondary drinking water standards. Groundwater in all four units is classified as Class II based on TDS (TDS greater than 1000 but less than 10,000 milligrams per liter (mg/l)), but it may be classified as Class III because of the concentrations of selenium, chromium, nitrate, and uranium in background samples that exceed proposed EPA MCLs for these constituents.

- Background groundwater quality in the top hydrostratigraphic unit is characterized by concentrations of chromium, molybdenum, nitrate, and selenium that exceed proposed EPA MCLs and state of Utah primary drinking water standards (except for molybdenum, which does not have a Utah standard).

- Background groundwater quality in the upper-middle hydrostratigraphic unit is characterized by concentrations of nitrate and selenium that exceed proposed EPA MCLs and state of Utah primary drinking water standards.

- Background groundwater quality in the lower-middle hydrostratigraphic unit is characterized by concentrations of molybdenum, nitrate, selenium, uranium, and gross alpha activity that exceed proposed EPA MCLs and state of Utah primary drinking water standards (except for molybdenum, which does not have a Utah standard).

- Background groundwater quality in the bottom hydrostratigraphic unit is characterized by concentrations of chromium, molybdenum, and selenium that exceed proposed EPA MCLs and state of Utah primary drinking water standards (except for molybdenum, which does not have a Utah standard).

- Contamination by tailings seepage is limited to the Brown's Wash alluvium and the upper-middle shale unit of the Cedar Mountain Formation beneath the present tailings pile. Major contaminants introduced by tailings seepage to these units include: molybdenum, nitrate (chemically reduced, in part due to ammonium), selenium, uranium, and gross alpha activity.

- The tailings seepage has been neutralized by the alluvium and shale bedrock beneath the tailings (the pH of the groundwater is near 7.0). Uranium concentrations in the alluvium and shale have not exceeded 3.11 mg/l in any of the wells, while concentrations in the tailings pore water (lysimeter samples) have been measured as high as 675 mg/l. Dilution by groundwater underflow and attenuation, probably as cation exchange in the alluvium and precipitation in the shale, have significantly lowered uranium concentrations, as well as other seepage contaminants, to well below the relatively high concentrations found in the tailings pore water.

D.5.2.2 Previous investigations

Bibliographies (ONWI, 1985; USGS, 1971-1985, 1972, 1964; La Pray and Hamblin, 1980; Buss and Geoltz, 1974; Childers and Smith, 1970; Buss, 1951) were reviewed to identify geological, hydrological, and hydrogeological investigations of the Green River site and vicinity. A number of regional studies (USGS, 1964; Howard and Love, 1945; Waring and Knechtel, 1936; Reeside, 1930, 1923; La Rue, 1916) were identified; however, much of the information contained in these reports is either outdated or not sufficient to aid in characterizing the hydrogeology of the site.

Five reconnaissance studies of the Paradox Basin, which contains the Green River site, were conducted as part of a program to evaluate the potential for storage of nuclear waste in salt deposits (Weir et al., 1983); one of these studies (Rush et al., 1982) included the area of the Green River tailings site.

A one-time sampling effort at the Green River tailings site was conducted by Geochemistry and Environmental Chemistry Research, Inc. (GECR, 1983). Data from this report are from sampling and analyses of groundwater and surface water from background areas, the area adjacent to the site, and the site. Soils samples were collected and archived, and have not been analyzed. Because of questionable quality assurance and control on the water sample analyses from the GECR report, the data were not used for analyses in this report.

An unpublished report by the DOE (1983) on the Green River site contains the results of drilling, groundwater sampling, and aquifer hydraulic testing of eight monitor wells; surface water sampling of Brown's Wash adjacent to and downstream of the site; and climatological data for the vicinity. Some of the data from the DOE (1983) report were used in this report. An engineering assessment (FBDU, 1981) includes site information as well as a summary of the milling operations and a history of the Green River site.

Hydrogeological data, including borehole logs, well completion records, groundwater elevations, aquifer hydraulic parameters, and water quality data, were collected at the Green River tailings site by the DOE during three drilling and testing phases from the fall of 1985 to the fall of 1987. Much of this information was included in an environmental assessment of the Green River tailings site (DOE, 1988a). All field and laboratory procedures and calculations were performed in accordance with the DOE's Standard Operating Procedures as contained in the Albuquerque Operations Manual (DOE, 1985).

Five two-inch diameter polyvinyl chloride (PVC) monitor wells, 28 four-inch diameter PVC monitor wells, and three two-inch diameter, low-carbon, galvanized steel well points were installed to characterize the Green River tailings and proposed disposal sites. The depths of these installations range from seven to 185 feet. Twelve exploratory geotechnical boreholes were also drilled, and ranged in depth from 16.5 to 32.5 feet. Lithologic logs were obtained from these boreholes prior to their abandonment by grouting and bentonite sealing from total depth to land surface. In addition, three suction lysimeters were installed in the unsaturated zone within the present tailings pile to characterize the pore water within the tailings. Since their installation, only one lysimeter has worked sufficiently to obtain samples. The locations of all monitor wells, lysimeters, abandoned boreholes, test pits and surface water sampling sites included in this investigation are shown in Figure D.5.1. Following installation and development of the monitor wells, slug injection/withdrawal tests and short-duration (less than 25 hours) pumping drawdown/recovery tests were performed to estimate the hydraulic properties of the aquifer materials within the screened zones of the wells. The monitor wells were surveyed and static groundwater elevations in the wells were measured to determine vertical and horizontal hydraulic gradients and directions of groundwater flow. Table D.5.2 summarizes monitor well information for the Green River tailings site.

D.5.2.3 Geology and hydrostratigraphy

The Green River site is in east-central Utah on the nose of a shallow, northward plunging anticline that is repeated by the arcuate east-northeast to west-northwest trending Little Grand Wash fault, which lies three miles to the south of the site. Bedrock exposed at the surface in the site area consists of sedimentary units of Cretaceous and Jurassic age. Rock units lying beneath the surface range in age from Jurassic to Pennsylvanian and, at depth, include the salt- and gypsum-bearing Paradox Member of the Pennsylvanian Hermosa Formation.

In descending sequence, the geologic units within 200 feet of the surface in the Green River site area are as follows:

- o Brown's Wash alluvium beneath the present tailings pile, and alluvial terrace deposits beneath the proposed disposal site (Quaternary age).
- o Tununk Shale Member of the Mancos Shale (Cretaceous age).
- o Dakota Sandstone (Cretaceous age).
- o Cedar Mountain Formation (Cretaceous age).

The Brown's Wash alluvium consists of a mixture of silt, sand, gravel, and some small cobbles. The alluvium is limited to an area that extends 300 to 400 feet on either side of Brown's Wash, and varies in thickness from zero to 35 feet. The tailings pile directly overlies the Brown's Wash alluvium. The terrace deposits consist mostly of silt and sand and are approximately 20 feet thick in the vicinity of the proposed disposal site.

The Tununk Shale Member of the Mancos Shale consists of carbonaceous shale interbedded with thin beds of sandstone. It subcrops beneath the Brown's Wash alluvium in the eastern half of the site but is mostly eroded away by the channel of Brown's Wash in the western half of the site area. This unit is exposed in the east-central section of the site, and forms the bluff at the south end of the existing tailings pile. This shale unit forms a wedge that thins toward the south and disappears completely between the tailings pile and the proposed disposal site. South of the tailings pile, the Tununk Shale is between zero and 25 feet thick.

In the site area, the Dakota Sandstone consists of fractured to unfractured, weathered to fresh sandstone, shale, and conglomerate. It rests unconformably on top of the Cedar Mountain Formation. This unit varies from zero to 10 feet thick and extends both east and west of the tailings and disposal sites. The Dakota lies between unconformable contacts with either the Mancos Shale, the Brown's Wash alluvium, or the alluvial terrace deposits (top contact), and the Cedar Mountain Formation (bottom contact). Where it has not been eroded away, the shale and dense, well-cemented sandstone, and conglomerate of the Dakota Sandstone are either not saturated or only partly saturated beneath the tailings pile.

The Cedar Mountain Formation consists of mudstone, shale, limestone, sandstone, conglomerate, and occasional interbedded coal. The Cedar Mountain Formation lies unconformably beneath the Dakota Sandstone and in the site area is at least 150 feet thick. Lithologic units within the Dakota Sandstone and Mancos Shale can be distinguished from units within the Cedar Mountain

Formation by visual inspection. The Dakota and Mancos sandstones and shales are generally black (shale) to light tan (sandstone); units within the Cedar Mountain are generally shades of gray to maroon in color. Fractured and unfractured sandstone, sandstone conglomerates, and fractured shales or limestones within the Cedar Mountain Formation are the primary water-bearing units.

Figure D.5.1 shows the locations of cross sections (Figures D.5.2 through D.5.6) that show the hydrostratigraphy at the Green River tailings site. Figure D.5.7 is a fence diagram of the Green River site. The surface topography shown on the cross sections and fence diagram was developed from a topographic survey of the site. Subsurface lithologic data were obtained from borehole logs, visual inspection of rock core, and correlation of subsurface data with surface geology.

Hydrological investigations have shown that horizontal and vertical fracturing occurs in the Dakota Sandstone and Cedar Mountain Formation beneath the proposed disposal site. Core samples from monitor wells 562, 807, 812, 813, 814, 816, and 818 at the disposal site (see Figure D.5.1) show that vertical and near-vertical fractures exist in the bedrock and start at the top of the bedrock section. Fracturing is uniform and consistent through the Cedar Mountain Formation at least in the upper 60 feet of bedrock. The degree of fracturing varies from moderate to intense and is typical of the fracturing observed in outcrops of the Cedar Mountain Formation in the vicinity of the disposal site. Fracturing of the bedrock beneath the present tailings pile is variable. The flowing monitor well (581), completed in the sandstone unit beneath the pile, is evidence that the confining unit for the sandstone unit at this location (the overlying shale) must be relatively impermeable. Evidence (aquifer hydraulic conductivities and water levels) suggests that joints, fractures, or minor faulting may be controlling groundwater flow in the shallow bedrock approximately along the alignment of Brown's Wash.

Within the upper 200 feet of Quaternary and Cretaceous sediments, four distinct water-bearing units were defined at the Green River tailings site. These units are described as follows:

- The top hydrostratigraphic unit is the Brown's Wash alluvium. Groundwater in this unit is locally perched by the dense, well-cemented sandstone conglomerate of the Dakota Sandstone and the shale and limestone of the Cedar Mountain Formation (where these bedrock units are not fractured). Directly beneath the tailings pile, a paleochannel of Brown's Wash has eroded away the Dakota Sandstone, and the Brown's Wash alluvium directly overlies shale of the Cedar Mountain Formation.

- The upper-middle hydrostratigraphic unit is the alternating layers of shale, limestone, and mudstone of the Cedar Mountain Formation.

- The lower-middle hydrostratigraphic unit is a relatively thick, but laterally limited, sandstone of the Cedar Mountain Formation. The unit intertongues with the upper-middle unit and is beneath the present tailings pile and the proposed disposal site.

- The bottom hydrostratigraphic unit is the Buckhorn Conglomerate Member of the Cedar Mountain Formation. This basal sandstone and sandstone conglomerate unit is 15 to 25 feet thick beneath the site area and is confined by overlying shale and mudstone.

Neither the lower-middle or bottom hydrostratigraphic units have been adversely affected by seepage through the present tailings pile. The lower-middle unit subcrops beneath the proposed disposal site and is therefore a potentially affected unit; the bottom unit is protected from any current or future contamination by strong, vertically upward hydraulic gradients and a thick, low-hydraulic-conductivity shale that overlies this unit. The following sections present more detailed discussions about the hydraulic characteristics and flow of groundwater within these units.

D.5.2.4 Hydraulic characteristics

A summary of the hydraulic characteristics of the top, upper-middle, lower-middle, and bottom hydrostratigraphic units is presented in Table D.5.3. A number of methods were used to calculate values of hydraulic conductivity for the units. The methods of analyses include the following:

- Ferris-Knowles slug test analysis (Ferris and Knowles, 1963).

- Cooper, Bredehoeft, and Papadopulos slug test analysis (Cooper et al., 1967).

- Bouwer-Rice slug test analysis (Bouwer and Rice, 1967).

- Pumping drawdown analyses.

- Pumping recovery analyses.

Slug test data from monitor wells 561, 581, 582, 583, 584, 585, 586, 587, 588, 701, 704, 707, 806, 807, 811, 813, 815, and 818 were analyzed by the Ferris-Knowles method. This method is best suited for fully developed wells that are open to the full thickness of an artesian aquifer of small to moderate transmissivity (less than 50,000 gallons per day per foot (gpd/ft)); it is also suited to some unconfined aquifers (Ferris and Knowles, 1963). The Ferris-Knowles equation is as follows:

$$k = \frac{q(1/t)}{4\pi sL}$$

where

k = hydraulic conductivity (ft/day).

q = slugged volume (cubic ft).

t = time (days).

s = residual drawdown at time t_s (ft).

L = length of interval being tested (ft).

The values of 1/t and s are obtained from a straight-line fit through the plotted data points. These data are available from the Albuquerque UMTRA Project Office, Albuquerque, New Mexico.

Slug test data from monitor wells 561, 582, 583, 584, 585, 586, 587, 588, 701, 704, 707, 806, 807, 811, 813, 815, and 818 were analyzed using the Cooper, Bredehoeft, and Papadopulos (Cooper et al., 1967) method, which has requirements similar to the Ferris-Knowles method, and is as follows:

$$k = \frac{r^2}{tL}$$

where

k = hydraulic conductivity (ft/day).

r = radius of well casing (ft).

t = time for point in "matched-type curve" (days).

L = length of interval being tested (ft).

The value t is obtained by matching data points of residual drawdown versus time (log scale) to a "type curve" referenced by Cooper, Bredehoeft, and Papadopulos (Lohman, 1972).

Short-duration aquifer pumping tests were analyzed from monitor wells 581, 582, 586, 587, 588, and 813 by the single-well pumping drawdown or recovery method, formally recognized as the modified Theis nonequilibrium formula (Freeze and Cherry, 1979). The pumping drawdown or recovery formula is as follows:

$$k = \frac{264q}{sL}$$

where

k = hydraulic conductivity (gpd/ft^2).

q = average pumping rate for the duration of the test (gpm).

s = drawdown per one log cycle (ft).

L = length of interval being tested (ft).

An aquifer pumping drawdown test was conducted on alluvial well 702 (DOE, 1983). Also, slug tests were performed and analyzed from monitor wells 701, 702, 704, 705, 706, and 707 using the Bouwer-Rice method (DOE, 1983).

Assumptions inherent in the analyses of the aquifer hydraulic test data, regardless of the method of analysis, are as follows:

- The unit being tested is homogeneous and isotropic.
- The radius of the well is small in comparison to the extent of the aquifer.
- The removal of the slug and the development of initial, residual drawdown are instantaneous.
- The influence of the filter pack is negligible.

To obtain the average hydraulic conductivity values listed in Table D.5.3, values from each analysis were summed and an arithmetic mean was calculated. Wells 701, 704, and 707 were tested in 1983 and 1986. Alluvial wells 702, 705, and 706 were only tested in 1983. All other wells listed in Table D.5.3 were tested in 1986 and 1987.

Average linear velocities listed in Table D.5.3 were calculated as follows (Freeze and Cherry, 1979):

$$v = \frac{ki}{n}$$

where

v = average linear velocity (ft/day).

k = average saturated hydraulic conductivity (ft/day).

i = average hydraulic gradient (ft/ft).

n = assumed porosity of aquifer material (dimensionless).

The saturated hydraulic conductivity of the unfractured bedrock of the Cedar Mountain Formation was measured by the triaxial backpressure falling head method (Table D.5.4). The measured conductivity is low, ranging from 2.4 x 10^{-8} centimeters per second (cm/s) to 2.4 x 10^{-11} cm/s. These values indicate that flow of groundwater in the bedrock is controlled by interconnected fractures and joints.

More detailed discussions of the hydraulic characteristics of the four hydrostratigraphic units are presented in the following sections. Table D.5.5 presents static groundwater elevations in the monitor wells for four sampling periods: June, 1986; September, 1986; March, 1987; and October, 1987.

D.5.2.5 Groundwater flow

Top hydrostratigraphic unit

Shallow, unconfined groundwater is present in Brown's Wash alluvium beneath the present tailings pile. The occurrence of this shallow groundwater is limited by the lateral extent of the alluvium. The top unit is a maximum of 600 feet wide near the tailings pile. Monitor wells 702, 704, 705, 706, 707, 708, 808, and well points 563, 564, and 821 are completed in this unit.

A water table contour map of the top hydrostratigraphic unit is presented in Figure D.5.8. This contour map was developed from water level data and the surveyed elevations of the wells in October, 1987 (see Table D.5.5). The depth to groundwater ranges from nine to 17 feet below the surface in the top unit. The hydraulic gradient within the top unit ranges from 0.0029 ft/ft near monitor well 707 to 0.0125 ft/ft near monitor wells 702 and 808.

Table D.5.6 presents a summary of aquifer hydraulic characteristics for the top hydrostratigraphic unit. The calculated geometric mean linear velocity of groundwater in the top unit is 1.14 ft/day. Groundwater in the top unit is recharged by flow from the upper-middle shale unit from the south, and by infiltration of surface runoff and precipitation in the channel of Brown's Wash. Groundwater discharges from Brown's Wash alluvium into the channel of Brown's Wash at a point west of the tailings pile where the site access bridge crosses Brown's Wash (see Figure D.5.1). From this point west to the Green River, the Dakota Sandstone and Cedar Mountain Formation inhibit the downward movement of water in the channel; however, a portion of this water likely infiltrates into the bedrock, especially where fractures are present. Water that flows west in the channel eventually mixes with backwater from the Green River (at surface-water sampling site 526, shown on Figure D.5.1). Groundwater also discharges from the Brown's Wash alluvium into the underlying upper-middle shale unit of the Cedar Mountain Formation, to the atmosphere as evaporation, and to the tamarisk vegetation that lines the channel of Brown's Wash. The DOE (1988a) measured the base flow in Brown's Wash channel in November, 1985, at 2.3 gallons per minute (gpm). The measurement was made immediately west of the access bridge to the site near well point 564 (see Figure D.5.1). The remainder of the shallow alluvial groundwater from beneath the present tailings pile is lost to evapotranspiration and vertical downward leakage into the Cedar Mountain Formation. Since well points 564 and 821 and monitor well 706 are dry (see Figure D.5.1), very little flow is assumed to move downgradient to the alluvium west of monitor wells 706.

The groundwater flux through the top hydrostratigraphic unit beneath the present tailings pile can be estimated by using Darcy's Law (Todd, 1980) as follows:

$$Q = WDki$$

where

Q = groundwater flux (ft^3/day).

W = saturated width of aquifer perpendicular to groundwater flow beneath the tailings.

D = saturated height of aquifer beneath the tailings (ft).

k = saturated hydraulic conductivity of the alluvium (ft/yr).

i = hydraulic gradient (ft/ft).

To calculate the groundwater flux in the alluvium beneath the tailings, the projected area perpendicular to the flow was divided into three areas represented by monitor wells 702 and 808 for the eastern area; monitor well 704 for the middle area; and monitor well 705 for the western area. The groundwater flux for each of these areas and the total flux in the alluvium beneath the tailings is summarized in Table D.5.7. The total flux is estimated to be 9.9 gpm beneath the tailings.

Upper-middle hydrostratigraphic unit

Confined and semiconfined groundwater is present in the upper-middle unit beneath the Green River tailings site. This unit consists mostly of limestone and shale of the Cedar Mountain Formation. Beneath the tailings and the proposed disposal site, the upper-middle unit is separated into two units by a sandstone and conglomerate channel deposit. To the west and east of the tailings and proposed disposal site this sandstone and conglomerate is not present or intertongues as thin layers with the upper-middle shale unit (see Figures D.5.2, D.5.3, and D.5.4).

Beneath the proposed disposal site, fracturing occurs in the upper- and lower-middle units. A total of six core holes were drilled beneath and peripheral to the proposed disposal site. Core from all of these holes shows moderate to intense vertical and horizontal fracturing and fractures extending from the upper-middle unit down into the lower-middle unit (DOE, 1987a). Monitor wells completed in the upper-middle unit include 583, 584, 585, 701, 806, 807 (completed below the sandstone and conglomerate channel deposit), 809, 810, 812, 814, 816, 822, and 823. Monitor wells 812, 814, 816, 822, and 823 were installed at the disposal site; only well 816 encountered groundwater (at a depth of 60 feet). Depth to groundwater in the upper-middle unit beneath the tailings surface is about 26 feet at monitor well 701.

A potentiometric contour map of the upper-middle hydrostratigraphic unit is presented in Figure D.5.9. This contour map was developed from water level data and the surveyed water elevations in the wells in October, 1987 (see Table D.5.5). The hydraulic gradient within the upper-middle hydrostratigraphic unit ranges from 0.0063 to 0.0083 ft/ft. Groundwater flux in the upper-middle unit is controlled by fractures, joints, or minor faulting, which is most evident in the vicinity of the tailings pile. A "trough" is present in the potentiometric surface, which trends east-west and is just south of the channel of Brown's Wash (see Figure D.5.9). Groundwater flux in the upper-middle unit is also controlled by vertical recharge from the overlying alluvial aquifer and the underlying lower-middle unit.

Table D.5.8 presents a summary of aquifer hydraulic characteristics for the upper-middle unit. The calculated average linear velocity of groundwater in the upper-middle unit ranges between 0.01 and 0.71 ft/day; the geometric mean velocity is 0.08 ft/day. Groundwater flux through the upper-middle unit beneath the present tailings pile was calculated based on the calculated hydraulic conductivities and water levels from monitor wells 584 and 701. The method for calculating groundwater flux was the same as that used to calculate flux through the top hydrostratigraphic unit. The total flux is estimated to be 4.9 gpm beneath the tailings in the upper-middle unit (Table D.5.9).

Lower-middle hydrostratigraphic unit

The lower-middle hydrostratigraphic unit is the sandstone and conglomerate channel deposit within the upper-middle geologic unit of the Cedar Mountain Formation. This unit is a maximum of 30 feet thick and is confined in the area of the present tailings pile by overlying shales and limestones of the upper-middle unit. The lower-middle unit does not appear to be present, or it intertongues as thin lenses with the limestone and shale, east and west of the tailings (see Figures D.5.2, D.5.3, and D.5.4). Monitor well 581 is drilled and completed in this unit beneath the tailings, and it flows at the surface. Monitor wells 561 and 562 are screened in both the upper-middle and lower-middle units and data collected from these wells may not represent actual conditions in either unit. However, monitor well 562 is completed beneath the proposed disposal site and well 561 is west of the disposal site; because of the fracturing present in the upper-middle and lower-middle units at the disposal site, these two units are probably somewhat hydraulically connected, and the screened intervals in monitor wells 561 and 562 probably include the zone of hydraulic connection. Other monitor wells drilled and completed in the lower-middle unit include 811, 813, and 815. Background monitor well 811, east of the tailings pile near Brown's Wash (see Figure D.5.1), encountered only thin, separated lenses of sandstone that are probably of the lower-middle unit.

A potentiometric contour map of the lower-middle unit is presented in Figure D.5.10. This map was developed from water level data for October 1987 (See Table D.5.4) and the surveyed elevations of the monitor wells. The potentiometric surface in the lower middle unit is two to three feet above the surface of the tailings at monitor well 581. The depth to water in this unit is approximately 60 feet at the proposed disposal site. The hydraulic gradient within the lower-middle unit ranges from 0.0083 to 0.025 ft/ft.

The flow of groundwater in the lower-middle unit is strongly influenced by the attitude (dip) of the unit, its limited lateral extent to the east and west, and its recharge by underlying aquifers. Rock cores from monitor wells 562, 807, and 813 indicate this unit is fractured and is probably hydraulically connected with the overlying upper-middle shale unit beneath the proposed disposal site; however, the lower-middle unit is confined by the shale beneath the present tailings. Additionally, monitor well 581, which is drilled and completed in the lower-middle unit, flows at the surface. The strong, vertically upward hydraulic gradient between the upper-middle and lower-middle units beneath the tailings pile has prevented any tailings seepage from moving into the lower-middle unit.

Table D.5.10 presents a summary of aquifer hydraulic characteristics for the lower-middle hydrostratigraphic unit. The calculated average linear velocity of groundwater in the lower-middle unit ranges between 0.02 and 2.7 ft/day; the geometric mean is 0.14 ft/day. Groundwater flux through the lower-middle unit beneath the tailings was not calculated since this unit has not been affected by tailings seepage.

Bottom hydrostratigraphic unit

The Buckhorn Conglomerate Member of the Cedar Mountain Formation has been defined as the bottom hydrostratigraphic unit. Confined groundwater is present beneath the tailings site vicinity in this unit. The unit is 15 to 25 feet thick in the site vicinity and is confined by the maroon to gray-blue shales and mudstones that separate the bottom unit from the overlying hydrostratigraphic units. Monitor wells 582 and 819, drilled and completed near Brown's Wash west of the tailings, flow at the surface. The other monitor wells completed in this formation (586, 587, 588, and 818) do not flow because they are at a higher elevation than the flowing wells. Monitor well 817, located east of the tailings near Brown's Wash (see Figure D.5.1), was thought to be drilled and completed in the bottom unit. Detailed analyses and comparison with other well data showed that well 817 is probably screened somewhere below the lower-middle unit (see Figure D.5.3). Because of the uncertainty associated with the completion of monitor well 817, data from the well have not been included in hydrogeologic analyses of any of the units.

A potentiometric contour map of the bottom unit is presented in Figure D.5.11. This contour map was developed from water level data for October 1987 (see Table D.5.4) and the surveyed elevations of the monitor wells. The potentiometric surface in the bottom unit is five to 14 feet above land surface in the vicinity of the present tailings, and 56 to 71 feet below land surface in the vicinity of the proposed disposal site. The hydraulic gradient within the bottom unit ranges from 0.040 to 0.044 ft/ft.

Table D.5.11 presents a summary of aquifer hydraulic characteristics for the bottom unit. The calculated average linear velocity of groundwater in the bottom unit ranges from 0.072 to 0.17 ft/day; the geometric mean is 0.12 ft/day. Groundwater flux through the bottom unit beneath the tailings was not calculated since tailings seepage has not affected this unit. Because of overlying confining layers and strong, vertically upward hydraulic gradients between the bottom unit and the two presently contaminated units, the bottom unit will not become contaminated from tailings seepage.

Vertical hydraulic gradients

Strong, vertically upward hydraulic gradients exist between the bedrock units in the vicinity of the Green River tailings site. These gradients have prevented the downward movement of tailings seepage into the lower-middle and bottom hydrostratigraphic units beneath the present tailings pile. Beneath the proposed disposal site these gradients may limit the amount of mixing of any tailings seepage (as a result of the proposed remedial action) between the upper-middle and lower-middle units. Additionally, the strong gradients will restrict the movement of any tailings seepage into the bottom unit. Tables D.5.12 and D.5.13 summarize the vertical hydraulic gradients at the present tailings site and the proposed disposal site, respectively.

D.5.2.6 Background groundwater quality

Background groundwater quality in the four hydrostratigraphic units at the Green River site was determined for the following constituents listed in the proposed EPA standards (40 CFR 192): chromium; molybdenum; nitrate; selenium; radium-226 and 228; uranium; and gross alpha activity. The other constituents listed in the proposed EPA standards (see Table D.5.1) were found to have levels below detection for the first two rounds of sampling in June 1986 and September 1986; consequently, these remaining constituents were excluded from subsequent sampling rounds and are not considered to be present as contamination in groundwater at the Green River tailings site. Table D.5.14 describes all of the groundwater sampling locations and Table D.5.15 presents the results of the chemical analyses for all of the wells and well points. Figure D.5.12 is a trilinear plot of the monitor wells at the Green River site. The trilinear plot shows the general types of groundwater in the alluvium and Cedar Mountain Formation.

Top hydrostratigraphic unit

The locations of background monitor well 707 and well point 563 are shown on Figure D.5.1. These monitoring locations are upstream and upgradient of the tailings.

A background groundwater quality summary of the top unit is presented in Table D.5.16. The maximum background concentration of the range exceeds the proposed EPA MCL for all the constituents in the table except for Ra-226 and 228. Many other constituents exceed EPA secondary and state of Utah drinking water MCLs. These include (but are not limited to): chloride (>250 mg/l), sulfate (>5500 mg/l), and TDS (>9000 mg/l). (See Table D.5.15 for specific concentrations of these constituents.) The general water type for the top unit is calcium or sodium sulfate; the water is Class II based on TDS (greater than 1000 mg/l TDS but less than 10,000 mg/l), but is Class III based on the high levels of chromium, molybdenum, nitrate, selenium, and uranium that occur naturally.

Upper-middle hydrostratigraphic unit

The locations of background monitor wells 816 and 806 are shown on Figure D.5.1. Monitor well 806 is upgradient of the tailings, and monitor well 816 is upgradient and updip of the tailings.

A background groundwater quality summary of the upper-middle unit is presented in Table D.5.17. The wide range of background quality reflects the range in concentrations found at each well. High concentrations of the contaminants listed in Table D.5.17 are found at well 816, which is located south (upgradient) of the tailings at the proposed disposal site. Proposed EPA MCLs for nitrate, selenium, and gross alpha activity are exceeded in monitor well 816. The measured uranium concentration is very close to the proposed MCL and chromium has been measured at levels as high as the MCL. The nature of the contamination present in this well suggests the source may be from the surface, as well as from recharge by naturally contaminated water from underlying aquifers. The general water type in background well 806 is sodium bicarbonate. The concentrations of both sodium and sulfate are much higher in monitor well 816 than in monitor well 806, but since alkalinity was not determined for well 816 (limited sample quantity), well 816 is not plotted on the trilinear plot. The water in the upper-middle unit is Class II based on TDS, but is Class III based on the high nitrate and selenium concentrations found in monitor well 816.

Monitor well 807 is completed in the upper-middle shale unit below the lower-middle sandstone (see Figure D.5.2). The screened interval in well 807 is from 78 to 98 feet (see Table D.5.2). The water quality analysis of a sample taken from this well in July 1988 (see Table D.5.15) shows that cadmium (0.125 mg/l), chromium (0.06 mg/l), nitrate (1280 mg/l), and selenium (0.322 mg/l) concentrations exceed proposed EPA and state of Utah MCLs for these constituents. In addition, the boron concentration was measured at 0.84 mg/l, which is slightly greater than the state of Utah maximum concentration limit for boron (see Table D.5.1). Finally, total dissolved solids were measured at 11,700 mg/l, and the sulfate concentration was 6450 mg/l. Since this saturated zone within the Cedar Mountain Formation is isolated from surface contamination by strong, vertically upward hydraulic gradients, the source for the contaminants formed within this unit is from somewhere off the site, and possibly from below the elevation of the well screen. It is possible that contaminants were discharged into this zone by injection, but there is no evidence that this is the case (Day, 1988).

Lower-middle hydrostratigraphic unit

The locations of background monitor wells 562, 811, and 813 are shown on Figure D.5.1. Monitor well 811 is upgradient of the tailings, and monitor wells 562 and 813 are upgradient and updip of the tailings.

A background groundwater quality summary of the lower-middle unit is presented in Table D.5.18. The background quality range for this unit is similar to that of the upper-middle unit. Beneath the proposed disposal area, the upper- and lower-middle hydrostratigraphic units may be hydraulically connected by numerous vertical fractures. In the north, away from the disposal area and toward the present tailings pile, the vertical fractures are not as intense or abundant and the lower-middle unit is confined by the overlying shales and limestones of the upper-middle unit. Background concentrations of chromium, molybdenum, nitrate, selenium, uranium, and gross alpha activity exceed the proposed EPA MCLs south (upgradient) of the tailings at the proposed disposal site. The source of this contamination, like that found in the upper-middle unit, is probably from upgradient sources south of the disposal area. There is no evidence at the ground surface that the proposed disposal site is a source of contamination. The general water type in the lower-middle unit is sodium sulfate; the water is Class II, based on TDS, but is Class III based on high levels of chromium, molybdenum, nitrate, selenium, uranium, and gross alpha activity.

Bottom hydrostratigraphic unit

The locations of background monitor wells 586, 587, 588, 817, and 818 are shown on Figure D.5.1. These monitor wells are upgradient and updip of the tailings.

Groundwater in this unit is much better in quality than the three shallower units; TDS levels are near 2000 mg/l. The general water type is sodium sulfate and the water is at the lower end of Class II, based on TDS, but is also Class III because of high levels of chromium, molybdenum, selenium, and gross alpha activity.

For the September 1986 and March 1987 rounds of water sampling, monitor wells 586 and 587 were considered to be cement grout contaminated since the time the wells were drilled and completed. The pH of the water samples from these wells ranged from 9.92 to 11.61 standard units. For the October, 1987, sampling, the pH was measured as 8.10 in monitor well 586 and 9.35 in monitor well 587, indicating the majority of the grout was removed from the producing intervals during the purging (sampling) process. The pH values for all of the sampling dates for monitor wells 586, 587, and 818 were plotted versus molybdenum, nitrate, selenium, uranium, and sulfate concentrations on a linear-linear graph (Figure D.5.13) to show the effect of pH on the concentrations of these constituents. A linear regression was done for each constituent, the coefficient of determination (r^2) was calculated, and Student's "t" statistic (McClave and Dietrich, 1979) was calculated to test the null hypothesis that the slopes of the best-fit regression lines for each parameter are not different from zero. The calculated "t" statistics indicate that at a 99 percent level of confidence there does not appear to be any linear relationship between pH and the concentrations of the constituents tested. Based on these results, values for these constituents and all other constituents analyzed from wells 586, 587, and 818 were included in the background water quality calculations, regardless of the water pH at the time of sampling.

A background groundwater quality summary of the bottom unit is presented in Table D.5.19. Concentrations of chromium, molybdenum, selenium, and gross alpha activity in the bottom unit are slightly higher than the proposed EPA standards for these constituents. These levels probably reflect high natural levels of these constituents, and indicate that the high levels of these constituents found in the over-lying hydrostratigraphic units may also be (at least in part) from natural sources.

Summary

The range of background groundwater quality in the upper- and lower-middle (Cedar Mountain Formation) hydrostratigraphic units is wide because background monitor wells are located both east (upstream) and south (updip) of the tailings. The wells south of the tailings (at the proposed disposal site) indicate there is a source of contamination upgradient of the disposal site that is not related to the milling processes since it would be outside the boundary of the mill site. If the high nitrate levels are an indication of the source, it may be from activities associated with the White Sands Missile Range test complex (DOE, 1988a). High levels of chromium, molybdenum, and selenium in the bottom hydrostratigraphic unit indicate these constituents are from natural sources; because this unit is confined by a thick shale unit in the vicinity of the tailings site contamination from the surface is unlikely. Because the high background levels of nitrate, molybdenum, chromium, and selenium indicate contamination from natural sources, groundwater in all four hydrostratigraphic units at the Green River site may be classified as Class III, according to 40 CFR 192.21(g), which states that Class III groundwater includes water that is not a current or potential source of drinking water because widespread, ambient contamination not due to activities involving residual radioactive materials from a designated processing site exists that cannot be cleaned up by using treatment methods reasonably employed in public water-supply systems.

The town of Green River currently takes water from the Green River upstream of its confluence with Brown's Wash for domestic use and irrigation. Because an ample supply of good-quality surface water is available for domestic use, the development of groundwater in the potentially affected environment of the Green River tailings site is highly unlikely. See Section D.5.2.10 for a more complete discussion of groundwater use, value, and alternate supplies at the Green River tailings site.

D.5.2.7 Extent of existing contamination

Percolation of tailings seepage into the groundwater system beneath the tailings pile has adversely impacted the water quality in both the top and upper-middle hydrostratigraphic units. The vertical extent of contamination is confined to these two shallow units by strong, vertically upward hydraulic gradients between the upper-middle unit and the underlying units. The maximum potential depth of contamination in groundwater beneath the surface of the present tailings pile is about 65 feet.

Top hydrostratigraphic unit

Gross alpha activity, molybdenum, nitrate, selenium, and uranium concentrations exceed background levels and proposed EPA and state of Utah groundwater MCLs beneath and downgradient of the tailings. Table D.5.20 shows the maximum and minimum observed concentrations of contaminants in the top unit and the proposed EPA maximum concentration limits. The range in concentrations of contaminants varies widely from sampling to sampling, probably in response to evaporation and percolation of rainfall and snowmelt through the tailings; this type of variation is also seen in the pore water sample analyses for the same reasons (see Section D.5.3.5). Figures D.5.14 through D.5.18 show the lateral extent of contamination as gross alpha activity, molybdenum, nitrate, selenium, and uranium, respectively, in the top unit (Brown's Wash alluvium) and in the channel of Brown's Wash, based on the maximum observed concentrations.

The contamination resulting from tailings seepage travels downgradient through the alluvium toward the northwest and the channel of Brown's Wash. Once in Brown's Wash, the contaminants move west with groundwater flow in the shallow alluvium or on the surface. Surface water sample analyses from Brown's Wash (DOE, 1988a) indicate contaminated groundwater discharges to Brown's Wash; however, flow in the channel is intermittent and the concentrations of contaminants (as well as major anions and cations) are a function of the evaporation of water in the channel (i.e., evaporation causes a relative increase in concentration of the contaminants). The contaminated water travels downstream (west) in Brown's Wash and mixes with backwater from the Green River approximately 400 feet west of surface water sampling station 710 (see Figures D.5.14 through D.5.18). Water quality analyses from samples of Green River water upstream and downstream from its confluence with Brown's Wash show that the discharge of contaminated water from Brown's Wash to the Green River has no adverse affect on the water quality of the Green River (DOE, 1988a). This is because the contaminants are diluted by a factor of 10^5 to 10^6 once they mix with the Green River.

As part of the site characterization, monitor well 705 (on-site and completed in the alluvium) was sampled and analyzed for EPA priority organic pollutants in July 1986. The analyses measured 13 parts per billion (ppb) of methylene chloride, but it is noted by the analytical laboratory that the elevated value may be a result of laboratory contamination. Two other unknown, semivolatile compounds were tentatively identified by the lab to have concentrations of 100 and 40 ppb. In July 1988, monitor well 705 together with monitor wells 561, 562, 583, 806, 807, and 816, and lysimeter 714 (see Figure D.5.1 for locations) were sampled for volatile and semi-volatile organic compounds. The analyses showed that the only compound detected in confirmable concentrations was methylene chloride; methylene chloride was also detected in the trip blank for this batch of samples. Based on these results, methylene chloride is suspected of being present as a result of contamination by the analytical laboratory. These analytical results are on file at the UMTRA Project Office in Albuquerque, New Mexico.

Contamination as ammonium was also identified in the top unit. Figure D.5.19 shows the extent of ammonium contamination in Brown's Wash alluvium and the channel of Brown's Wash. Ammonium was used in the milling process (see Section D.5.2.8) and may be present in groundwater beneath the tailings by the reduction of nitrate (NO_3^-) within the tailings to ammonium (NH_4^+). The chemical characteristics of the tailings pore fluid are discussed in detail in Section D.5.2.8; geochemical conditions present in the Green River site area are discussed in Section D.5.2.9.

Upper-middle hydrostratigraphic unit

Gross alpha activity, molybdenum, nitrate, selenium, and uranium exceed background levels and proposed EPA and state of Utah groundwater standards beneath and downgradient of the tailings. Table D.5.21 shows the maximum observed concentrations of contaminants in the upper-middle unit and the proposed EPA MCLs. Figures D.5.20 through D.5.24 show the lateral extent of contamination as gross alpha activity, molybdenum, nitrate, selenium, and uranium, respectively, in the upper-middle hydrostratigraphic unit, based on the maximum observed concentrations.

Contamination from tailings seepage in the upper-middle unit extends northwest from the tailings pile (from monitor well 701, on the site), roughly following the "trough" shown by the potentiometric contours (see Figures D.5.20 through D.5.24). This trough probably is a result of higher secondary permeability in the shale caused by joints, fractures, or minor faulting that is oriented the same direction as the trough. Groundwater flow in the upper-middle unit is discussed in more detail in Section D.5.2.4.

Contamination is also present in monitor well 583 west of the tailings and Brown's Wash (see Figures D.5.20 through D.5.24). This contamination is probably a result of seepage of contaminated water in Brown's Wash down into the bedrock channel bottom. As discussed previously, the contaminated water in Brown's Wash is a result of the discharge of contaminated alluvial groundwater into the channel adjacent to and downgradient of the tailings.

Contamination as ammonium was identified in monitor well 701 on the site; however, the ammonium appears to be limited to the area directly beneath the tailings because elevated levels of ammonium are not found in any of the off-site monitor wells. The maximum observed concentration of ammonium observed in monitor well 701 was 47 mg/l.

D.5.2.8 Tailings and milling process characterization

Tailings

The tailings pile at the Green River site is eight acres in area. The tailings are not presently saturated and there is no evidence of a groundwater mound beneath the tailings. The depth to groundwater beneath the base of the tailings ranges from four to ten feet, using the available monitor well and water level information.

The tailings are a fairly well-sorted, white to pink sand with some silt. Based on laboratory test data (Table D.5.22), the average saturated hydraulic conductivity of compacted tailings is 1.5 x 10^{-4} cm/s. This value is probably representative of the tailings since there are no slimes within the pile and the tailings are uniform in texture. Under natural, uncompacted conditions, the vertical hydraulic conductivity is probably greater than 10^{-4} cm/s. The horizontal hydraulic conductivity of the underlying Brown's Wash alluvium (top hydrostratigraphic unit) is near 1×10^{-2} cm/s, based on average hydraulic conductivities at monitor wells 702, 704, 705, and 708 (see Table D.5.7). Considering that the alluvium is anisotropic (Bouwer, 1978), the vertical hydraulic conductivity is probably in the range of 5×10^{-3} to 1×10^{-3} cm/s.

In an attempt to calculate the current percolation rate through the present tailings pile, the following mixing relationship was used:

$$C_b(Q_r - Q_t) + C_tQ_t = C_rQ_r$$

where

C_b = concentration of water quality constituent upgradient (background) of the tailings (mg/l).

Q_r = volume flux rate of alluvial groundwater beneath the tailings (resultant volume flux rate from mixing the background groundwater with the fluid percolating through the tailings) (gpm).

Q_t = volume flux rate (percolation) through the tailings (gpm).

C_t = concentration of water quality constituent in tailings pore fluid (lysimeter sample) (mg/l).

C_r = concentration of water quality constituent in the alluvium beneath the tailings (resultant concentration from mixing background alluvial water with tailings pore water) (mg/l).

Using Q_r = 9.9 gpm (see Table D.5.8), average pore water concentrations from lysimeter GRN01-714 (Table D.5.23), average background groundwater concentrations from alluvial monitor wells 563 and 707, and resultant groundwater concentrations from alluvial on-site wells 702, 704, and 705, Q_t was calculated to be 0.010 gpm using both uranium and manganese concentrations. Other constituents were considered but were not useful either because their background concentrations were higher than resultant concentrations or pore water analyses were not available.

Based on the calculated Q_t, the continuous infiltration rate over the eight-acre area of the tailings is 6.4×10^{-11} feet per second (ft/s) (2.0×10^{-9} cm/s); the average annual rate is equal to 0.024 inches per year (in/yr) (0.06 cm/yr), or 0.4 percent of the average annual precipitation. While this method of calculating Q_t has inherent uncertainties (e.g., averages are used and geochemical attenuation is not considered), it indicates that the percolation of water through the tailings is very little, and is probably within the range estimated by Rush et al. (1982). Detailed mixing calculations to estimate Q_t are on file in the UMTRA Project Office, Albuquerque, New Mexico.

Tailings pore water samples were collected and analyzed from lysimeter 714 located at the east end of the pile (see Figure D.5.1) in September 1986 and March 1987 (Table D.5.23). Less than 500 milliliters could be obtained from the lysimeter each time, so only a select number of parameters could be analyzed. No pore water at all could be collected during October 1987 and January 1988 samplings. Since radionuclide analyses require one liter of water or more, radionuclide concentrations in the pore water could not be determined. In addition, since only a select number of constituents were analyzed, a cation/anion balance could not be accurately performed and the reliability of the results are uncertain. Finally, the pore water samples are highly sensitive to fluctuations in soil moisture content (responses to rainfall and evaporation); this seems to be reflected by the high variance in pore water parameters like chloride, potassium, nitrate, sulfate, TDS, and uranium.

Uranium mill tailings, buffer material, and contaminated windblown soils samples were collected from representative stockpiles at the Green River site in March 1989. The stockpiles for tailings, buffer material, and windblown soils are located near test pit 544, between monitor wells 588 and 561, and near test pit 577, respectively (see Figure D.5.1). The samples were used to determine the mobility of contaminants in the materials to be placed in the disposal cell. Batch leach and column extraction tests were conducted on the samples, and the batch solutions and column feed solutions were analyzed for all of the hazardous constiutents identified at the site (see Table D.5.27). Radionuclides were not analyzed because of the limited quantity of solution from the batch leach and column extraction tests.

Results show that, for all of the hazardous constiutents identified at the Green River site, except for uranium and vanadium, the extract concentrations from batch experiments using windblown soils are below the interim concentration limits proposed by NRC (see Table E.1.1). Concentrations of vanadium slightly exceed the NRC-proposed interim concentration of 0.09 mg/l, but are well below the observed range of maximum values from background groundwater samples beneath the disposal site (0.38 mg/l maximum). Uranium concentrations from the windblown extract are above both the interim concentration limit of 0.044 mg/l (which is EPA's established MCL) and the maximum observed value in groundwater of 0.146 mg/l. However, the column feed experiments show that uranium is attenuated by the buffer material to a concentration greater than one order of magnitude less than the feed concentration (from tailings solution). Based on the batch and column experiments, it can be assumed that the windblown soils are "clean" and are "buffer" material in addition to the clean select-fill buffer material placed in the bottom of the cell. With this assumption, travel of contaminants can be assumed to be from the base of the tailings (top of the windblown soils) through the base of the buffer materials.

Milling process

The Green River processing plant was operated from March 1958 to January 1961 (FBDU, 1981). Ore from uranium mines at Temple Mountain, Utah, was upgraded, and the ore concentrate was shipped by railroad to Rifle, Colorado, for further processing.

The uranium ore was sandstone loosely cemented with clay and asphaltic material, with part of the uranium intimately associated with carbonaceous minerals. After crushing and grinding, the ore was screened, with minus-35 mesh material going to flotation and the plus-35 mesh material joining the flotation concentration to form a carbonaceous concentrate. The flotation tailings were separated into sand and slime fractions. The sands were leached with acid, the leached slurry washed, and the spent sands discarded to the tailings area. The recovered slimes and pregnant solution were then joined with a portion of the initial slime fraction. Any excess acid was neutralized with ammonia. This mixed product plus the remainder of the primary slimes were then dewatered and dried for shipment to the Rifle, Colorado, processing plant.

D.5.2.9 Geochemical conditions

The presence of pyrite and organic matter in the Cedar Mountain Formation aquifer of the Green River site indicates that groundwater at the site is relatively reducing (DOE, 1988b). The Cedar Mountain Formation contains mudstones with occasional thin and discontinuous calcareous beds. Groundwater flow is controlled by fractures, joints, and faults, which are continuous through the upper middle portion of the stratum. Fracture surfaces in the unsaturated zone contain significant quantities of ferric oxyhydroxide, calcite, gypsum, and oxidized pyrite. The presence and movement of groundwater beneath the tailings impoundment is controlled by connected fractures. Strong, upward, vertical hydraulic gradients are prevalent through the entire saturated hydrostratigraphic sections.

Results of selected water-quality analyses of the Cedar Mountain Formation aquifer are provided in Table D.5.24. The monitor wells were sampled in May 1988 and the water-quality data collected during this period are representative of the aquifer. This groundwater generally is a sodium sulfate type and the TDS content is higher than 4500 mg/l. Monitor wells 562 and 813 are upgradient of the tailings impoundment; however, groundwater samples from these monitor wells have high concentrations of nitrate, sulfate, and TDS. Monitor well 701 is completed beneath the tailings impoundment and groundwater samples from this well are contaminated from tailings leachate. Concentrations of nitrate, ammonium, selenium, and macro-solutes are elevated above background. The groundwater remains buffered by limestone lenses within the aquifer.

Monitor wells 581 and 584 are downgradient from the tailings impoundment, and groundwater samples from these wells contain relatively low concentrations of nitrate and most other macro-solutes. Dissolved hydrogen sulfide occurs in monitor well 581, where field Eh measurements indicate relatively reducing conditions. Field alkalinity values recorded at monitor well 581 are relatively high, which may be the result of the oxidation of solid organic matter in the presence of hydrogen sulfide. Sulfate reduction is a bacterial reaction in which bacteria use the oxygen in $SO_4{}^{2-}$ to oxidize organic matter to CO_2, which contributes to alkalinity, producing sulfide species. Sulfate reduction is represented by the following equation with pH values above 7:

$$SO_4{}^{2-} + 2C_{organic} + 2H_2O = HS^- + H^+ + 2HCO_3{}^- \qquad (1)$$

Petrographic analyses of core material taken near monitor well 581 show unoxidized, euhedral pyrite crystals in a matrix of solid organic matter, calcite, and quartz. Groundwater chemistry and mineralogy indicate that the Cedar Mountain Formation is relatively reducing downgradient of the tailings impoundment.

Uranium concentrations within the Cedar Mountain Formation decrease by several orders of magnitude within 600 feet downgradient of the tailings pile. For example, the concentration of uranium in groundwater samples from monitor well 701, completed beneath the tailings pile, is 2.69 mg/l, whereas the concentrations of uranium in groundwater samples from monitor wells 581 and 584 are below 0.001 mg/l. Figure D.5.24 shows the distribution of uranium in the upper-middle hydrostratigraphic unit at the Green River site.

The Cedar Mountain Formation consists of a Cretaceous marine limestone with lenses of sandstone and siltstone (see

Section D.5.2.3). Many secondary minerals are found on the fracture surfaces in the foundation bedrock beneath the disposal site. These include, but are not limited to, calcite, gypsum, and iron and magnesium oxides; pyrite is abundant on the fracture surfaces in the lower-middle sandstone unit.

Core samples collected above the water table contain fracture coatings consisting of calcite, gypsum, and iron and manganese oxides. The fractures have a higher permeability than the matrix permeability.

In general, the core samples collected below the water table indicate a considerable amount of carbonate is present, primarily as cement and vein filling, in the siltstones and sandstones. The sulfide (pyrite) content of the core samples ranged from 0.1 percent to 1.0 percent; in some cases oxidation to iron oxides affects the outer surfaces of individual grains.

The porosity appears to be low in the siltstones and moderate to low in the sandstones, and increases with increasing grain size. Fracture permeability probably has a significant role in fluid migration through these rocks. The fractures observed in the core samples are generally cemented with carbonate, and contain coatings of iron oxides. Fracture porosity is variable, but in general the existing fractures have moderate to low porosity.

Geochemical modeling using PHREEQE (Parkhurst et al., 1980) was performed to mix the tailings leachate with the ambient groundwater. Results of the modeling show that most heavy metals and trace elements have the potential to adsorb or precipitate from solution as a result of contact with the calcite and iron oxides in the aquifer. Where reducing conditions exist in the saturated zone and pyrite is present, the groundwater is predicted to be oversaturated with uraninite and amorphous UO_2, and precipitation of uranium would occur.

The solubility of uranium within the Cedar Mountain Formation aquifer may be controlled by precipitation of tetravalent uranium minerals such as uraninite and coffinite, by adsorption of uranium onto ferric oxyhydroxides and clay minerals, or by a combination of precipitation and adsorption processes. Cedar Mountain Formation groundwater is sufficiently reducing downgradient of the tailings pile to account for uraninite precipitation. Table D.5.25 shows the measured field Eh and the theoretical Eh required for Cedar Mountain Formation groundwater to be in equilibrium with uraninite. The measured field Eh value for monitor well 581 is more reducing than the theoretical Eh value calculated by the computer code PHREEQE. For monitor well 584, the measured Eh is approximately 0.02 volts more oxidizing than the theoretical Eh value required for uraninite equilibrium. The discrepancy between the field Eh and theoretical Eh values may be insignificant with respect to uraninite precipitation. Uranium concentrations, however, in groundwater samples from monitor wells 581 and 584 are in the low microgram/liter range.

Reduction of the uranyl ion (UO_2^{2+}) by aqueous sulfide forming poorly crystalline uraninite has been investigated by Mohogheghi and Goldhaber (1982). Their investigation shows that uranium concentrations greater than 2.75 ppm results in the precipitation of uraninite within 24 hours. Adsorption of hexavalent uranium may be necessary prior to chemical reduction. The partial pressures of hydrogen sulfide and carbon dioxide during their experiments were 4.3×10^{-2} atmospheres. Based on their experiments, concentrations of hydrogen sulfide within the Cedar Mountain Formation should provide conditions favorable for uraninite precipitation.

Speciation and saturation index calculations by PHREEQE can be made using either field Eh or calculated Eh values. Determining the most appropriate redox couple to use for model simulations is very difficult because internal disequilibrium exists between the redox couples (Lindberg and Runnells, 1984). Field Eh values were used as input for the PHREEQE simulations because they are intermediate to the calculated redox couples. It must be shown, however, that electron-transfer reactions taking place between the aqueous species of interest and the electrode surface are similar to reactions taking place between the aqueous species and the electron donor/acceptor present in the Cedar Mountain Formation aquifer. Small uncertainties in the measured electrode potentials and in the calculated Eh values from the redox couples may be important for simulating whether solubility control or adsorption is the major attenuation mechanism for uranium in the Cedar Mountain Formation aquifer. The Fe^{3+}/Fe^{2+} and Sato dissolved oxygen redox couples appear to be in close agreement with the measured Eh values for monitor wells 562, 701, and 813 upgradient from the tailings impoundment, whereas the HS^-/Rhombic S redox couple approximates measured Eh values for monitor wells 581 and 584 downgradient from the tailings impoundment. Berner (1963) has shown that the HS^-/Rhombic S couple is reversible for marine sediments and this redox couple is useful for approximating redox conditions in certain portions of the Cedar Mountain Formation aquifer where detectable concentrations of aqueous hydrogen sulfide are present.

The saturation indices for uraninite, coffinite, calcite, gypsum, pyrite, and amorphous $Fe(OH)_3$ with $PCO_2 = 10^{-2}$ atmospheres were computed by PHREEQE from analytical results (Tables D.5.23 and D.5.24) obtained from the groundwater analyses from monitor wells 562, 581, 584, 701, and 813. These modeling results are shown in Table D.5.26. Groundwater samples from monitor wells 562, 701, and 813 are undersaturated with respect to uraninite, coffinite, and pyrite and are oversaturated with respect to gypsum and amorphous $Fe(OH)_3$.

Cedar Mountain Formation groundwater is in equilibrium with calcite. Therefore, uranium is likely to be mobile in the Cedar Mountain Formation aquifer at the proposed disposal site and downgradient towards the existing tailings pile.

Petrographic analysis has shown the ubiquitous occurrence of calcite, gypsum, and ferric oxyhydroxide within the fractures. Uranium, stable as $UO_2(CO_3)_2^{2-}$ and $UO_2(CO_3)_3^{4-}$ complexes, is likely to be mobile in this portion of the aquifer. Conversely, groundwater is predicted to be oversaturated with respect to uraninite and pyrite downgradient of the tailings impoundment where uranium concentrations are below 0.001 mg/l. Pyrite occurs as euhedral crystals with no detectable oxidation coatings, indicating that oxidizing solutions are not presently in contact with the sediments. The analytical detection limit for total uranium is <0.001 mg/l and the saturation index values for uraninite and coffinite are maximum values. If the actual concentrations are less than 0.001 mg/l, then groundwater samples from monitor wells 581 and 584 could be undersaturated with respect to uraninite and coffinite. The occurrence of uraninite and coffinite in this portion of the Cedar Mountain Formation has not been established by petrographic techniques.

Solubility experiments conducted by Ryan and Rai (1983), however, show that $U(OH)_5^-$ may not be as strong a complex of U(IV) because no evidence for the predominance of $U(OH)_5^-$ was observed under alkaline pH conditions. In addition, thermochemical data (hydrolysis constant) for $U(OH)_5^-$ may be suspect (Bruno et al., 1987) and the stability fields for dissolved U(IV) species can be much larger than what are reported in the literature. This implies that the stability fields for U(IV) species may be much more restricted in nature.

In light of these concerns, additional speciation calculations which did not include $U(OH)_5^-$ in the database still show that Cedar Mountain Formation groundwater remains oversaturated with uraninite using analytical data from monitor well 581. Uranyl tricarbonate becomes the dominant solution species of uranium in the absence of $U(OH)_5^-$. Input Eh value is the dominant control, in addition to uranium concentrations, for calculating the saturation index of uraninite.

Adsorption of uranium onto ferric oxyhydroxides, clay minerals, and other adsorbents present in the Cedar Mountain Formation (DOE, 1988b) may partially account for the observed concentration decrease of uranium. Complete adsorption of uranium onto ferric oxyhydroxide under relatively oxidizing conditions, however, is inhibited by the formation of $UO_2CO_3^0$, $UO_2(CO_3)_2^{2-}$, and $UO_5(CO_3)_3^{4-}$ complexes (Hsi and Langmuir, 1985; Tripathy, 1984). Speciation calculations for uranium show that the hydrolysis species $U(OH)_5^-$ is the dominant uranium species predicted for groundwater samples from monitor well 581, whereas $UO_2(CO_3)_3^{4-}$ is the dominant species in groundwater samples for monitor well 584. Adsorption of uranium onto minerals such as goethite, amorphous $Fe(OH)_3$, and hematite may occur to a greater extent where uranium hydroxo complexes are more abundant than uranyl carbonato complexes (Hsi and Langmuir, 1985; Tripathy, 1984).

In nature, uranium can become chemically reduced and concentrated to form an ore deposit. Uranium roll-front deposits consist of naturally occurring ore-grade uranium and the geochemical environment of these deposits may be similar to that of the Cedar Mountain Formation. The ore deposits are formed by several geochemical processes including dissolution, chemical reduction, complexation, sorption, and precipitation. The Eh of groundwater in contact with the ore deposit is relatively reducing (Eh $\leq$-0.100 V) and dissolved uranium concentrations can vary from 0.001 to 2000 mg/l (Deutsch and Serne, 1984; Runnells and Lindberg, 1984; Chathan et al., 1981; Cowart and Osmond, 1980). Downgradient from the ore deposit, uranium concentrations are in the low mcg/l range under chemically reducing conditions. Uranium rollfront and tabular deposits are found throughout the world in different geologic strata. The Cedar Mountain Formation is chemically reducing and uranium is being attenuated downgradient from the tailings pile through geochemical processes. Hydrogen sulfide, pyrite, and solid organic matter occur in the Cedar Mountain Formation and these materials are chemical reducing agents for uranium and other metals. Generation of hydrogen sulfide within the Cedar Mountain Formation has been occurring for millions of years. Subsequently, long-term reducing conditions are established for this formation.

D.5.2.10 Groundwater use, value, and alternative supplies

Existing use and value

There are 15 registered wells in Township 21 South, Range 16 East (State of Utah, 1985). Thirteen of these wells are on the west side of the Green River; one well is on the east side of the river one mile northeast of the tailings site (Figure D.5.25). The final well, the Crystal Geyser well, is in the southeastern corner of Section 34, Township 21 South, Range 16 East on the east bank of the Green River. Most or all of these wells, except for Crystal Geyser, are shallow (less than 20 feet deep) and are completed in the Green River alluvium. Information was obtained regarding 10 of the 15 wells. The majority of the wells are not being used because of the poor quality of the water, disrepair of the wells, and the availability of better-quality water from the city of Green River. This is consistent with Rush et al. (1982) on groundwater use on a regional basis.

The reported past use of water from these wells was for watering gardens or livestock. Groundwater in the Green River area is not considered potable (Rush et al., 1982). The city of Green River provides water to residents on the eastern side of the Green River. The nearest resident to the tailings site hauls potable water from a coin-operated outlet in the city of Green River (Casper, 1985). In summary, there are no known uses of groundwater within the potentially affected hydrogeologic setting of the tailings site.

It is difficult to assign an absolute value to water resources, especially those of lesser quality. Qualitatively, it can be stated that the shallow groundwater affected by the Green River mill tailings has a very low value due to its origin in an area affected by the Mancos Shale and other shale and limestone deposits of the Cedar Mountain Formation. The Utah Division of Water Resources (DWR, 1975) states, "Water originating from this [Mancos Shale] formation has little value . . . ."

Future use and value

Future use of shallow groundwater for domestic consumption in the site area is not expected due to the poor natural quality and low yield of aquifers in the area. Groundwater in the area of Green River is not considered to be potable (Rush et al., 1982).

Drill stem tests have indicated that the relative ability of the shallow groundwater system to yield fluid during testing is small and permeability values are low (Rush et al., 1982). Other studies in the region also report a lack of groundwater resources. The water found during oil and gas drilling corroborates these reports (DWR, 1975):

> "Most all wells that were drilled contacted water, but the quality of this water has been such that it was not fit to drink."

The detrimental effects of the Mancos Shale on the availability of good-quality groundwater is one of the main factors limiting future development of groundwater in the area (DWR, 1976):

> "Groundwater development of fissured or fractured areas of the Mancos Formation has not been successful because most water located in fissures or by complete penetration into other strata has been of poor quality . . . ."

Present development of alluvial groundwater is limited because of natural and man-made degradation of the water, and these conditions will persist. The availability of better-quality water from the municipal supply has caused a decline in the use of alluvial groundwater. In spite of the poor water quality in the Brown's Wash alluvium and in the underlying shales and limestones of the Cedar Mountain Formation, water suitable for crop irrigation and livestock watering was located in a sandstone unit of the lower Cedar Mountain Formation beneath the tailings site (bottom hydrostratigraphic unit). The value of this potentially usable source of groundwater is very difficult to determine; however, an estimate of the value can be made by comparing the value of alternate sources of water for irrigation and stock watering. The city of Green River charges water users outside the city limits $23 for the first 6000 gallons per month, and $2 for each additional 1000 gallons per month (City of Green River, 1984).

The cost of municipally supplied water for users outside the city's limits is twice that for users within the city's limits. While groundwater obtained from the Buckhorn Conglomerate member of the Cedar Mountain Formation cannot replace current domestic supplies unless better-quality water can be found in this unit elsewhere, the value of municipally supplied water provides an upper limit for the value of the water available in these units. The ultimate value of the water in the Buckhorn Conglomerate will also be dependent upon the lateral extent of this unit, its recharge capacity, and the long-term availability of water from this unit.

In summary, the future usage of groundwater will be limited by the generally small supply and relatively poor quality of groundwater in the area, and the availability of a good quality municipal water supply.

Alternative supplies

The tailings have not affected any groundwater currently being used. Alternate water supplies include Green River water as currently supplied by the city of Green River, and commercial water supply (e.g., delivery by tanker).

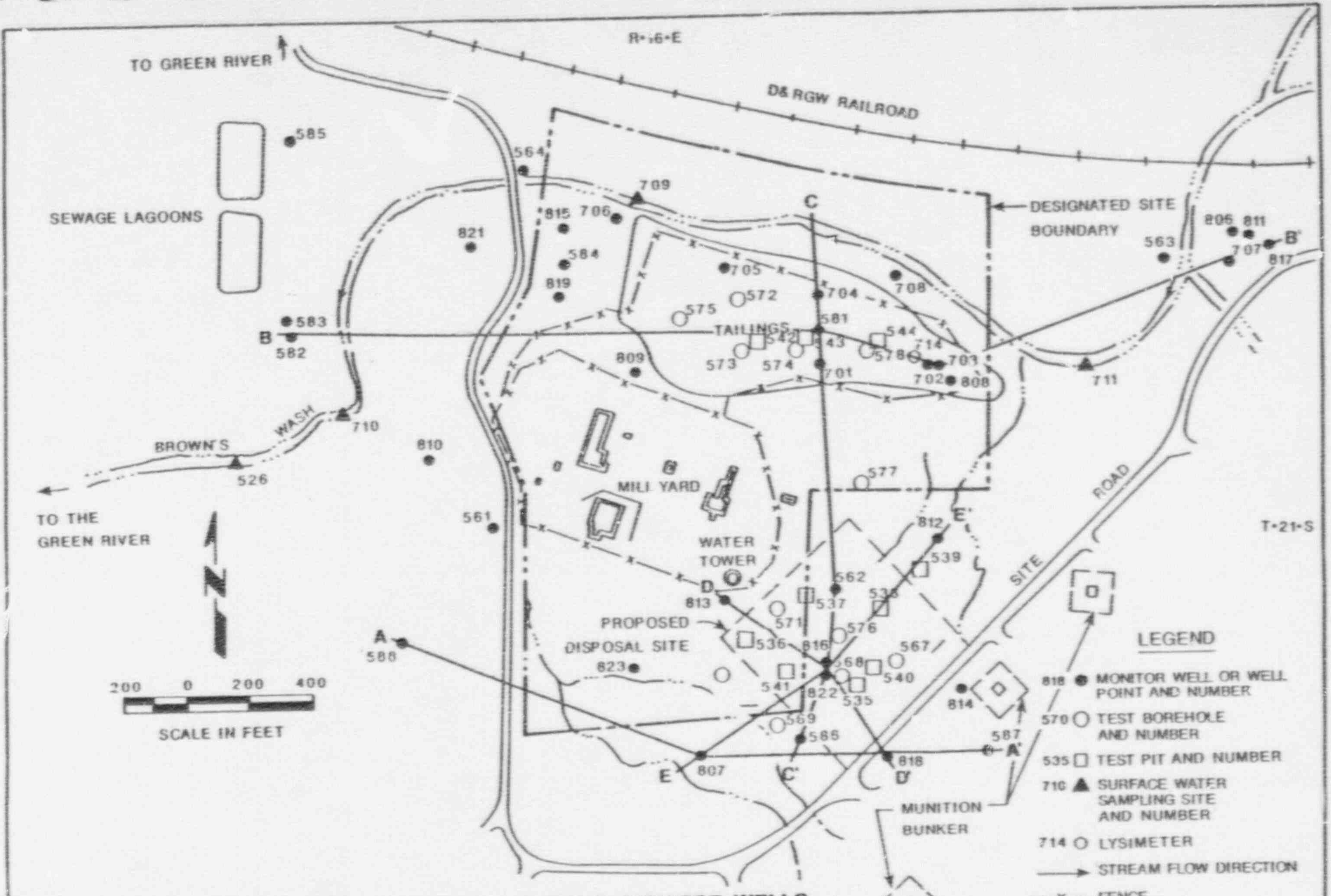


FIGURE D.5.1 LOCATIONS OF CROSS SECTIONS, MONITOR WELLS, LYSIMETER, ABANDONED BOREHOLES, TEST PITS, AND SURFACE WATER SAMPLING SITES, GREEN RIVER, UTAH, TAILINGS SITE

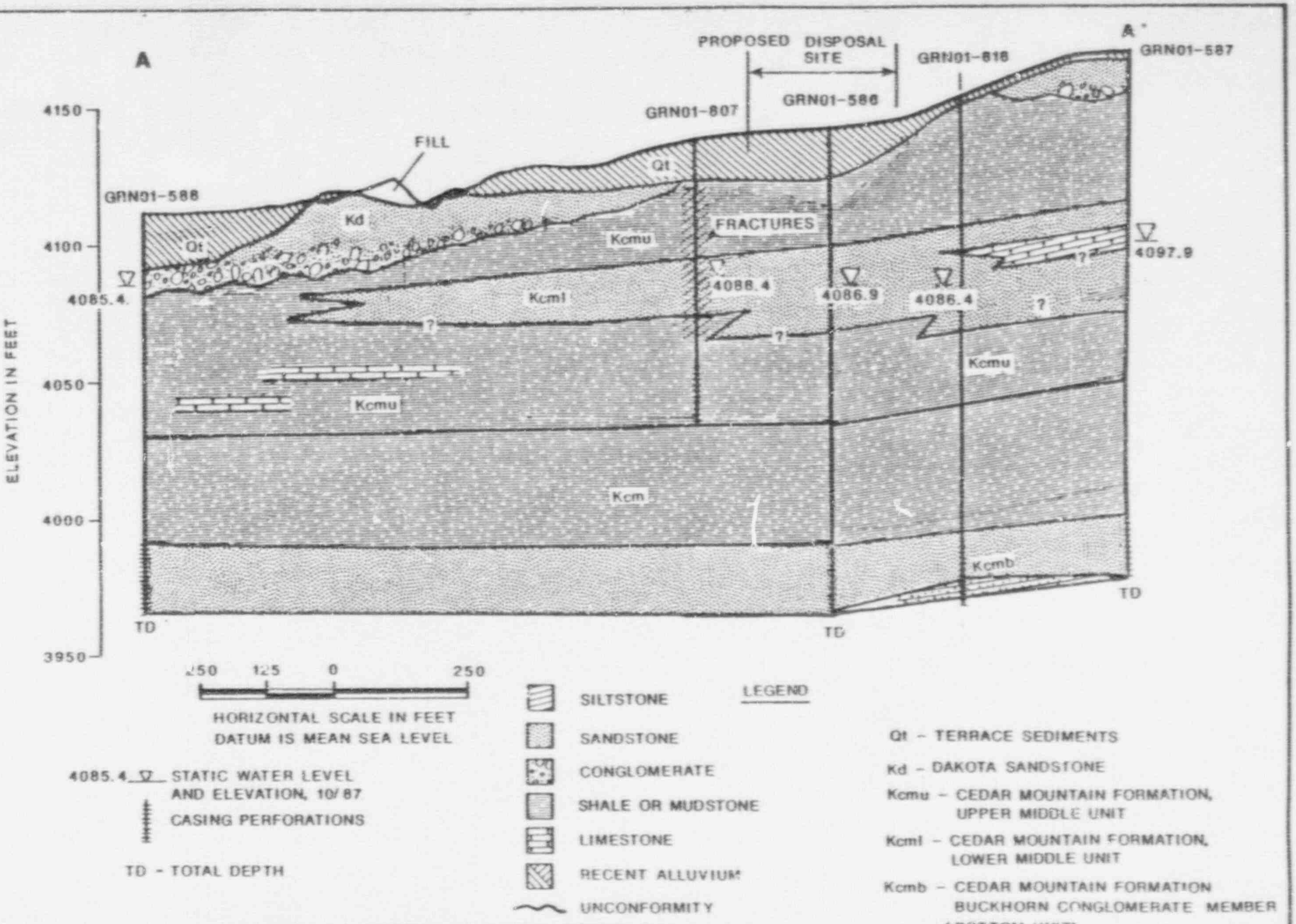


FIGURE D.5.2 HYDROGEOLOGICAL CROSS SECTION A-A', GREEN RIVER, UTAH, TAILINGS SITE

NOTE: VERTICAL EXAGGERATION X 5

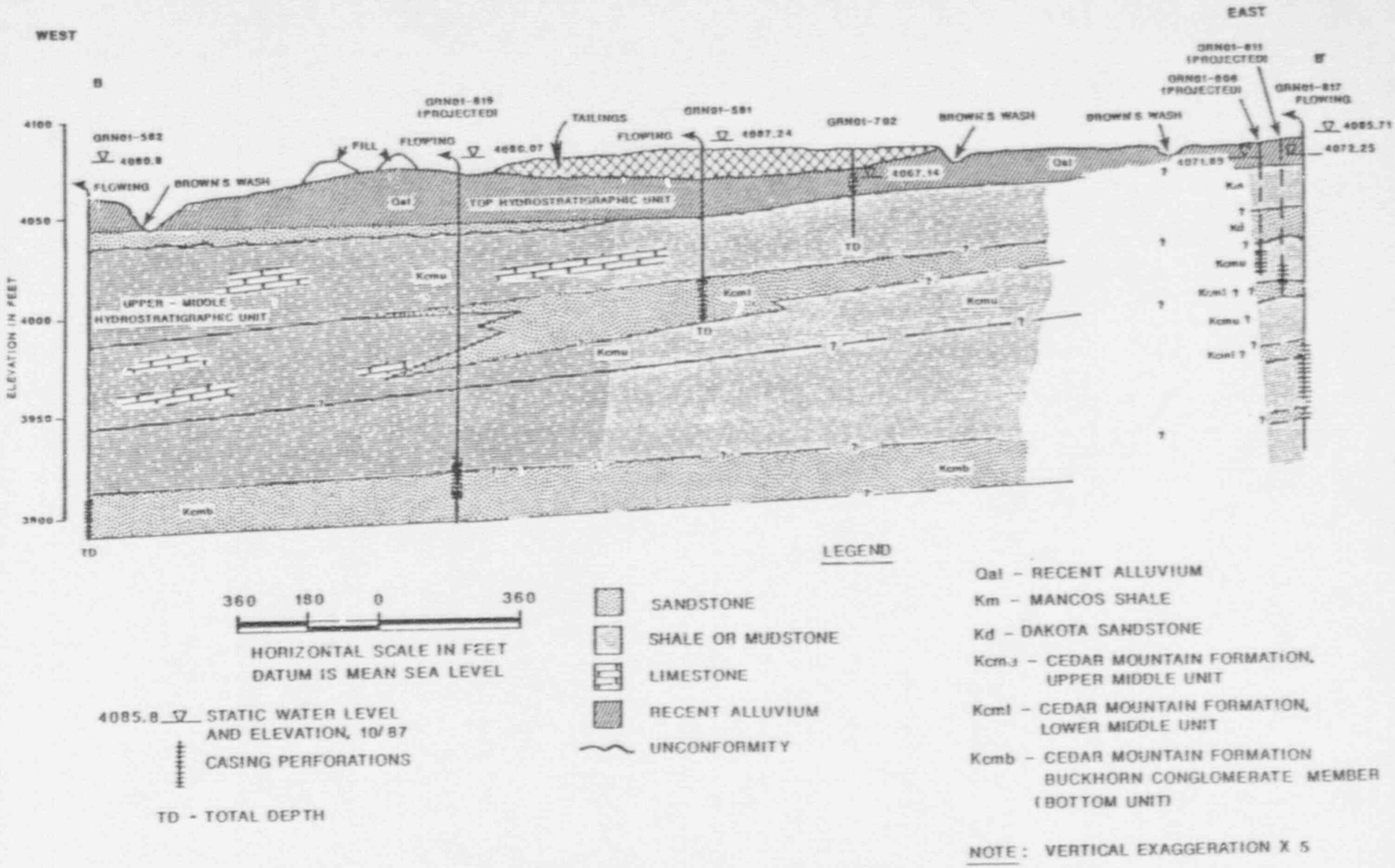


FIGURE D.5.3
HYDROGEOLOGICAL CROSS SECTION B-B'
GREEN RIVER, UTAH, TAILINGS SITE

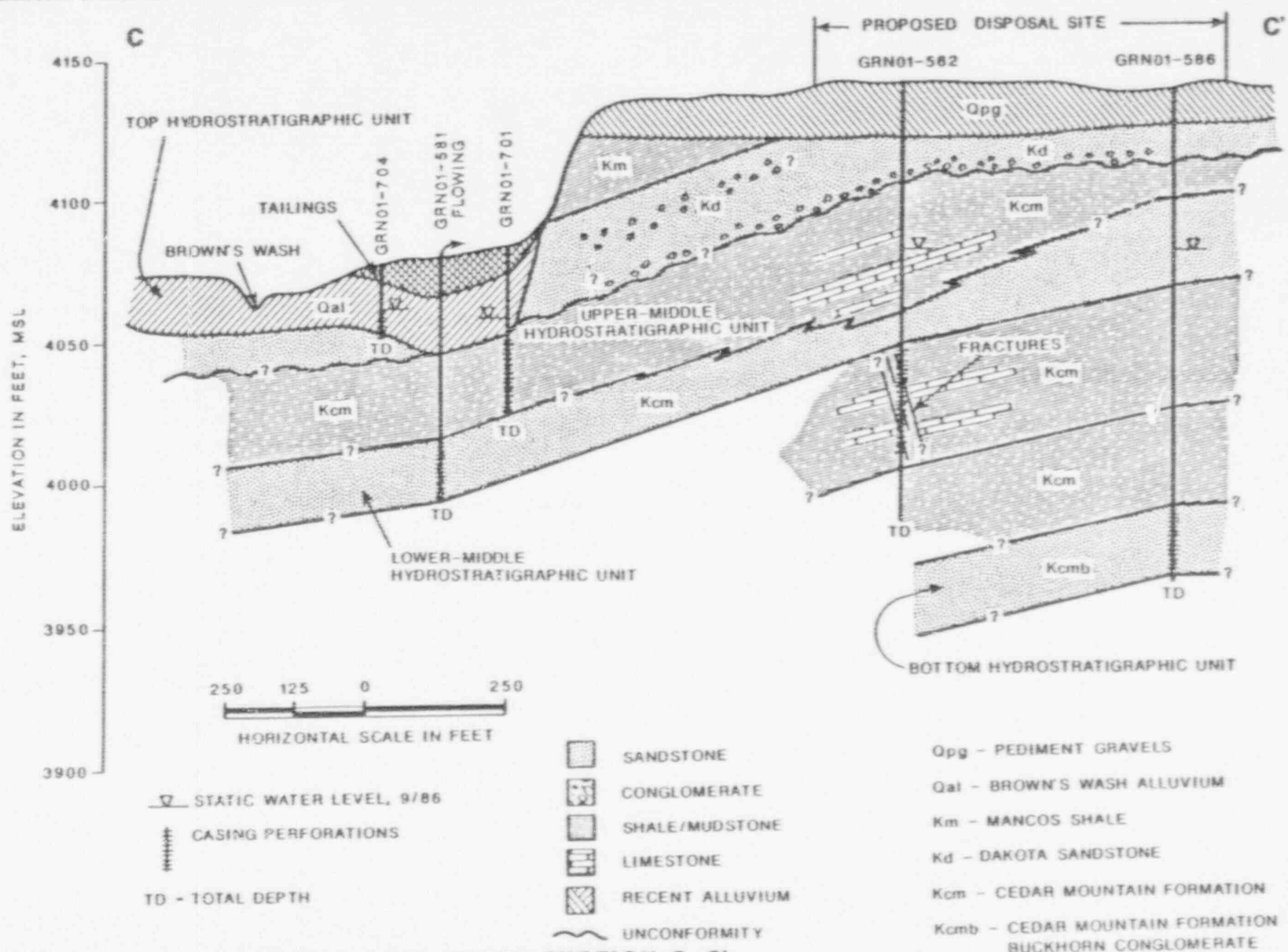


FIGURE D.5.4 HYDROGEOLOGIC CROSS SECTION C-C', GREEN RIVER TAILINGS SITE

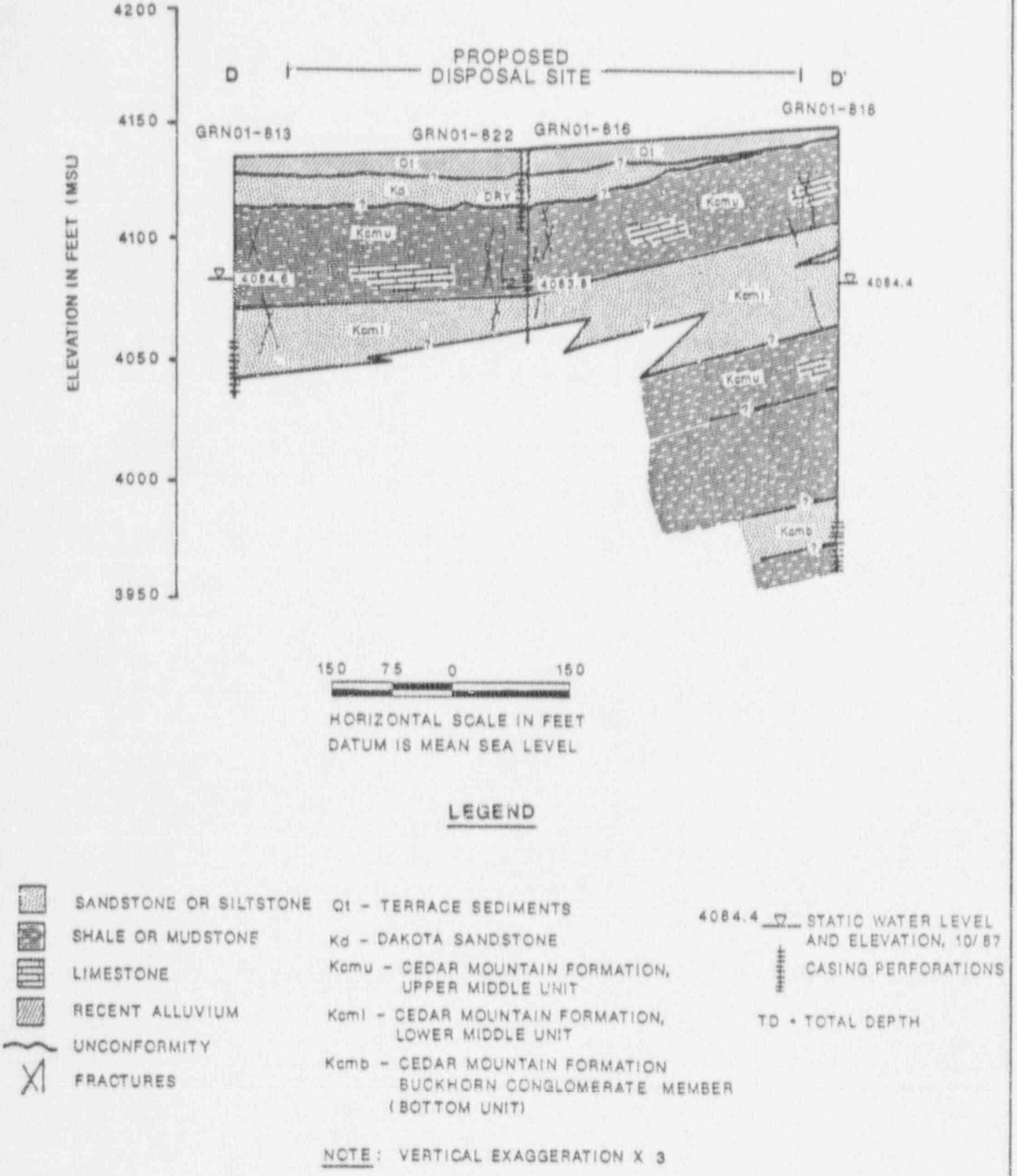


FIGURE D.5.5
HYDROGEOLOGICAL CROSS SECTION D-D'
GREEN RIVER, UTAH, TAILINGS SITE

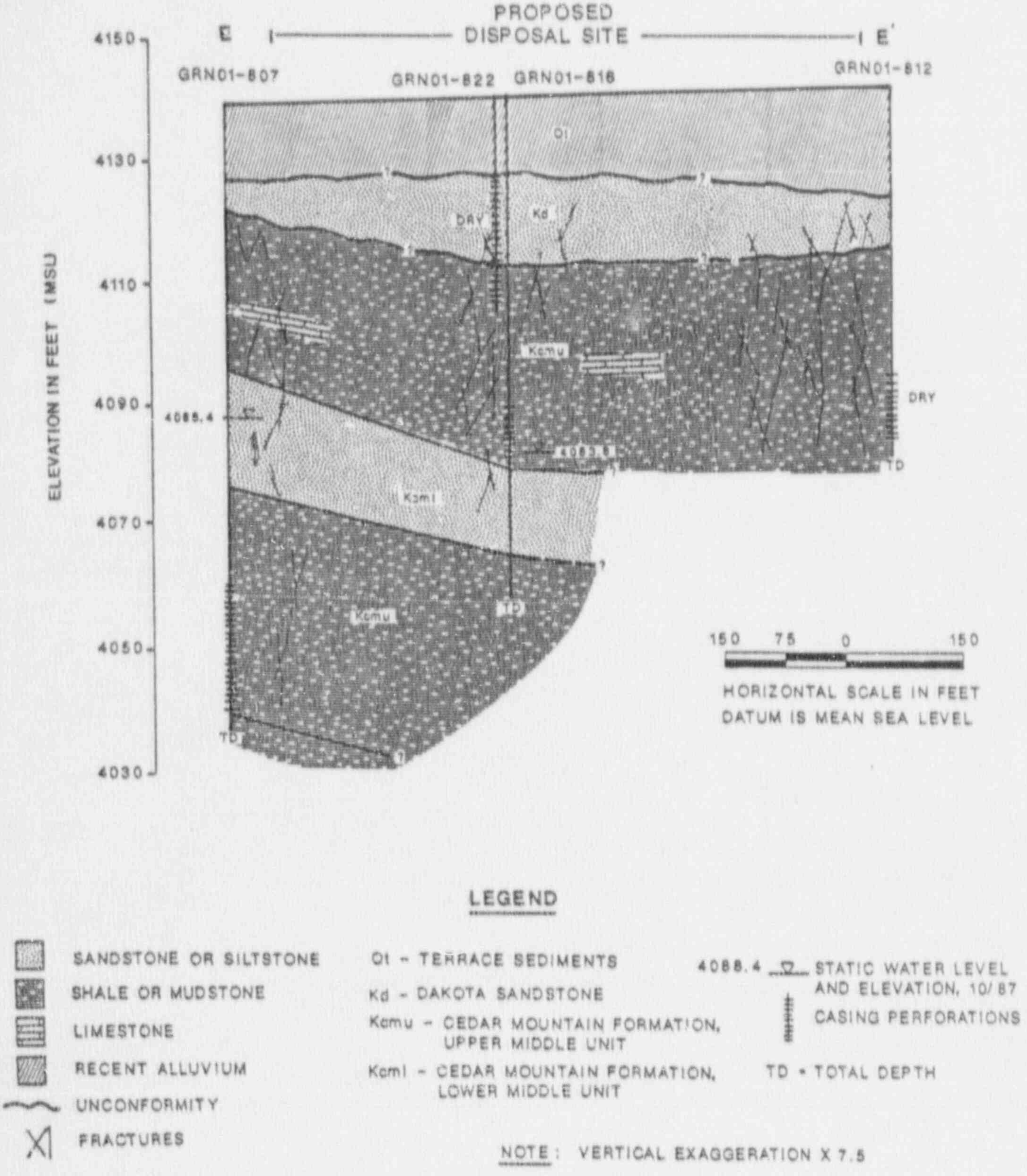


FIGURE D.5.6
HYDROGEOLOGICAL CROSS SECTION E-E'
GREEN RIVER, UTAH, TAILINGS SITE

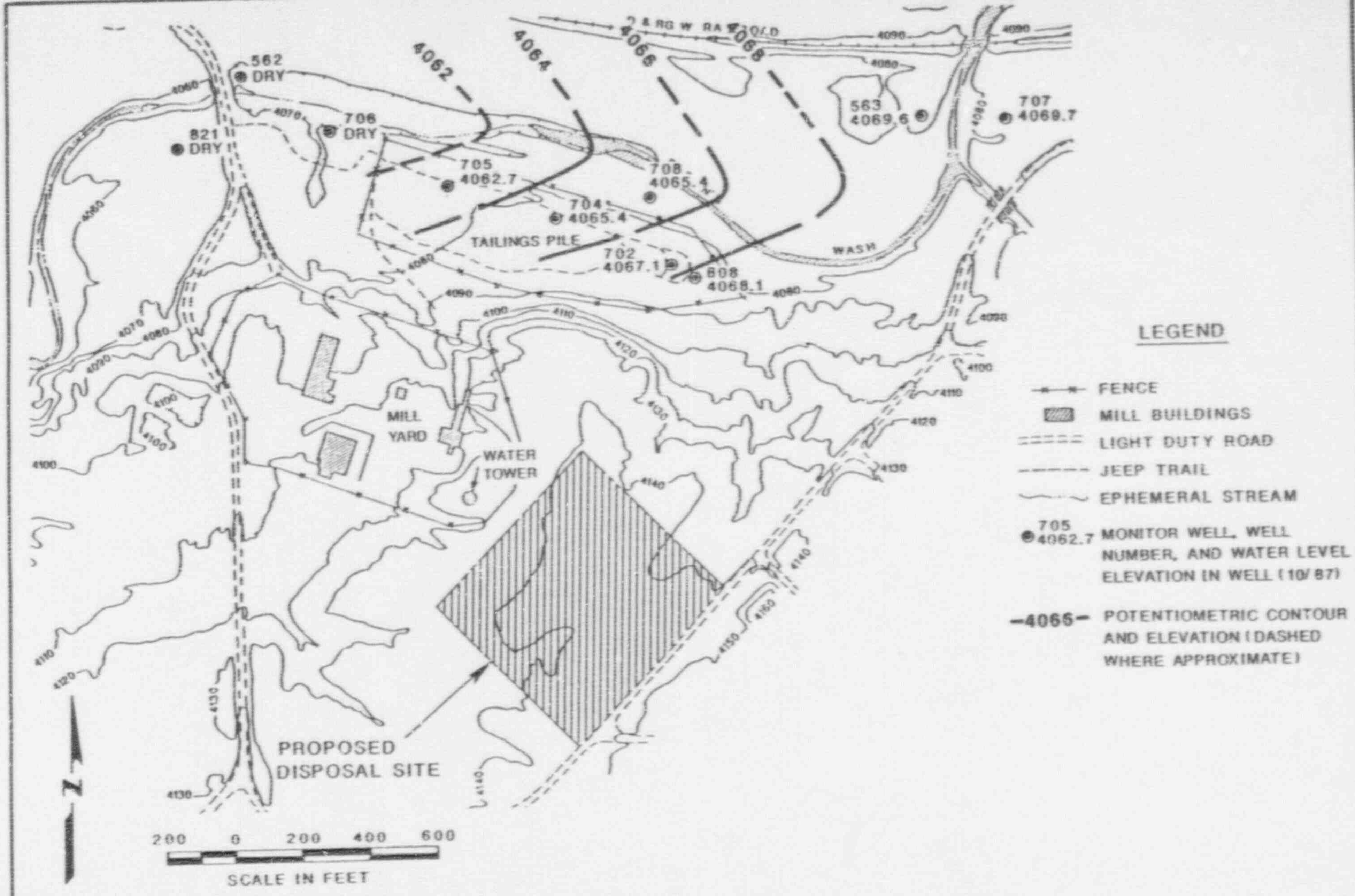


FIGURE D.5.7

WATER TABLE CONTOUR MAP AND MONITOR WELLS, TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE, OCTOBER, 1987

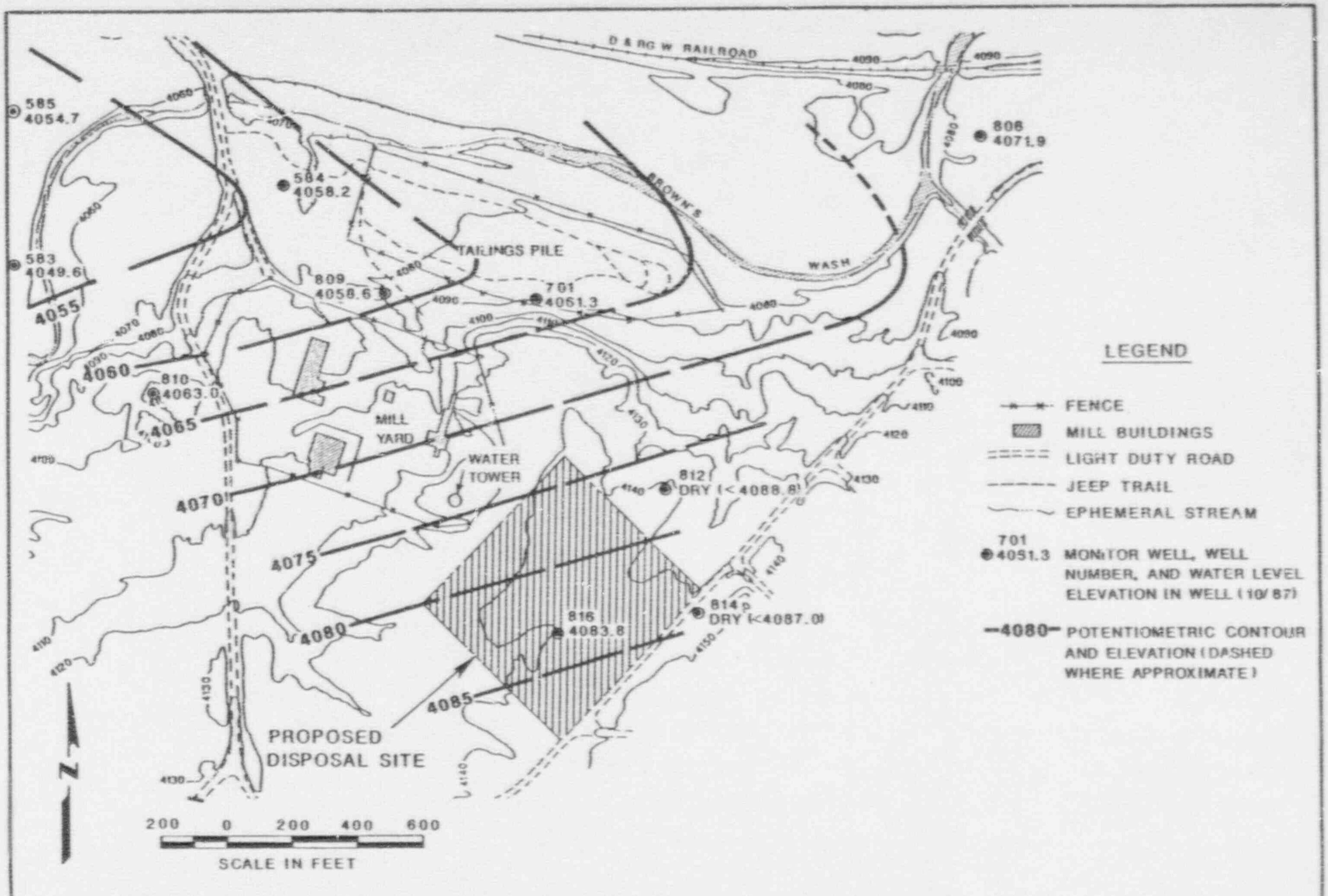


FIGURE D.5.8

POTENTIOMETRIC CONTOUR MAP AND MONITOR WELLS, UPPER - MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE, OCTOBER, 1987

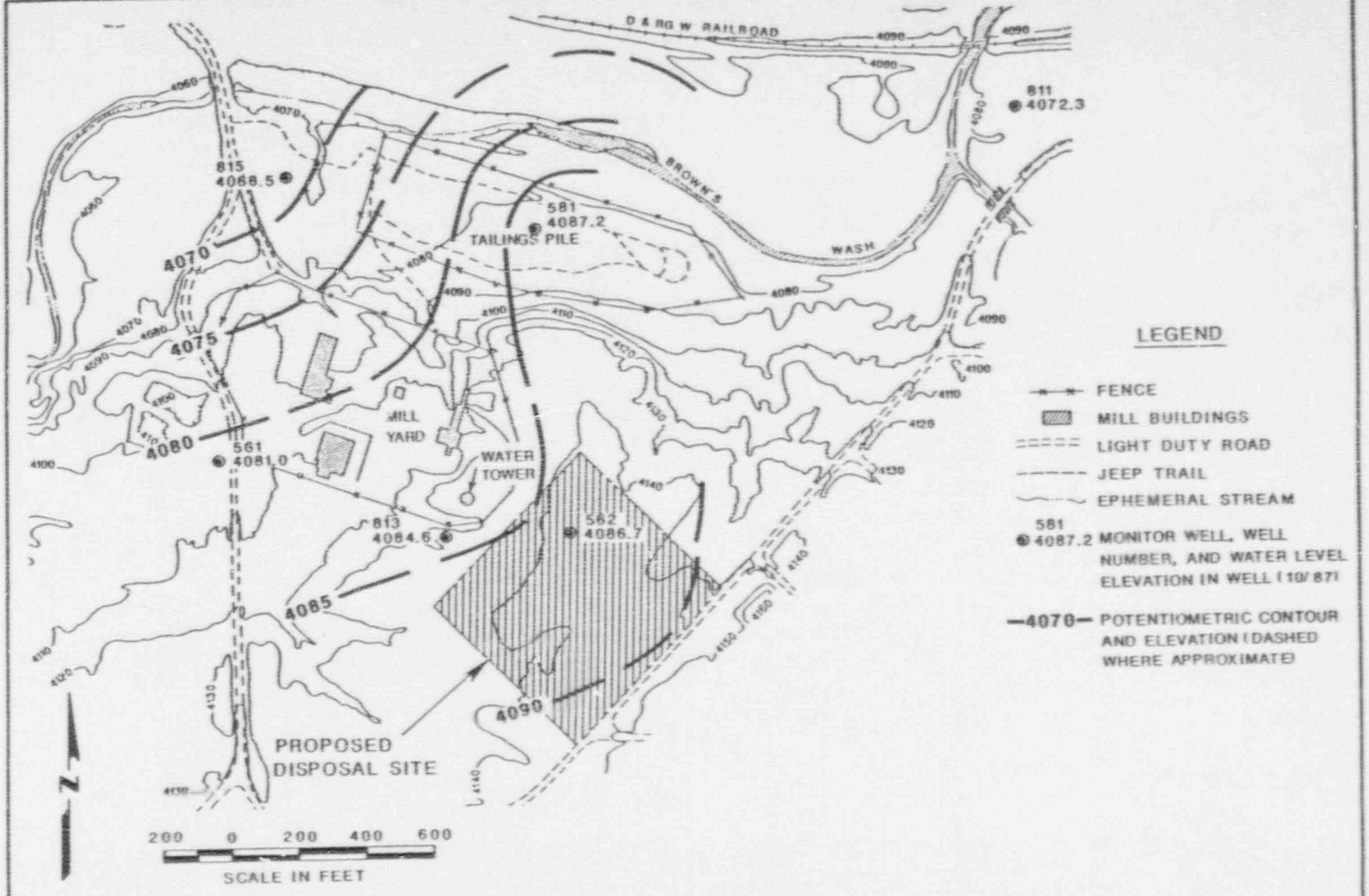


FIGURE D.5.9

POTENTIOMETRIC CONTOUR MAP AND MONITOR WELLS, LOWER - MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE, OCTOBER, 1987

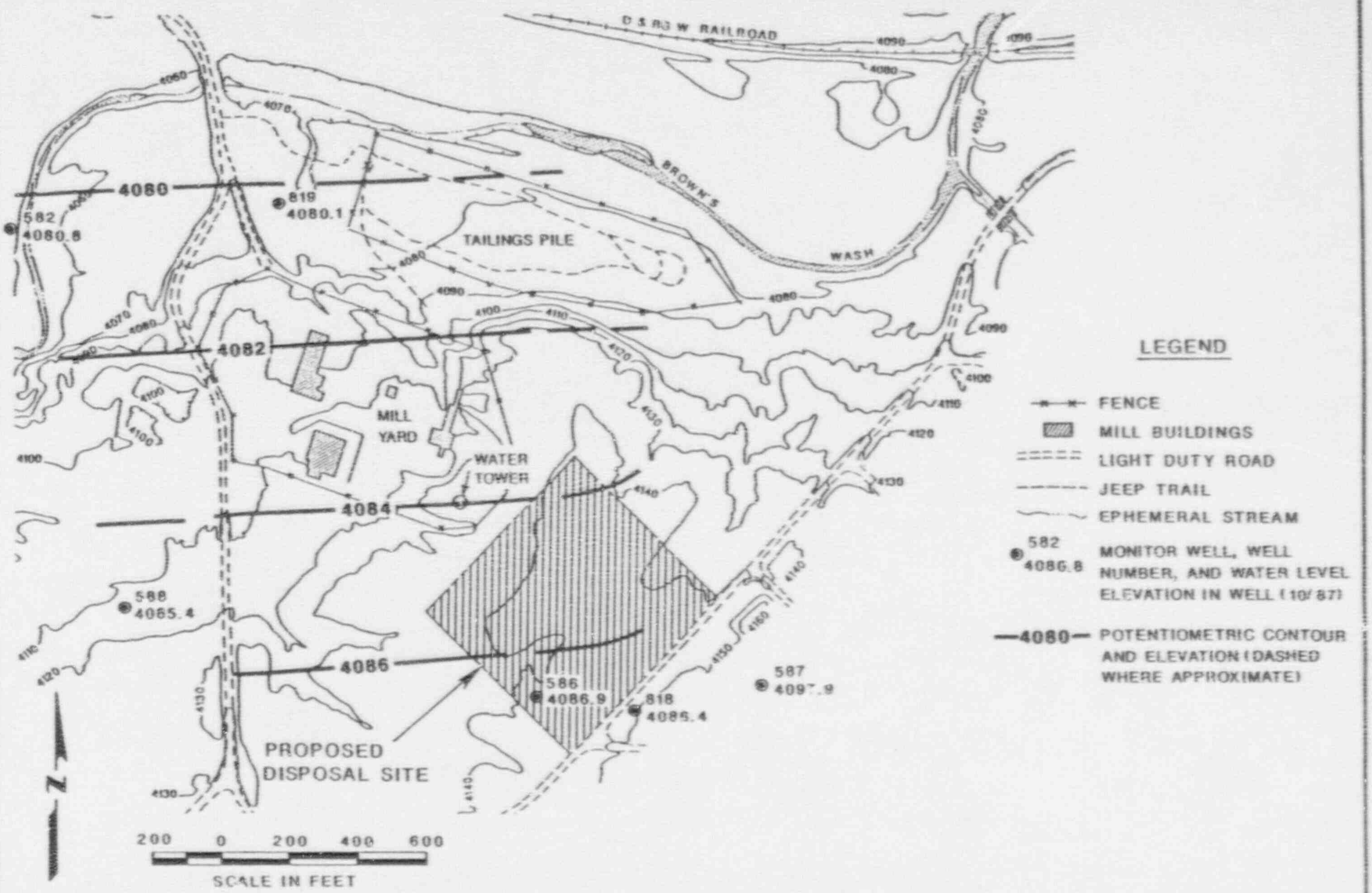
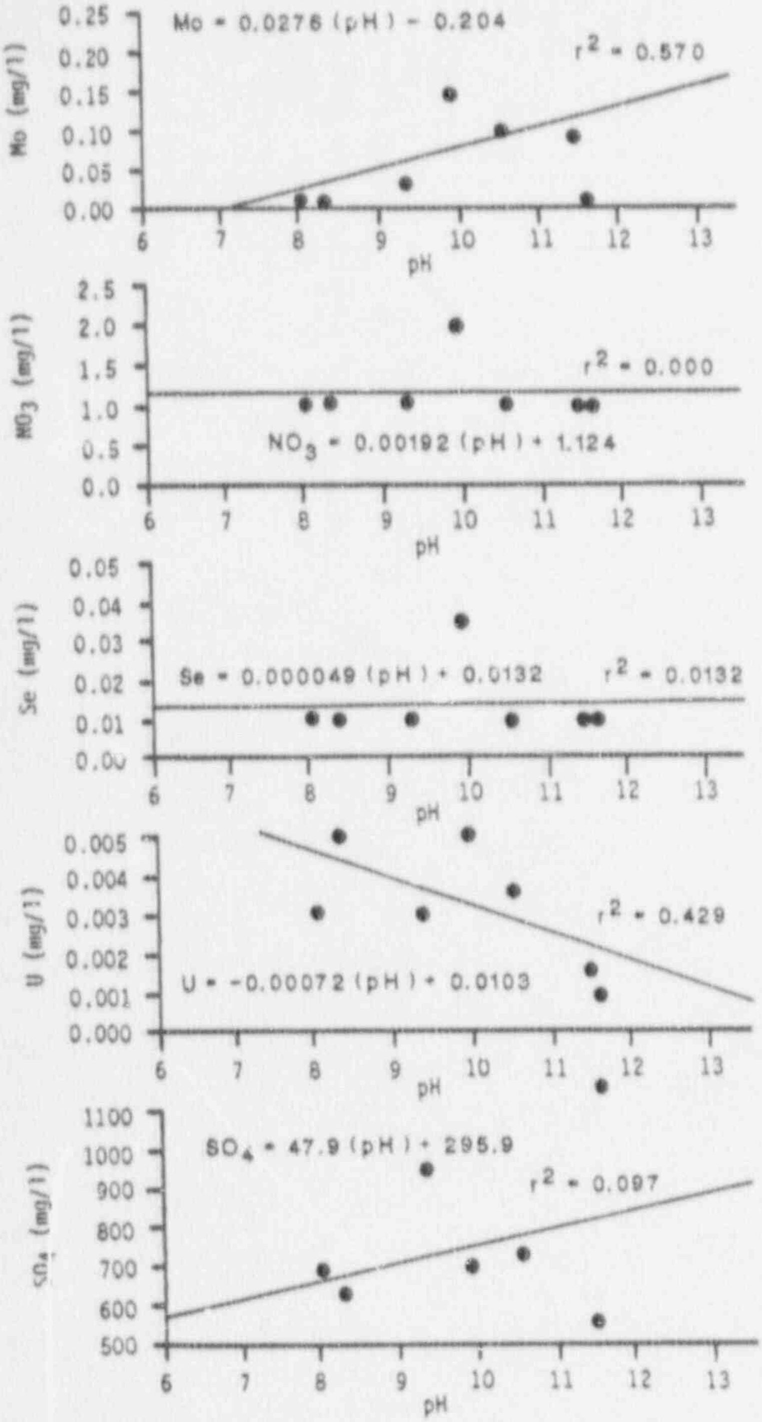


FIGURE D.5.10

POTENTIOMETRIC CONTOUR MAP AND MONITOR WELLS, BOTTOM HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE, OCTOBER, 1987



pH	Molybdenum (mg/l)
8.10	<0.01
8.30	<0.01
9.35	0.03
9.92	0.14
10.51	0.10
11.49	0.09
11.61	<0.10

pH	Nitrate (mg/l)
8.10	<1
8.30	<1
9.35	<1
9.92	2
10.51	<1
11.49	<1
11.61	<1

pH	Selenium (mg/l)
8.10	<0.01
8.30	<0.01
9.35	<0.01
9.92	0.036
10.51	<0.01
11.49	<0.01
11.61	<0.01

pH	Uranium (mg/l)
8.10	<0.003
8.30	0.005
9.35	<0.003
9.92	0.005
10.51	0.0036
11.49	0.0015
11.61	<0.001

pH	Sulfate (mg/l)
8.10	690
8.30	620
9.35	950
9.92	700
10.51	720
11.49	540
11.61	1170

FIGURE D.5.11

PLOTS OF pH vs. MOLYBDENUM,
NITRATE, SELENIUM, URANIUM, AND SULFATE
FOR BOTTOM UNIT BACKGROUND MONITOR WELLS 586, 587, AND 818

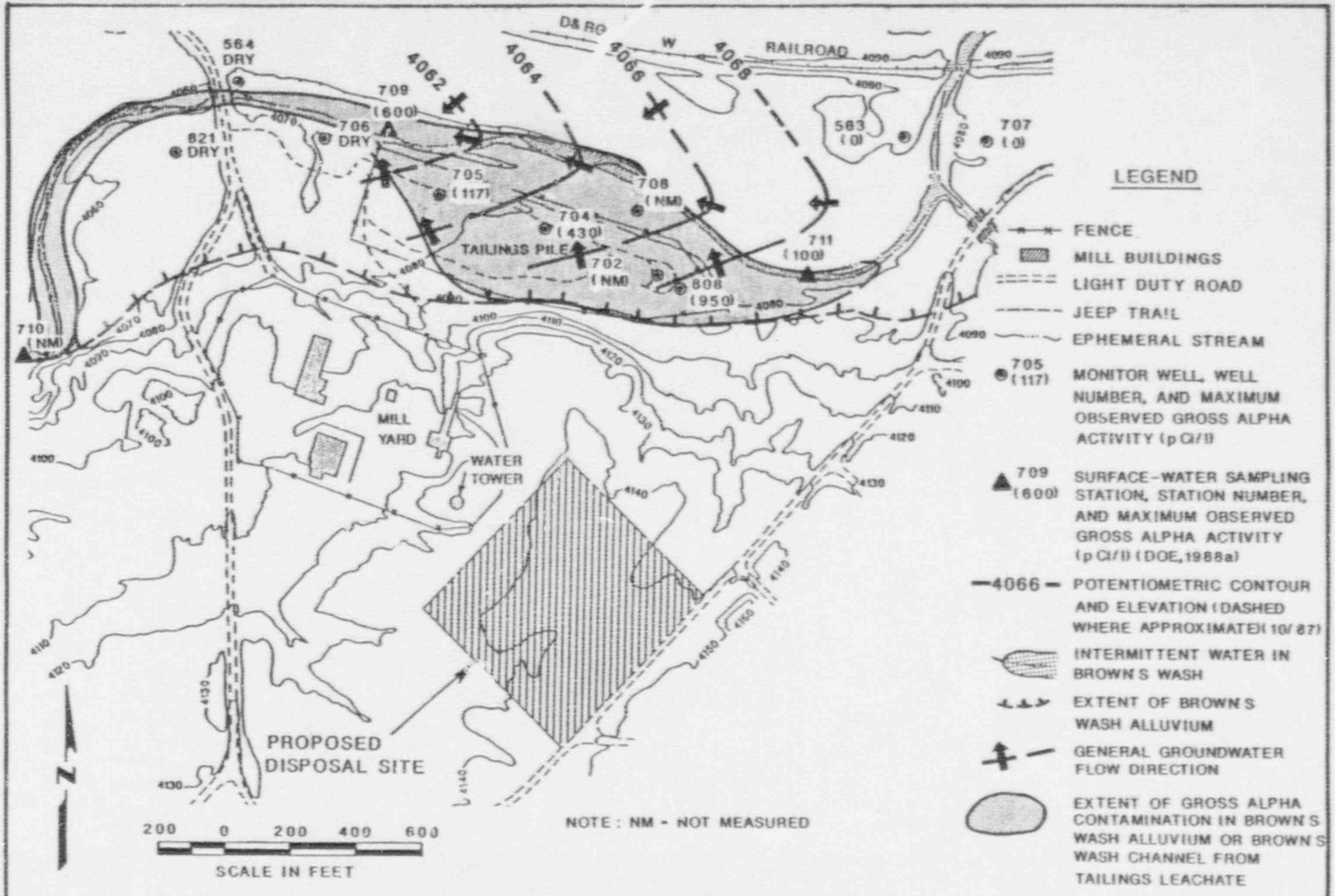


FIGURE D.5.12
MAXIMUM OBSERVED ACTIVITIES AND EXTENT OF GROSS ALPHA CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

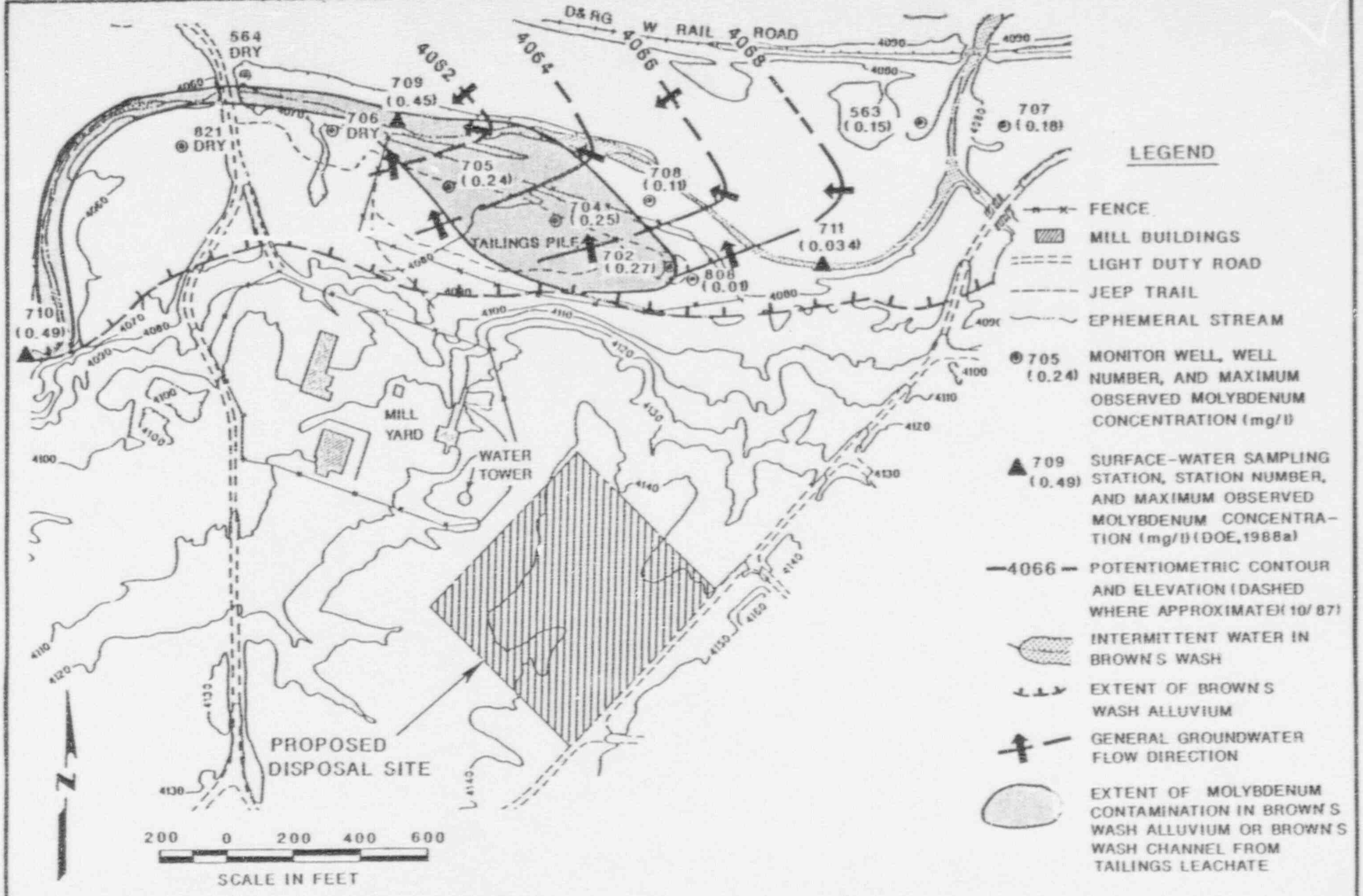


FIGURE D.5.13
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF MOLYBDENUM CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

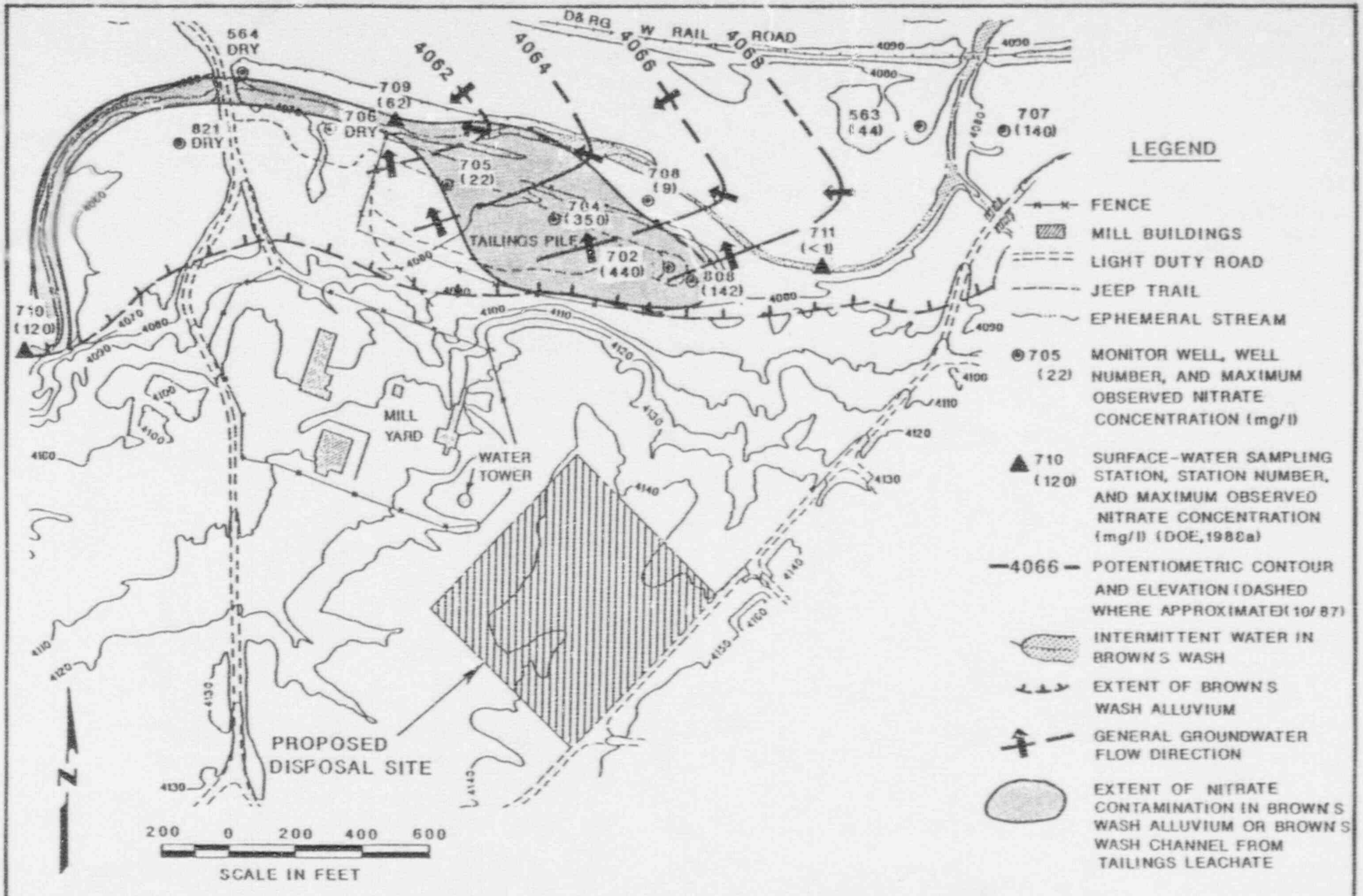


FIGURE D.5.14
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF NITRATE CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

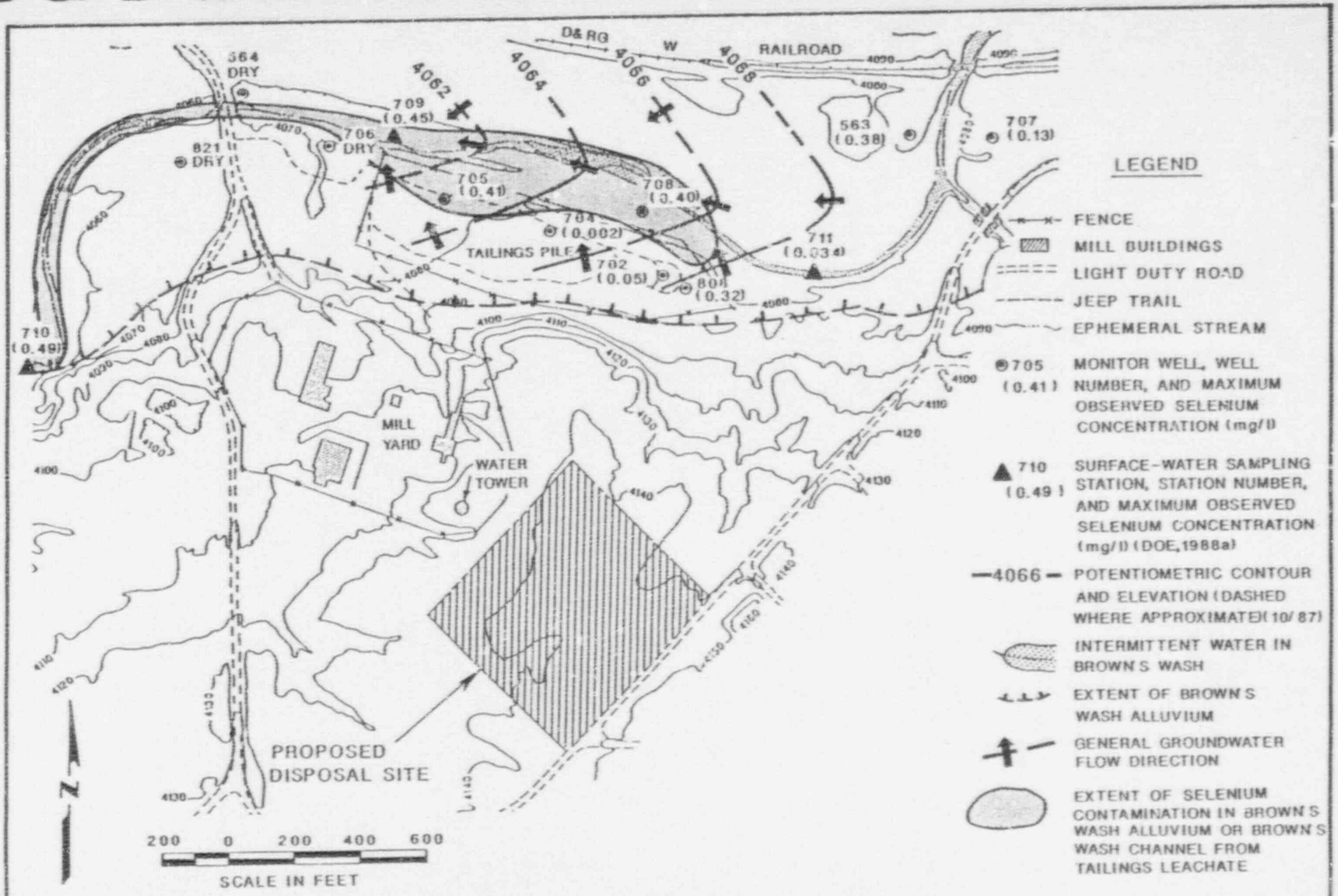


FIGURE D.5.15
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF SELENIUM CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

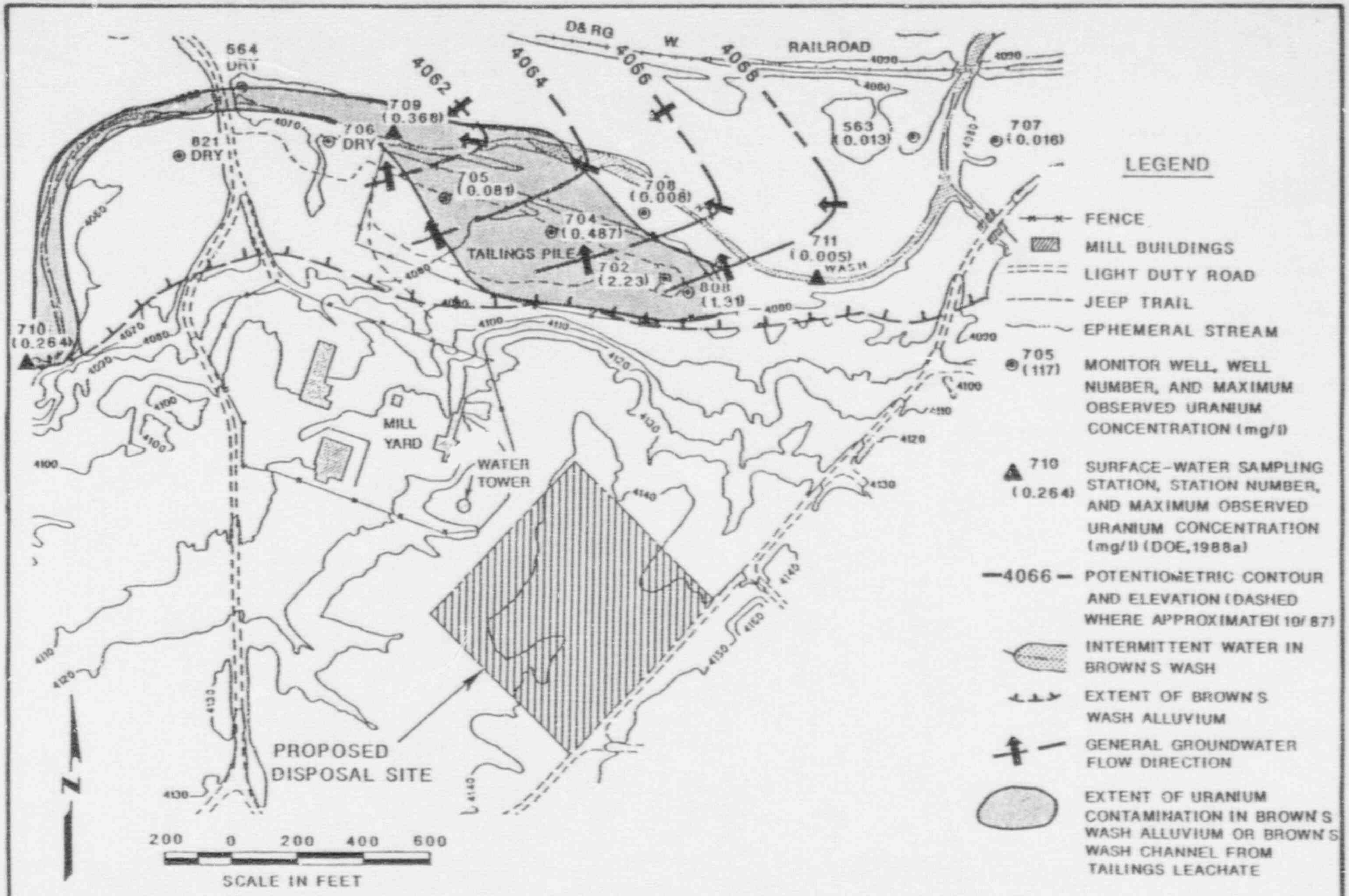


FIGURE D.5.16
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF URANIUM CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

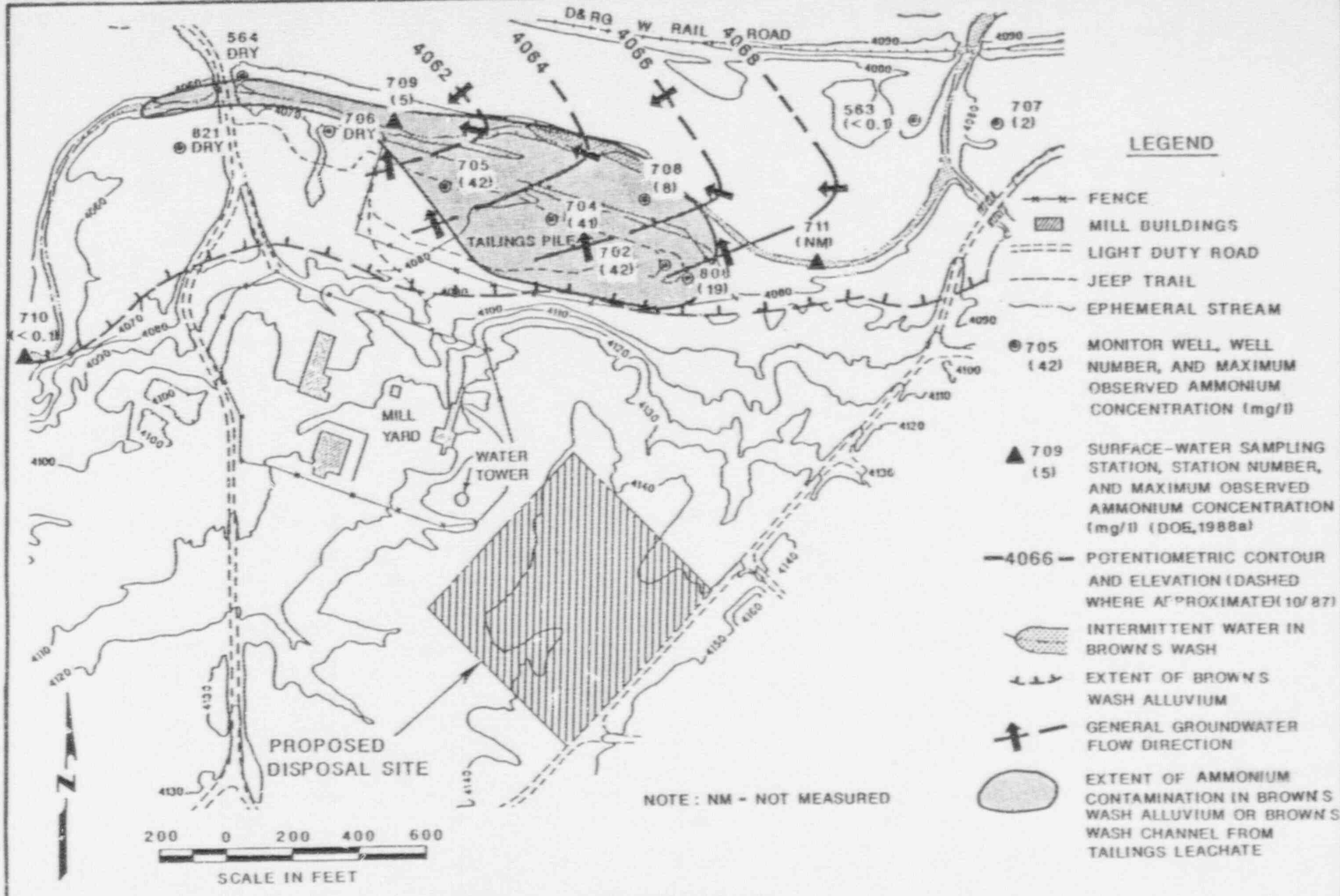


FIGURE D.5.17
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF AMMONIUM CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

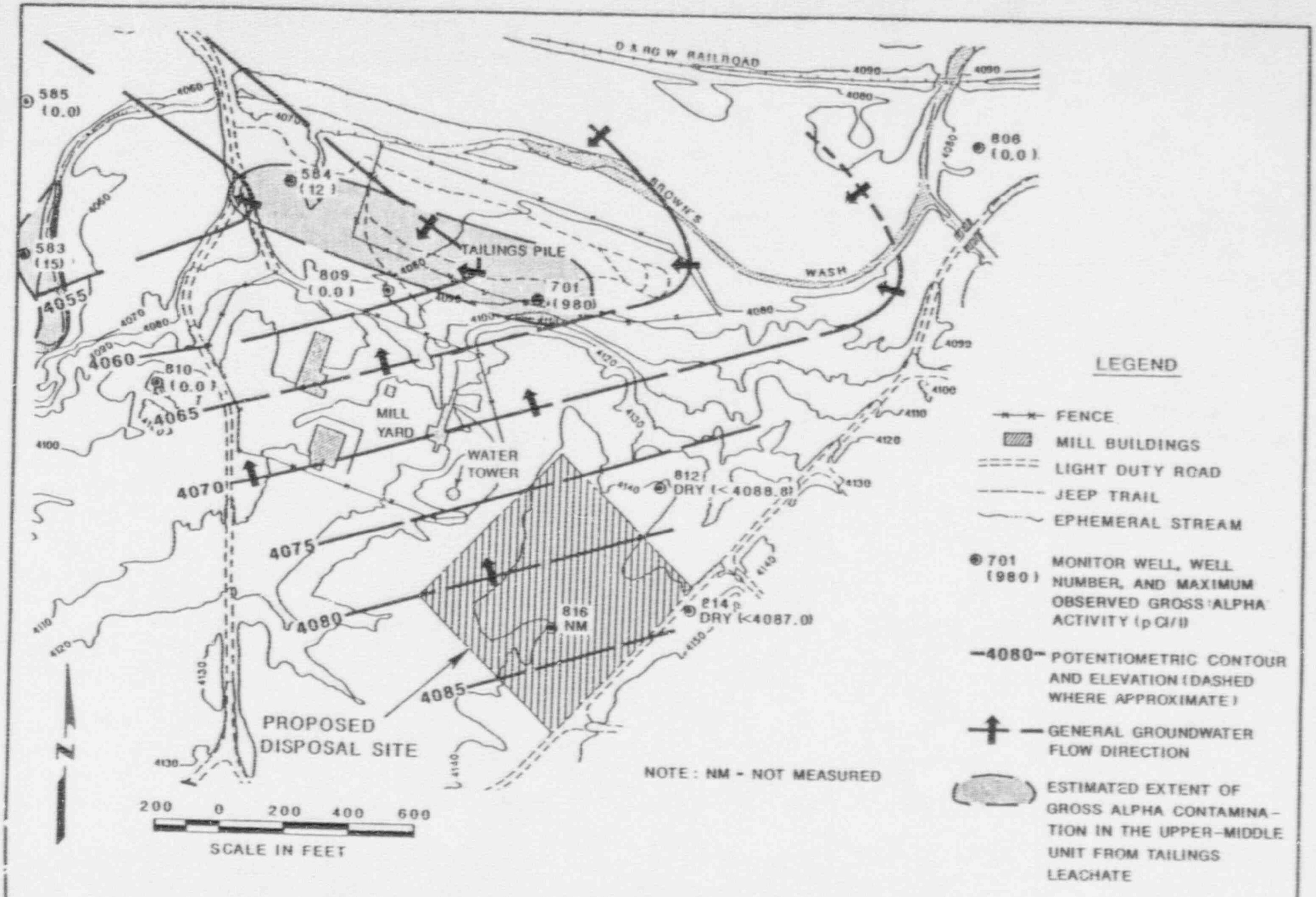


FIGURE D.5.16
MAXIMUM OBSERVED ACTIVITIES AND ESTIMATED EXTENT OF GROSS ALPHA CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

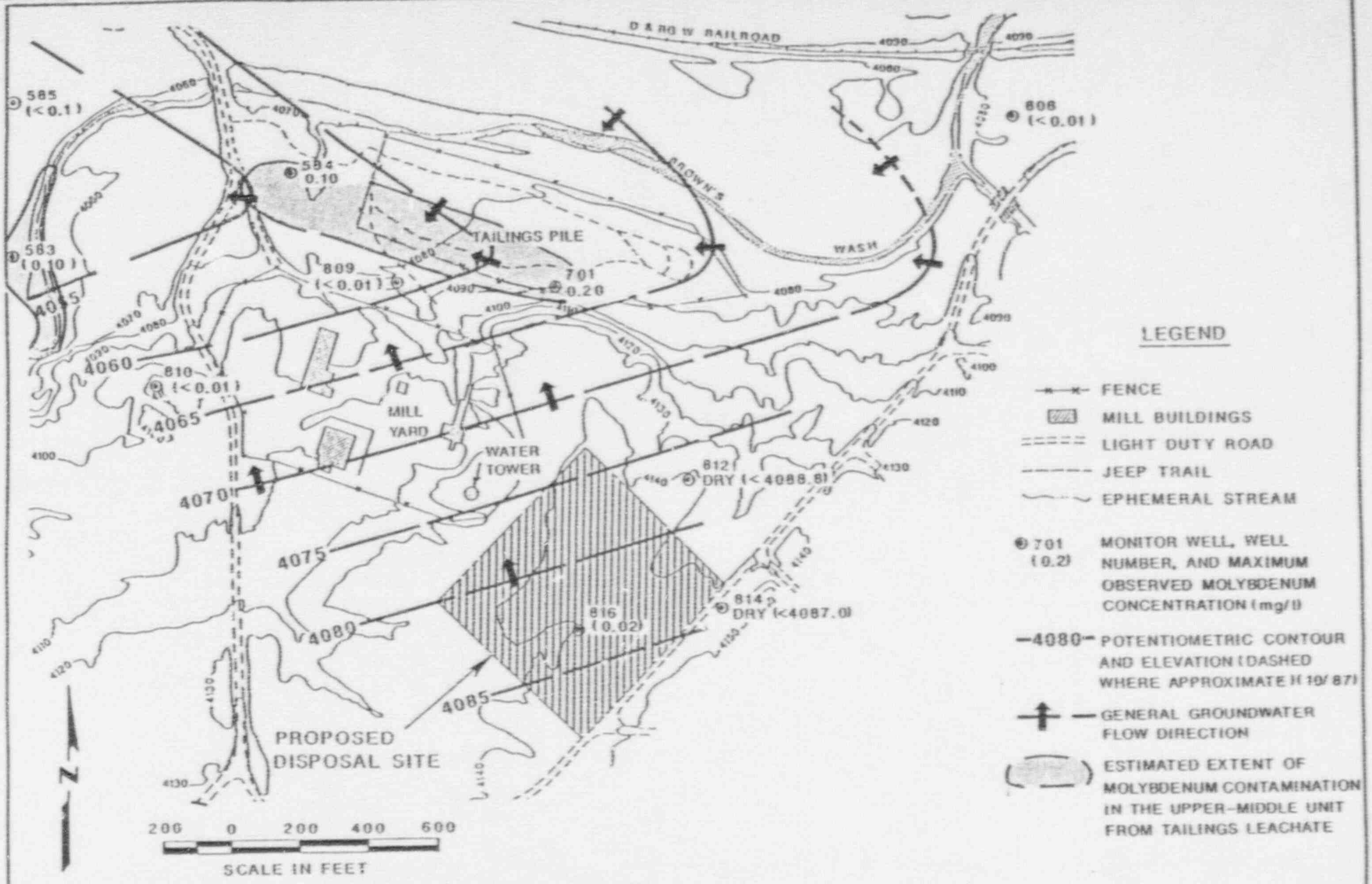


FIGURE D.5.19
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF MOLYBDENUM CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

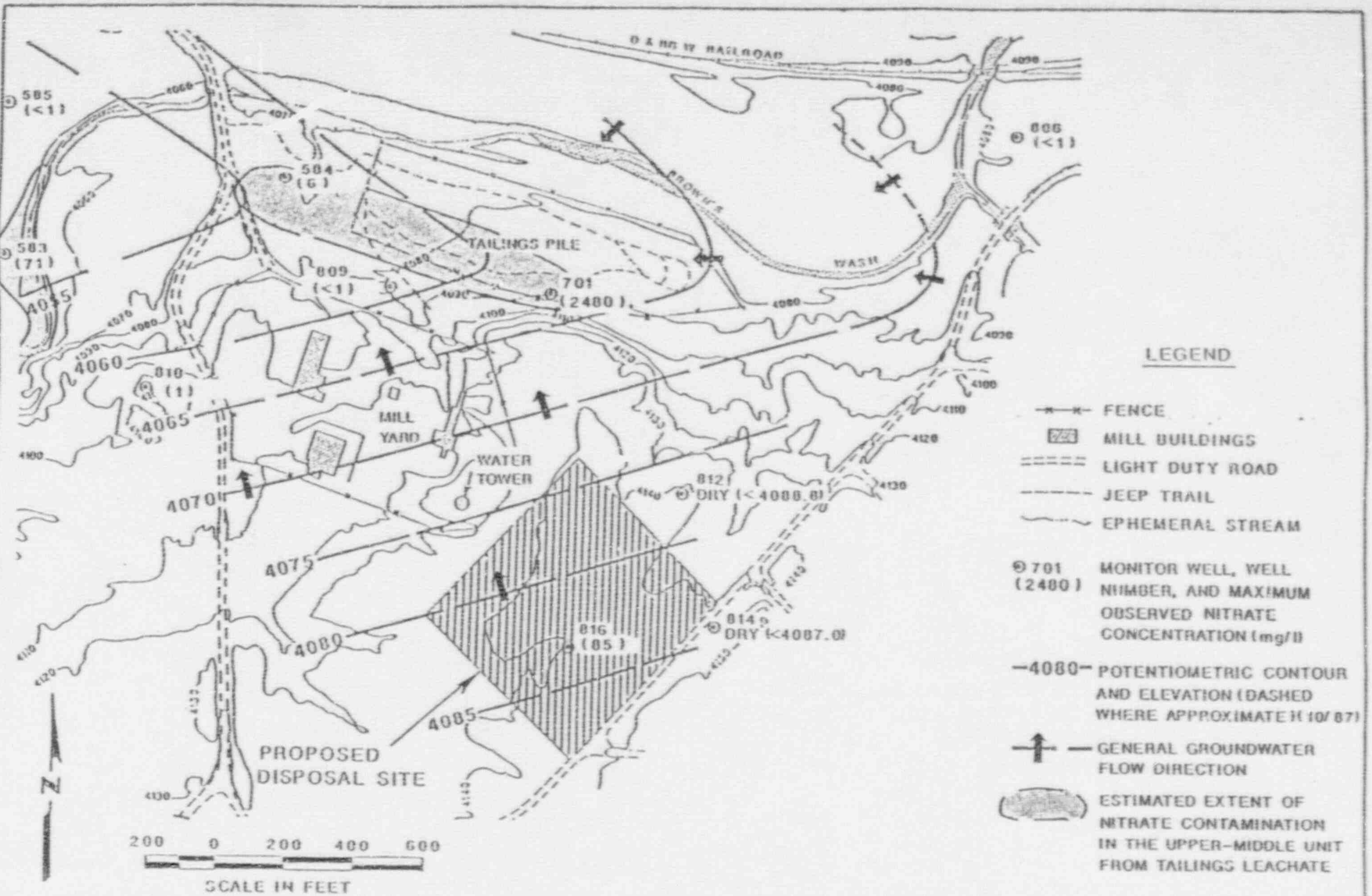


FIGURE D.5.20
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF NITRATE CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

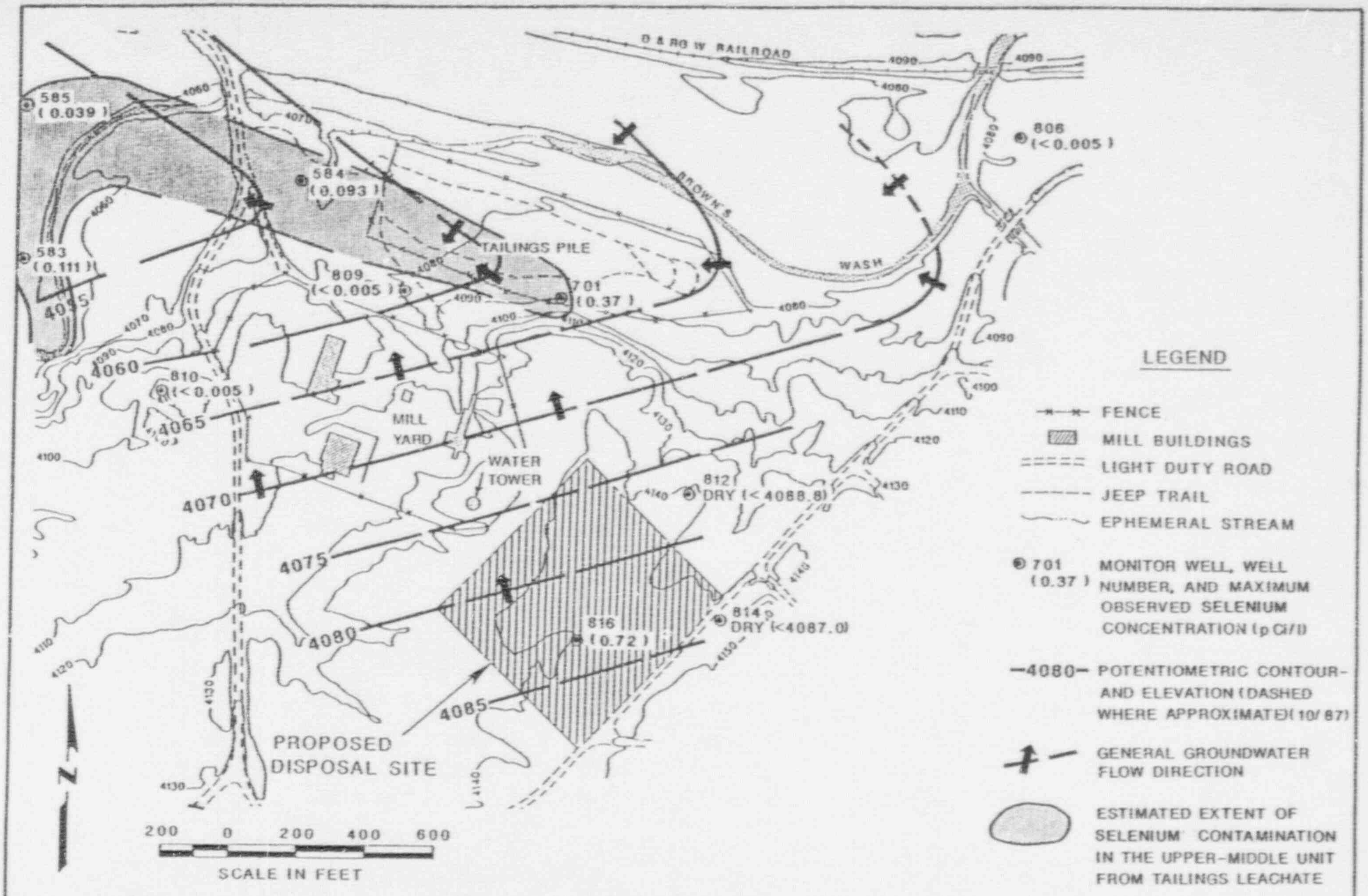


FIGURE D.5.21
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF SELENIUM CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

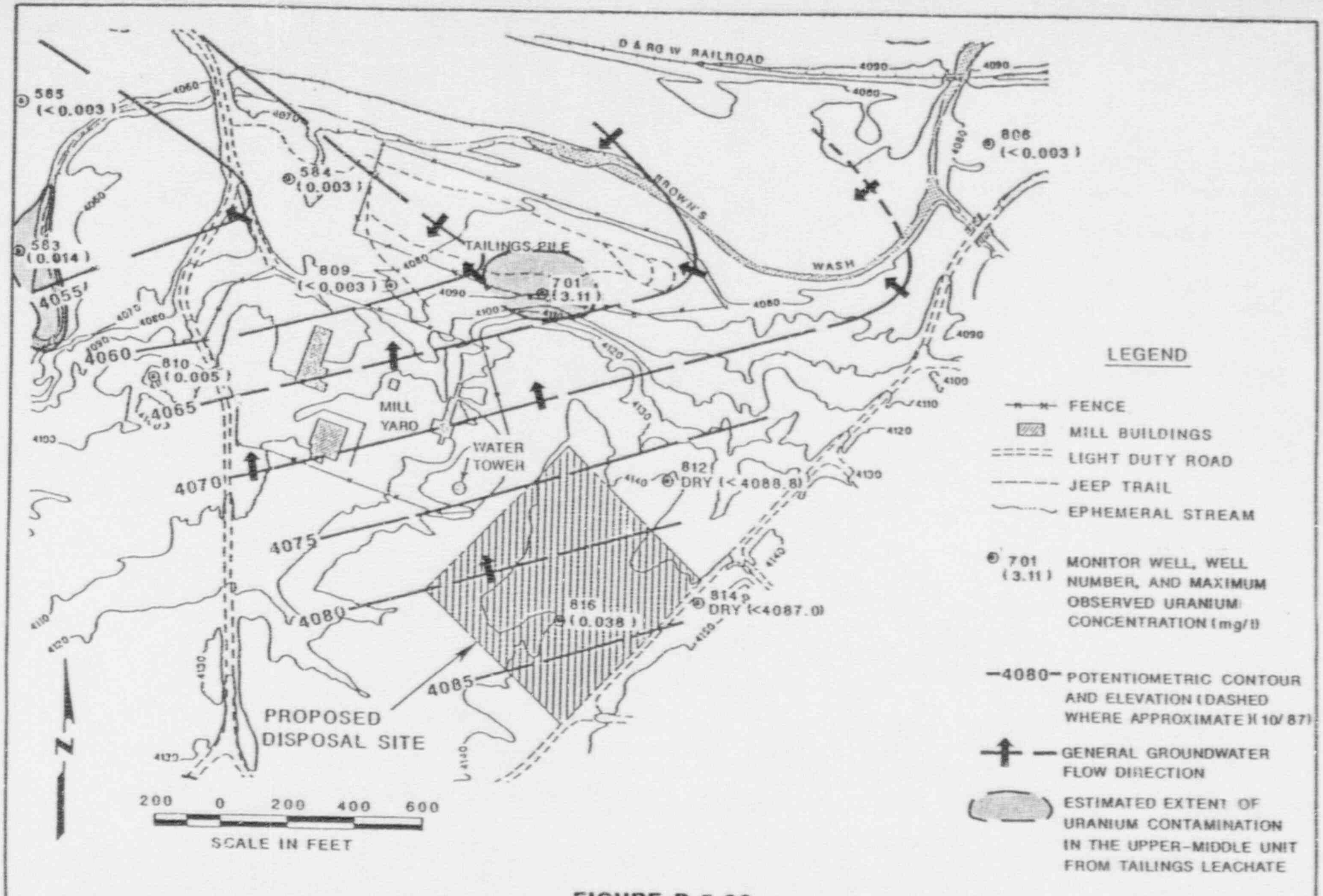
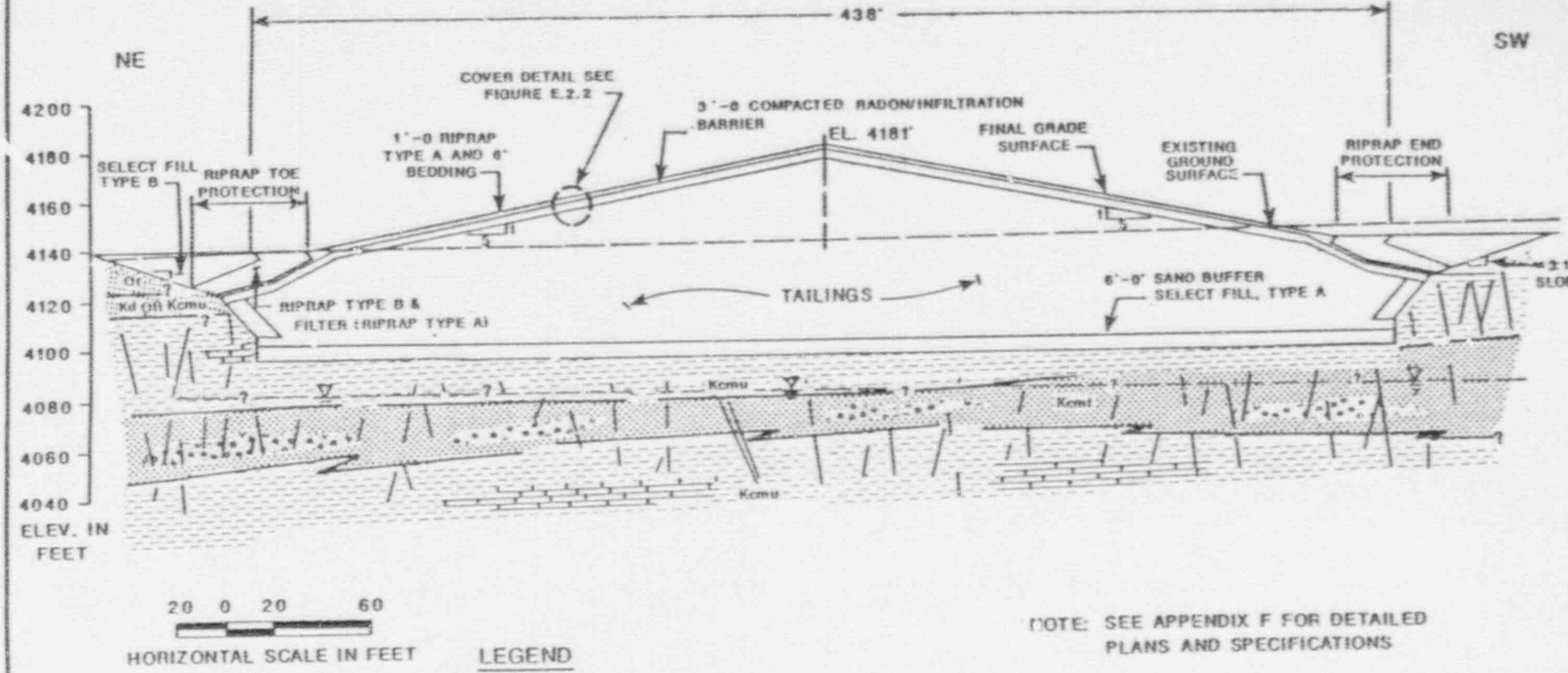


FIGURE D.5.22
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF URANIUM CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE



NOTE: SEE APPENDIX F FOR DETAILED PLANS AND SPECIFICATIONS

LEGEND

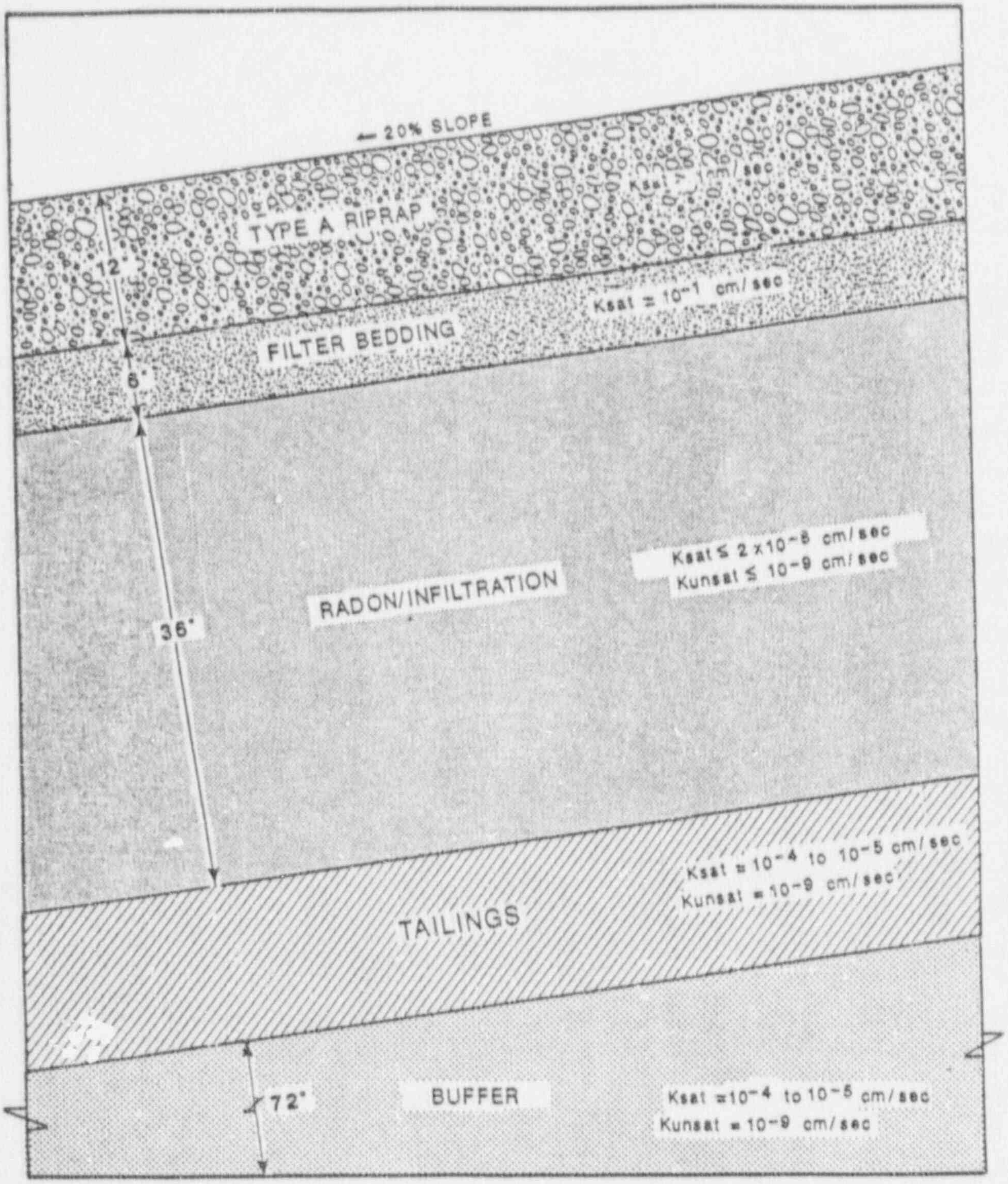
	FORMATION	MATERIAL	SYMBOL	
Qt	TERRACE SEDIMENTS	SOILS	▨	
Kd	DAKOTA SANDSTONE	BEDROCK	▨	SANDSTONE OR SILTSTONE
Kcmu	CEDAR MOUNTAIN FORMATION UPPER-MIDDLE UNIT		☐	SWALE OR MUDSTONE
Kcml	CEDAR MOUNTAIN FORMATION LOWER-MIDDLE UNIT		⊞	LIMESTONE
			⁘	CONGLOMERATE

// FRACTURES

—∇— POTENTIOMETRIC SURFACE

FIGURE D.5.23

DIAGRAMMATIC CROSS SECTION OF PROPOSED DISPOSAL CELL AND FOUNDATION
GREEN RIVER, UTAH, TAILINGS SITE



NOTE: SEE SECTION E.2.2 FOR DETAILED DESCRIPTION OF COVER COMPONENT PROPERTIES; Ksat=SATURATED HYDRAULIC CONDUCTIVITY; Kunsat = UNSATURATED HYDRAULIC CONDUCTIVITY; cm/sec=CENTIMETER PER SEC; SEE FIGURE E.2.1 FOR LOCATION OF THIS DETAIL IN RELATION TO THE DISPOSAL CELL.

FIGURE D.5.24
DISPOSAL CELL COVER SYSTEM
GREEN RIVER, UTAH, TAILINGS SITE

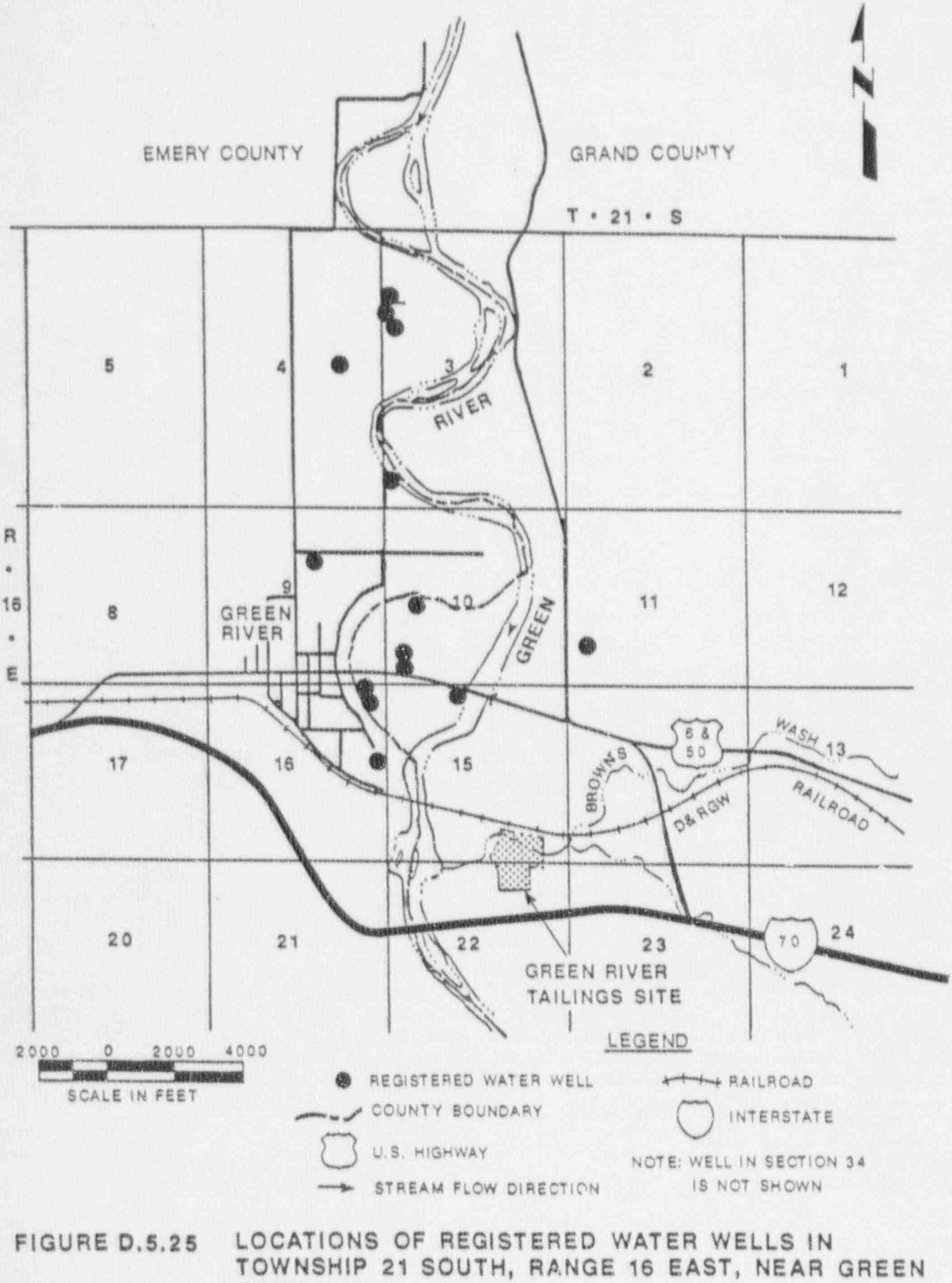


FIGURE D.5.25 LOCATIONS OF REGISTERED WATER WELLS IN TOWNSHIP 21 SOUTH, RANGE 16 EAST, NEAR GREEN RIVER, UTAH

Table D.5.1 Water quality standards and maximum concentration limits applicable to the Green River UMTRA Project site[a]

Constituent	Proposed EPA groundwater maximum concentration limits[b]	EPA National Drinking Water Standards[c]		State of Utah Drinking Water Standards
		Primary	Secondary	
Inorganic <u>Chemical</u>				
Arsenic	0.05	0.05		0.05
Barium	1.0	1.0		1.0
Boron				0.75
Cadmium	0.010	0.010		0.010
Chloride			250	250
Chromium	0.05	0.05		0.05
Copper			1.0	1.0
Iron			0.3	0.3
Lead	0.05	0.05		0.05
Manganese			0.05	0.05
Mercury	0.002	0.002		0.002
Molybdenum	0.1			
Nitrate	44	44		44
Selenium	0.01	0.01		0.01
Silver	0.05	0.05		0.05
Sulfate			250	250
Zinc			5.0	5.0
TDS			500	500
pH (standard units)			6.5-8.5	6.5-8.5
<u>Radionuclides</u>				
Ra-226 and 228	5.0 pCi/l			5.0 pCi/l
U-234 and 238	30 pCi/l (0.044 mg/l)			
Gross alpha	15 pCi/l			15 pCi/l

[a] Concentrations are given in mg/l except as noted.

[b] Proposed EPA groundwater standards and constituents most commonly associated with uranium mill tailings for UMTRA Project sites; 40 CFR 192. Proposed standards also include a list of hazardous organic constituents, plus antimony, beryllium, and thallium, that are not normally associated with uranium mill tailings or are present in very small quantities; these additional constituents do not have associated maximum concentration limits. See Appendix VIII of 40 CFR 261.

[c] EPA National Drinking Water Standards: Primary, 40 CFR 141; Secondary, 40 CFR 143.

Table D.5.2 Monitor well data, Green River, Utah, tailings site

Location ID	North coordinate (ft)	East coordinate (ft)	Borehole Elevation (ft)	Borehole Depth[a] (ft)	Borehole Diameter (in)	Well casing Elevation (ft)	Well casing Depth[a] (ft)	Well casing Diameter (in)	Screened depth[a] (ft)	Interval length (ft)	Flow relationship
Formation of completion:		Alluvium (top unit)									
563	60760.1	60003.5	4079.70	16.0	2.0	4081.10	16.0	2.0	10.0	5.0	Upgradient
564	60917.7	58100.1	4064.60	11.0	2.0	4068.10	11.0	2.0	5.0	5.0	Downgradient
702	60355.8	59295.1	4081.80	43.0	8.0	4082.60	26.0	4.0	15.0	8.0	On-site
704	60556.4	58941.0	4080.70	23.0	8.0	4082.10	23.0	4.0	15.0	8.0	On-site
705	60640.1	58665.7	4076.10	20.0	8.0	4078.30	20.0	4.0	14.0	6.0	On-site
706	60779.0	58379.2	4069.80	34.0	8.0	4070.90	18.0	4.0	8.0	6.0	Downgradient
707	60750.9	60224.0	4081.80	37.0	8.0	4083.10	16.0	4.0	9.0	6.0	Upgradient
708	60605.4	59218.6	4073.10	11.0	8.0	4074.70	11.0	4.0	7.0	4.0	Crossgradient
808	60317.9	59333.8	4082.27	25.0	8.0	4084.27	25.0	4.0	13.0	10.0	On-site
821	60689.9	57916.6	4065.32	7.0	2.0	4068.32	7.0	2.0	2.0	5.0	Downgradient
Formation of completion:[b]		Shale (upper-middle unit, Cedar Mountain Formation)									
583	60462.5	57425.9	4065.60	56.5	6.0	4067.10	56.5	2.0	34.5	20.0	Downgradient
584	60654.2	58236.8	4072.10	50.0	6.0	4073.60	50.0	2.0	29.5	20.0	Downgradient
585	60925.6	57423.5	4067.60	50.0	6.0	4069.10	50.0	2.0	39.5	10.0	Downgradient
701	60330.9	58929.2	4087.00	57.0	8.0	4087.20	57.0	4.0	30.0	27.0	On-site
806	60839.6	60243.9	4082.00	67.0	8.0	4084.00	67.0	4.0	55.0	10.0	Upgradient
807	59155.2	58668.8	4139.14	100.0	8.0	4141.14	100.0	4.0	78.0	20.0	Upgradient
809	60371.1	58519.2	4080.30	70.0	8.0	4082.50	70.0	4.0	48.0	20.0	Downgradient
810	60011.6	57868.6	4098.76	80.0	8.0	4100.76	80.0	4.9	58.0	20.0	Downgradient
812	59740.3	59350.1	4142.75	59.0	8.0	4144.75	59.0	4.0	46.0	10.0	Upgradient
814	59377.7	59412.5	4143.03	60.0	8.0	4145.03	60.0	4.0	48.0	10.0	Upgradient
816	59392.3	59003.8	4141.26	60.0	6.0	4143.56	60.0	4.0	48.0	10.0	Upgradient
822	59366.8	59003.0	4140.64	35.0	8.0	4143.14	35.0	4.0	13.0	20.0	Upgradient
823	59408.0	58450.5	4132.86	30.0	8.0	4135.06	30.0	4.0	17.0	10.0	Upgradient
Formation of completion:		Sandstone and conglomerate (lower-middle unit, Cedar Mountain Formation)									
561[c]	59838.7	58028.8	4108.70	143.5	6.0	4111.20	143.5	2.0	111.0	30.0	Crossgradient
562[c]	59585.9	59014.3	4143.60	130.0	6.0	4147.70	129.5	2.0	87.5	40.0	Upgradient
581	60450.2	58932.9	4083.30	85.0	8.0	4084.60	85.0	4.0	64.3	20.0	On-site
811	60818.9	60300.0	4082.83	80.0	8.0	4085.33	80.0	4.0	62.5	15.0	Upgradient
813	59622.2	58669.9	4135.10	99.5	8.0	4136.40	99.5	4.0	77.7	20.0	Upgradient
815	60738.7	58225.6	4071.53	100.0	8.0	4073.53	100.0	4.0	88.0	10.0	Downgradient
Formation of completion:		Sandstone (bottom unit, Buckhorn Conglomerate Member of Cedar Mountain Formation)									
582	60427.0	57424.8	4065.50	168.5	8.0	4067.00	168.5	4.0	148.0	22.0	Downgradient
586	59171.8	58915.7	4142.40	166.5	8.0	4143.40	166.5	4.0	145.5	20.0	Upgradient
587	59177.2	59540.5	4167.90	185.0	8.0	4169.40	185.0	4.0	164.5	20.0	Upgradient
588	59445.0	57782.7	4112.20	145.0	8.0	4113.50	145.0	4.0	124.3	20.0	Upgradient
817	60794.8	60347.9	4083.31	145.0	8.0	4085.31	145.0	4.0	113.2	30.0	Upgradient
818	59145.1	59189.7	4150.58	187.0	8.0	4152.58	187.0	4.0	165.0	20.0	Upgradient
819	60583.3	58230.8	4072.70	166.0	8.0	4074.70	166.0	4.0	144.0	20.0	Downgradient

---

[a] Depth below land surface.

[b] Excludes monitor well 703. The bentonite seal breached in this well shortly after installation (DOE, 1983) and information from this well has been excluded from analyses.

[c] Wells 561 and 562 are screened in both the upper-middle and lower-middle hydrostratigraphic units.

Table D.5.3 Summary of aquifer hydraulic characteristics, Green River, Utah, tailings site

Monitor well number[a]	Hydrostratigraphic unit[a]	Tested interval (ft)[b]	Test method[c]	Average hydraulic conductivity (ft/day)[d]	Average transmissivity (ft^2/day)[e]	Average linear velocity (ft/day)[f]
702	Top	15-23.8	PD[g],BR[g]	32.8	289	0.92
704	Top	15-21.2	BR[g],FK,CBP	54.6	339	1.51
705	Top	14-18.6	BR[g]	16.4	75	0.55
706[h]	Top	8-12.5	BR[g]	3.3	15	NA
707	Top	9-12.6	BR[g],FK,CBP	226.3	815	2.19
808	Top	15.8-23.0	BR	11.1	79.9	0.92
583	Upper-Middle	33-53	FK,CBP	2.4	48	0.13
584	Upper-Middle	28-48	FK,CBP	2.4	48	0.12
585	Upper-Middle	28-41	FK,CBP	0.5	10	0.03
701	Upper-Middle	52-57	FK,CBP,BR[g]	17.0	85	0.71
806	Upper-Middle	55-65	FK,CBP	0.23	4.6	0.01
807	Upper-Middle	78-98	FK,CBP	0.0068	0.14	ND
561	Lower-Middle	115-145	FK,CBP	0.0055	0.17	ND
581	Lower-Middle	63-83	FK,PR	21.6	432	2.7
811	Lower-Middle	62.5-77.5	FK,CBP	0.22	3.28	0.02
813	Lower-Middle	77.7-97.7	FK,CBP,PD	4.53	90.8	0.19
815	Lower-Middle	88-98	FK,CBP	0.37	3.7	0.04
582	Bottom	146.5-166.5	FK,CBP,PR	3.6	72	0.072
586	Bottom	144.5-164.5	FK,CBP,PR	0.13	2.6	ND
587	Bottom	163-183	FK,CBP,PR	0.076	1.5	ND
588	Bottom	123-143	FK,CBP,PR	5.8	116	0.13
818	Bottom	165-185	FK,CBP	7.6	151	0.17

---

[a] See Figure D.5.1 for locations of monitor wells. Slug tests were unsuccessful for well 708 and no data are available. Well 561 is partially screened in the upper-middle unit. Wells 562 and 703 were not tested. Wells 586 and 587 were grout-contaminated at the time of testing, and hydraulic conductivity values are not representative of bottom unit. Well 807 is screened in the upper-middle unit below the lower-middle unit.

[b] Tested interval is in feet below land surface.

[c] PD is pumping drawdown (type-curve) method; PR is pumping recovery (single well) method; BR is Bouwer and Rice slug test method; FK is Ferris and Knowles slug test method; CBP is Cooper, Bredehoeft, and Papadopulos slug test method.

[d] Arithmetic average of all applied methods of analysis; wells 701, 704, and 707 have been tested twice.

[e] Average hydraulic conductivity multiplied by tested interval length.

[f] Average linear velocity calculated for silty, gravelly sand (top unit, assumed porosity of 0.30); shale and limestone (upper-middle unit, assumed porosity of 0.15); sandstone and sandstone conglomerate (lower middle unit, assumed porosity of 0.20); sandstone/conglomerate (bottom unit, assumed porosity of 0.20) (Walton, 1970). NA = not available; ND = not determined.

[g] Analyses by DOE (1983).

[h] Hydraulic conductivity at well 706 was measured shortly after drilling by DOE (1983), but the well has been dry for each sampling period thereafter.

Table D.5.4 Triaxial hydraulic conductivities of selected rock core from monitor wells 907, 813, 816, and 818, Green River, Utah, tailings site

Location ID[a]	Sample ID	Depth interval (ft)[b]	Test meth.[c]	Moisture content (%)		Dry density (PCF)[d]		Saturation (%)		Total pressure head (ft)	Hydraulic conductivity (cm/s)
				Init.	Final	Init.	Final	Init.	Final		
807	A	50 (Kcml)	TX	1.1	3.5	159.3	159.3	31.8	100	97.0	4.7×10^{-10}
807	B	80 (Kcmu)	TX	2.4	5.0	153.4	153.4	47.7	100	95.6	2.4×10^{-11}
813	A	40 (Kcmu)	TX	7.6	14.9	137.8	120.7	89.7	100	95.7	1.3×10^{-9}
813	B	65 (Kcml)	TX	0.8	4.8	149.2	149.2	17.0	100	4.3	7.0×10^{-9}
816	A	40 (Kcmu)	TX	8.5	12.6	133.9	125.0	92.6	100	96.4	3.5×10^{-9}
816	B	65 (Kcml)	TX	1.6	7.0	141.8	141.8	22.8	100	4.4	2.4×10^{-8}
818	A	125 (Kcm)	TX	8.0	14.6	139.2	123.4	90.5	100	95.0	5.0×10^{-9}

Location/sample ID	Depth, ft	Unit and visual description
807-A	50	Kcm lower-middle unit: Siltstone, light buff to gray, moderately well cemented, minor horizontal fracturing with iron staining.
807-B	80	Kcm upper-middle unit below the lower-middle sand: Shale, medium gray, moderately well cemented, minor cemented horizontal fractures, layering, minor pyrite crystallization.
813-A	40	Kcm upper-middle unit: Shale, dark gray, fissle, moderately well cemented, secondary mineralization in horizontal joints as calcite or gypsum, iron staining.
813-B	65	Kcm lower-middle unit: Sandstone, silty, very fine grained, soft, gray and light brown, minor iron staining.
816-A	40	Kcm upper-middle unit: Shale and mudstone, light gray micro-crystalline to dark gray fissle; secondary mineralization and iron staining on layered surfaces.
816-B	65	Kcm lower-middle unit: Sandstone, medium brown to gray speckled, silty, fine to very fine grained, minor mud inclusions.
818-A	125-130	Kcm confining unit for bottom unit: Shale, fissle, moderately hard to soft, dark purple and medium gray.

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[a] See Figure D.5.1 for location of monitor wells.

[b] Kcml = lower-middle unit Cedar Mountain Formation; Kcmu = upper-middle unit of Cedar Mountain Formation; Kcm = Cedar Mountain Formation between lower-middle and bottom unit.

[c] TX = Triaxial back pressure falling head method.

[d] PCF = pounds per cubic foot (lb/ft^3).

Table D.5.5 Groundwater elevations, Green River, Utah, tailings site

Well number	Elevation (top of casing)	Water elevation[a] June 1986	September 1986	March 1987	October 1987
Top unit					
563	4081.1	4069.2	4070.1	4069.2	4069.6
564	4068.1	Dry	Dry	Dry	Destroyed
702	4082.6	4067.3	4068.3	4067.9	4067.1
704	4082.1	4065.2	4065.4	4065.4	Clogged
705	4078.3	4062.9	4063.3	4063.6	4062.7
706	4070.9	Dry	Dry	Dry	Dry
707	4083.1	4070.2	4070.9	4070.8	4069.7
708	4074.7	NS	4065.4	4066.7	Clogged
808	4084.3	NS	NS	NS	4068.1
821	4068.3	NS	NS	NS	Dry
Upper-middle unit					
583	4067.1	NS	4052.4	4051.0	4049.6
584	4073.6	NS	4058.8	4059.5	4058.2
585	4069.1	NS	4054.7	4055.2	4054.7
701	4087.9	4062.8	4062.7	4063.1	4061.3
806	4084.0	NS	NS	NS	4071.9
807[b]	4141.1	NS	NS	NS	4088.4
809	4082.5	NS	NS	NS	4058.6
810	4100.8	NS	NS	NS	4063.0
812	4144.8	NS	NS	NS	Dry
814	4145.0	NS	NS	NS	Dry
816	4143.6	NS	NS	NS	4083.8
822	4143.1	NS	NS	NS	Dry
823	4135.1	NS	NS	NS	Dry
Lower-middle unit					
561[b]	4111.2	4085.8	4084.3	4082.6	4081.0
562	4147.7	4087.5	4088.3	4088.4	4086.7
581	4084.6	NS	Flowing(NM)	Flowing(NM)	4087.2
811	4085.3	NS	NS	NS	4072.3
813	4136.4	NS	NS	NS	4084.6
815	4073.5	NS	NS	NS	4068.5

Table D.5.5 Groundwater elevations, Green River, Utah, tailings site (Concluded)

Well number	Elevation (top of casing)	Water elevation[a] June 1986	September 1986	March 1987	October 1987
Bottom unit					
582	4067.0	NS	Flowing(NM)	Flowing(NM)	4080.8
586	4143.4	NS	4085.6	4087.6	4086.9
587	4169.4	NS	4086.3	4094.8	4097.9
588	4113.5	NS	4083.1	4086.2	4085.4
817[b]	4085.3	NS	NS	NS	4085.7
818	4152.6	NS	NS	NS	4086.4
819	4074.7	NS	NS	NS	4080.1

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[a] NS = well was either not sampled or was not yet installed; NM = not measured; Destroyed = surface casing was destroyed and well could not be measured; Clogged = well sounder could not be lowered down the casing because of an obstruction in the well. The potentiometric surface in the flowing wells was measured by shutting the well in and measuring the shut in pressure and/or by using a clear plastic riser hose, if possible.

[b] Monitor wells 561 and 562 partially screen the upper-middle and lower-middle units; monitor well 807 screens the upper-middle unit below the lower-middle unit; monitor well 817 probably does not screen the bottom unit (see text for explanation).

Table D.5.6 Summary of aquifer hydraulic characteristics for the top hydrostratigraphic unit, Green River, Utah, tailings site[a]

Monitor well number	Average hydraulic conductivity (ft/day)	Average transmissivity (ft^2/day)	Average linear velocity (ft/day)
702	32.8	289	0.92[b]
704	54.6	339	1.51
705	16.4	75	0.55
706[c]	3.3	15	NA
707	226.3	815	2.19
808	11.1	80	0.92[b]
mean[d]	25.0	139	1.14

[a] Linear velocity is a function of an assumed porosity of 0.30 for silty, gravelly sand (Walton, 1970); NA = not available (see Footnote c); hydraulic gradient is calculated at each well from October 1987 water levels.

[b] Average of monitor wells 702 and 808.

[c] Hydraulic conductivity at monitor well 706 was measured shortly after drilling by DOE (1983), but the well has been dry for each sampling period thereafter.

[d] Geometric mean.

Table D.5.7 Groundwater flux within the top hydrostratigraphic unit beneath the present tailings, Green River, Utah, tailings site

Flux component	Monitor wells 702 and 808	Monitor well 704	Monitor well 705
v (ft/day)[a]	0.28	0.45	0.17
W (ft)[b]	300	275	425
D (ft)[c]	9.7	6.3	4.4
Q (ft^3/s)[d]	0.0094	0.0090	0.0036
Q (gpm)[d]	4.2	4.1	1.6

Total flux = 4.2 + 4.1 + 1.6 = 9.9 gpm

[a] Groundwater velocity.

[b] Width perpendicular to groundwater flow beneath the tailings pile represented by the respective well(s).

[c] Depth of flow represented by the depth of water in the respective well(s).

[d] Groundwater flux for incremental area represented by the respective well(s).

Table D.5.8 Summary of aquifer hydraulic characteristics for the upper-middle hydrostratigraphic unit, Green River, Utah, tailings site[a]

Monitor well number	Average hydraulic conductivity (ft/day)	Average transmissivity (ft^2/day)	Average linear velocity (ft/day)
583	2.4	48	0.13
584	2.4	48	0.12
585	0.5	10	0.03
701	17.0	85	0.71
806	0.2	5	0.01
mean[b]	1.6	25	0.08

[a] Linear velocity is a function of an assumed porosity of 0.15 for shale and limestone (Walton, 1970); hydraulic gradient is calculated at each well from October 1987 water levels.

[b] Geometric mean.

Table D.5.9 Groundwater flux within the upper-middle hydrostratigraphic unit beneath the present tailings, Green River, Utah, tailings site

Flux component	Monitor well 584	Monitor well 701	Average of monitor wells 584 and 701
v (ft/day)[a]	0.018	0.107	0.063
W (ft)[b]	450	450	450
D (ft)[c]	34.6	31.1	32.9
Q (ft^3/s)[d]			0.011
Q (gpm)[d]			4.9

[a] Groundwater velocity.

[b] Width perpendicular to groundwater flow beneath the tailings pile.

[c] Depth of flow represented by the depth of water in the respective well(s).

[d] Total groundwater flux.

Table D.5.10 Summary of aquifer hydraulic characteristics for the lower-middle hydrostratigraphic unit, Green River, Utah, tailings site[a]

Monitor well number	Average hydraulic conductivity (ft/day)	Average transmissivity (ft^2/day)	Average linear velocity (ft/day)
581	21.6	432	2.70
811	0.2	3	0.02
813	4.5	91	0.19
815	0.4	4	0.04
mean[b]	1.7	26	0.14

[a] Linear velocity is a function of an assumed porosity of 0.20 for sandstone and conglomerate (Walton, 1970); hydraulic gradient is calculated at each well from October 1987 water levels.

[b] Geometric mean.

Table D.5.11 Summary of aquifer hydraulic characteristics for the bottom hydrostratigraphic unit, Green River, Utah, tailings site[a]

Monitor well number	Average hydraulic conductivity (ft/day)	Average transmissivity (ft^2/day)	Average linear velocity (ft/day)
582	3.6	72	0.07
588	5.8	116	0.13
818	7.6	151	0.17
mean[b]	5.3	103	0.12

[a] Linear velocity is a function of an assumed porosity of 0.20 for sandstone and conglomerate (Walton, 1970); hydraulic gradient is calculated at each well from October 1987 water levels.

[b] Geometric mean.

Table D.5.12 Summary of vertical hydraulic gradients beneath the present tailings pile, Green River, Utah, tailings site[a]

	Top unit	Upper-middle unit	Lower-middle unit	Bottom unit
Top unit	--	0.12 downward	0.38 upward	0.11 upward
Upper-middle unit	--	--	0.87 upward	0.16 upward
Lower-middle unit	--	--	--	0.07 downward

[a] Gradient values are in foot per foot. Gradients were calculated using October 1987 water levels at the areal center of the tailings pile; the vertical distance between units was measured from cross section B-B' on Figure D.5.3.

Table D.5.13 Summary of vertical hydraulic gradients beneath the proposed disposal site, Green River, Utah, tailings site[a]

	Top unit	Upper-middle unit	Lower-middle unit	Bottom unit
Top unit	(The top unit is not present at the disposal site)[b]			
Upper-middle unit	--	--	0.55 upward	0.03 upward
Lower-middle unit	--	--	--	0.02 downward

[a] Gradient values are in foot per foot. Gradients were calculated using October 1987 water levels at the areal center of the disposal site; the vertical distance between units was measured from cross section C-C' in Figure D.5.4.

[b] Groundwater is first encountered at a depth of about 60 feet beneath the proposed disposal site (near the contact of the upper-middle unit with the lower-middle unit).

Table D.5.14 Description of groundwater samples, Green River, Utah, tailings site

Sample number	Hydrostratigraphic unit	Description of sample location
563	Top	Well point, north side of Brown's Wash, approximately 250 feet upgradient from tailings.
702	Top	Well, on-site.
704	Top	Well, on-site.
705	Top	Well, west edge of tailings, on-site.
707	Top	Well, south side of Brown's Wash approximately 900 feet upgradient from tailings.
708	Top	Well, between Brown's Wash and tailings, crossgradient.
808	Top	Well, 60 feet east of well 702, on-site.
583	Upper-middle	Well, north side of Brown's Wash, approximately 1000 feet downgradient from tailings.
584	Upper-middle	Well, south side of Brown's Wash, approximately 200 feet downgradient from tailings.
585	Upper-middle	Well, north side of Brown's Wash, approximately 1100 feet downgradient from tailings.
701	Upper-middle	Well, on-site.
806	Upper-middle	Well, upgradient, approximately 75 feet north of well 707.
809	Upper-middle	Well, downgradient, north of mill yard.
810	Upper-middle	Well, downgradient, in retention structure west of mill yard.
816	Upper-middle	Well, upgradient, center of disposal site.
561	Lower-middle	Well, approximately 100 feet southwest of mill site, west side of road and crossgradient from tailings.

Table D.5.14 Description of groundwater samples, Green River, Utah, tailings site (Concluded)

Sample number	Hydrostratigraphic unit	Description of sample location
562	Lower-middle	Well, approximately 600 feet south (upgradient) from tailings, and 1000 feet east of well 561, located on proposed disposal site.
581	Lower-middle	Flowing well, on-site, between wells 701 and 704.
811	Lower-middle	Well, upgradient, approximately 60 feet east of well 808.
813	Lower-middle	Well, upgradient near disposal site, 100 feet south of water tower.
815	Lower-middle	Well, downgradient, west of tailings.
582	Bottom	Flowing well, north of Brown's Wash, adjacent to well 583 and downgradient from tailings.
586	Bottom	Well, approximately 1100 feet south of and upgradient from tailings, located on SOS disposal site.
587	Bottom	Well, approximately 120 feet southeast of tailings and 650 feet east of well 586, and upgradient from tailings.
588	Bottom	Well, approximately 1200 feet southwest of mill site and 1200 feet west of well site and upgradient from tailings.
818	Bottom	Well, between wells 587 and 586, upgradient from tailings.
819	Bottom	Well, downgradient, west of tailings.

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site

FORMATION OF COMPLETION: URANIUM MILL TAILINGS
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		714-01 03/12/87	714-01 09/11/86			
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALUMINUM	MG/L	6300.	1840.			
AMMONIUM	MG/L	14.	11.			
ANTIMONY	MG/L	-	< 0.003			
ARSENIC	MG/L	-	0.03			
BARIUM	MG/L	-	< 0.1			
BORON	MG/L	0.5	< 0.1			
CADMIUM	MG/L	-	0.032			
CALCIUM	MG/L	457.	385.			
CHLORIDE	MG/L	143.	2900.			
CHROMIUM	MG/L	2.61	1.14			
COBALT	MG/L	-	30.9			
COPPER	MG/L	-	45.8			
FLUORIDE	MG/L	< 0.1	0.2			
IRON	MG/L	2200.	267.			
LEAD	MG/L	-	0.02			
MAGNESIUM	MG/L	2640.	1090.			
MANGANESE	MG/L	360.	122.			
MERCURY	MG/L	-	0.			
MOLYBDENUM	MG/L	0.2	0.10			
NICKEL	MG/L	-	25.3			
NITRATE	MG/L	4500.	2.			
NITRITE	MG/L	-	< 0.1			
PHOSPHATE	MG/L	-	< 0.1			
POTASSIUM	MG/L	0.19	16.0			
SELENIUM	MG/L	0.092	0.208			
SILICA	MG/L	-	60.			
SILVER	MG/L	-	< 0.01			
SODIUM	MG/L	89.2	111.			
STRONTIUM	MG/L	-	0.1			
SULFATE	MG/L	56200.	16000.			
TIN	MG/L	-	< 0.005			
TOTAL SOLIDS	MG/L	80800.	26100.			
URANIUM	MG/L	675.	221.			
VANADIUM	MG/L	-	178.			
ZINC	MG/L	-	259.			

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE						
		563-01 06/04/86	563-01 09/07/86	563-01 02/27/87	563-01 10/02/87		563-01 01/10/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	457.	182.	138.	165.		162.	
ALUMINUM	MG/L	0.4	0.3	< 0.1	< 0.1		0.3	
AMMONIUM	MG/L	< 0.1	< 0.1	< 0.1	0.1		< 0.1	
ANTIMONY	MG/L	< 0.003	< 0.003	-	-		-	
ARSENIC	MG/L	< 0.01	< 0.01	-	0.01		0.01	
BALANCE	%	0.16	0.06	-	-		-	
BARIUM	MG/L	0.2	0.2	-	-		-	
BICARBONATE	MG/L	-	-	-	-		-	
BORON	MG/L	0.3	0.5	0.22	0.4		0.48	
CADMIUM	MG/L	< 0.001	< 0.001	-	-		-	
CALCIUM	MG/L	488.	500.	377.	440.		417.	
CHLORIDE	MG/L	312.	240.	312.	290.		310.	
CHROMIUM	MG/L	0.05	0.02	0.03	< 0.01		0.03	
COBALT	MG/L	0.09	0.07	-	-		-	
CONDUCTANCE	UMHO/CM	5500.	6250.	6500.	8300.		6530.	
COPPER	MG/L	0.05	0.03	-	-		-	
FLUORIDE	MG/L	0.6	0.7	0.48	0.6		0.48	
GROSS ALPHA	PCI/L	-	-	-	0.0	43.	41.	38.
GROSS BETA	PCI/L	-	-	-	15.	48.	1.	27.
IRON	MG/L	0.18	0.20	0.59	0.79		1.23	
LEAD	MG/L	< 0.01	< 0.01	-	-		-	
MAGNESIUM	MG/L	364.	367.	347.	340.		337.	
MANGANESE	MG/L	0.04	0.03	0.03	< 0.01		0.06	
MERCURY	MG/L	< 0.0002	< 0.0002	-	-		-	
MOLYBDENUM	MG/L	0.15	0.14	< 0.1	< 0.01		0.20	
NICKEL	MG/L	0.09	< 0.04	-	-		-	
NITRATE	MG/L	11.	41.	44.3	34.		23.9	
NITRITE	MG/L	< 0.1	< 0.1	-	-		-	
ORG. CARBON	MG/L	-	-	-	< 1.		39.8	
PB-210	PCI/L	-	-	-	-		-	
PH	SU	7.69	7.55	7.58	7.25		7.5	
PHOSPHATE	MG/L	< 0.1	< 0.1	-	-		-	
PO-210	PCI/L	-	-	-	-		-	
POTASSIUM	MG/L	18.8	22.6	12.6	16.7		17.4	
RA-226	PCI/L	-	-	-	0.3	0.2	0.	0.1
RA-228	PCI/L	-	-	-	1.4	1.0	0.4	0.9
SELENIUM	MG/L	< 0.005	< 0.005	0.38	0.12		0.320	
SILCON	MG/L	-	-	-	-		-	
SILICA	MG/L	4.	7.	-	-		-	
SILVER	MG/L	< 0.01	< 0.01	-	-		-	
SODIUM	MG/L	1680.	1830.	1810.	1600.		1900.	
STRONTIUM	MG/L	7.2	0.6	-	-		-	
SULFATE	MG/L	5540.	5960.	5490.	5500.		5740.	
SULFIDE	MG/L	-	-	-	-		-	
TEMPERATURE	C - DEGREE	19.	17.	9.5	17.5		9.9	
TH-230	PCI/L	-	-	-	-		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		563-01 06/04/86	563-01 09/07/86	563-01 02/27/87	563-01 10/02/87	563-01 01/10/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	< 0.005	< 0.005	-	-	-
TOTAL SOLIDS	MG/L	9230.	8800.	9240.	8740.	9080.
URANIUM	MG/L	0.0424	0.0404	0.0405	0.043	0.0405
VANADIUM	MG/L	0.32	0.22	-	< 0.01	0.07
ZINC	MG/L	0.026	0.431	-	0.026	0.045

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		707-01 07/15/82	707-01 09/16/82	707-01 11/23/82	707-01 06/04/86	707-01 09/07/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	180.00	190.00	254.00	360.	176.
ALUMINUM	MG/L	0.13	< 0.01	0.023	0.4	0.2
AMMONIUM	MG/L	-	-	-	< 0.1	2.4
ANTIMONY	MG/L	-	-	-	< 0.003	< 0.003
ARSENIC	MG/L	< 0.01	< 0.01	0.006	< 0.01	< 0.01
BALANCE	%	-	-	-	-1.20	0.18
BARIUM	MG/L	< 0.10	0.015	< 0.05	0.3	< 0.1
BICARBONATE	MG/L	220.00	232.00	306.00	-	-
BORON	MG/L	-	-	-	0.6	0.4
CADMIUM	MG/L	< 0.01	< 0.01	< 0.005	< 0.004	< 0.001
CALCIUM	MG/L	450.00	470.00	460.00	488.	520.
CHLORIDE	MG/L	430.00	345.00	561.00	312.	590.
CHROMIUM	MG/L	< 0.01	< 0.01	< 0.005	0.05	0.02
COBALT	MG/L	-	-	-	0.09	0.07
CONDUCTANCE	UMHO/CM	8640.00	9650.00	9440.00	4900.	6200.
COPPER	MG/L	0.057	0.021	< 0.005	0.05	0.04
FLUORIDE	MG/L	1.00	< 1.00	< 1.00	0.6	0.7
GROSS ALPHA	PCI/L	200.00	-	230.00	-	-
GROSS BETA	PCI/L	-	-	-	-	-
IRON	MG/L	< 0.05	< 0.05	< 0.05	0.18	0.04
LEAD	MG/L	< 0.01	< 0.01	< 0.005	< 0.01	< 0.01
MAGNESIUM	MG/L	360.00	225.00	361.00	368.	388.
MANGANESE	MG/L	-	-	-	0.04	0.03
MERCURY	MG/L	< 0.002	< 0.002	< 0.002	< 0.0002	< 0.0002
MOLYBDENUM	MG/L	< 0.05	< 0.05	< 0.05	0.18	0.06
NICKEL	MG/L	-	-	-	0.09	0.08
NITRATE	MG/L	1.00	14.00	< 5.00	11.	120.
NITRITE	MG/L	-	-	-	< 0.1	< 0.1
ORG. CARBON	MG/L	-	-	-	-	41.
PB-210	PCI/L	-	-	-	-	0.0 1.3
PH	SU	7.40	7.12	6.93	7.88	7.56
PHOSPHATE	MG/L	-	-	-	< 0.1	< 0.1
PO-210	PCI/L	-	-	-	-	0.0 0.6
POTASSIUM	MG/L	18.00	21.00	18.00	19.3	26.1
RA-226	PCI/L	4.00	< 2.00	< 2.00	0.2 0.2	0.2 0.2
RA-228	PCI/L	8.00	< 2.00	-	1.1 0.9	0.0 0.8
SELENIUM	MG/L	0.13	0.104	0.124	< 0.005	0.069
SILICON	MG/L	8.80	6.70	6.20	-	-
SILICA	MG/L	-	-	-	4.	8.
SILVER	MG/L	0.014	< 0.01	< 0.005	< 0.01	< 0.01
SODIUM	MG/L	1880.00	1945.00	1790.00	1680.	2080.
STRONTIUM	MG/L	-	-	-	7.2	6.3
SULFATE	MG/L	5830.00	5537.00	6240.00	5530.	6070.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	21.00	22.00	16.00	15.	19.
TH-230	PCI/L	< 0.10	< 0.10	< 0.10	-	0.0 1.6

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		707-01 07/15/82	707-01 09/16/82	707-01 11/23/82	707-01 06/04/86	707-01 09/07/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	-	-	-	< 0.005	< 0.005
TOTAL SOLIDS	MG/L	9080.00	8680.00	9560.00	9420.	9480.
URANIUM	MG/L	0.016	0.025	0.03	0.0425	0.0090
VANADIUM	MG/L	< 0.05	< 0.05	< 0.05	0.29	0.16
ZINC	MG/L	-	-	-	0.023	0.023

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		707-01 03/13/87		707-01 10/02/87		707-01 01/10/88		707-01 07/18/88			
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	261.		159.		160.		166.			
ALUMINUM	MG/L	0.2		< 0.1		0.4		0.20			
AMMONIUM	MG/L	< 0.1		0.1		< 0.1		< 0.1			
ANTIMONY	MG/L	-		-		-		-			
ARSENIC	MG/L	-		< 0.01		0.01		0.025			
BALANCE	%	-		-		-		-			
BARIUM	MG/L	-		-		-		< 0.01			
BICARBONATE	MG/L	-		-		-		-			
BORON	MG/L	0.6		0.4		0.51		0.5			
CADMIUM	MG/L	-		-		-		0.006			
CALCIUM	MG/L	425.		449.		509.		407.			
CHLORIDE	MG/L	295.		300.		340.		330.			
CHROMIUM	MG/L	0.03		< 0.01		< 0.01		0.14			
COBALT	MG/L	-		-		-		-			
CONDUCTANCE	UMHO/CM	4400.		8500.		7480.		6500.			
COPPER	MG/L	-		-		-		0.01			
FLUORIDE	MG/L	0.5		0.6		0.47		0.5			
GROSS ALPHA	PCI/L	-		0.0	51.	7.	38.	0.	77.		
GROSS BETA	PCI/L	-		0.0	44.	17.	28.	32.	44.		
IRON	MG/L	0.05		< 0.03		0.2		0.10			
LEAD	MG/L	-		-		-		< 0.01			
MAGNESIUM	MG/L	355.		380.		416.		331.			
MANGANESE	MG/L	0.02		< 0.01		0.03		0.02			
MERCURY	MG/L	-		-		-		< 0.0002			
MOLYBDENUM	MG/L	< 0.1		< 0.01		0.20		0.08			
NICKEL	MG/L	-		-		-		-			
NITRATE	MG/L	140.		36.		8.7		25.			
NITRITE	MG/L	-		-		-		-			
ORG. CARBON	MG/L	-		4.		35.5		44.4			
PB-210	PCI/L	-		-		-		-			
PH	SU	7.77		7.4		7.5		7.56			
PHOSPHATE	MG/L	-		-		-		-			
PO-210	PCI/L	-		-		-		-			
POTASSIUM	MG/L	34.2		17.2		16.9		22.2			
RA-226	PCI/L	-		0.2	0.1	0.	0.1	0.0	0.1		
RA-228	PCI/L	-		1.5	1.0	0.	0.7	0.0	0.7		
SELENIUM	MG/L	0.034		0.12		0.324		0.231			
SILICON	MG/L	-		-		-		-			
SILICA	MG/L	-		-		-		-			
SILVER	MG/L	-		-		-		< 0.01			
SODIUM	MG/L	1920.		1790.		1680.		1830.			
STRONTIUM	MG/L	-		-		-		-			
SULFATE	MG/L	5840.		5700.		5820.		5720.			
SULFIDE	MG/L	-		-		-		< 0.1			
TEMPERATURE	C - DEGREE	14.0		17.0		13.7		17.5			
TH-230	PCI/L	-		-		-		-			

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE			
		707-01 03/13/87	707-01 10/02/87	707-01 01/10/88	707-01 07/18/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE +/-UNCERTAINTY	PARAMETER VALUE +/-UNCERTAINTY	PARAMETER VALUE +/-UNCERTAINTY	PARAMETER VALUE +/-UNCERTAINTY
TIN	MG/L	-	-	-	-
TOTAL SOLIDS	MG/L	9130.	9000.	9090.	8980.
URANIUM	MG/L	0.0109	0.016	0.0167	0.0081
VANADIUM	MG/L	-	< 0.01	0.07	0.07
ZINC	MG/L	-	< 0.005	0.007	< 0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		702-01 07/14/82		702-01 09/16/82		702-01 06/07/86		702-01 09/07/86		702-02 09/07/86	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	245.00		270.00		237.		245.		245.	
ALUMINUM	MG/L	< 0.10		0.01		-		0.3		0.3	
AMMONIUM	MG/L	-		-		21.		24.		24.	
ANTIMONY	MG/L	-		-		-		< 0.003		< 0.003	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
BALANCE	%	-		-		-0.12		0.08		0.08	
BARIUM	MG/L	< 0.10		0.02		-		< 0.1		< 0.1	
BICARBONATE	MG/L	262.00		329.00		-		-		-	
BORON	MG/L	-		-		-		0.4		0.4	
CADMIUM	MG/L	< 0.01		< 0.01		-		< 0.001		< 0.001	
CALCIUM	MG/L	470.00		-		499.		520.		520.	
CHLORIDE	MG/L	120.00		101.00		92.		100.		100.	
CHROMIUM	MG/L	< 0.01		< 0.01		-		0.02		0.02	
COBALT	MG/L	-		-		-		< 0.05		< 0.05	
CONDUCTANCE	UMHO/CM	4900.00		5560.00		3500.		3900.		3900.	
COPPER	MG/L	0.027		0.011		-		0.03		0.03	
FLUORIDE	MG/L	2.00		2.00		0.8		0.9		0.9	
GROSS ALPHA	PCI/L	700.00		-		-		-		-	
GROSS BETA	PCI/L	-		-		-		-		-	
IRON	MG/L	< 0.05		< 0.05		0.07		< 0.03		< 0.03	
LEAD	MG/L	< 0.01		< 0.01		-		< 0.01		< 0.01	
MAGNESIUM	MG/L	160.00		150.00		122.		175.		175.	
MANGANESE	MG/L	-		-		0.37		0.47		0.47	
MERCURY	MG/L	< 0.002		< 0.002		-		< 0.0002		< 0.0002	
MOLYBDENUM	MG/L	< 0.05		< 0.05		0.27		0.09		0.10	
NICKEL	MG/L	-		-		-		0.05		0.05	
NITRATE	MG/L	2.00		14.00		3.		440.		440.	
NITRITE	MG/L	-		-		-		< 0.1		< 0.1	
ORG. CARBON	MG/L	-		-		-		70.		70.	
PB 210	PCI/L	-		-		-		4.4	1.6	3.5	1.6
PH	SU	7.20		6.95		7.34		6.81		6.81	
PHOSPHATE	MG/L	-		-		-		< 0.1		< 0.1	
PO 240	PCI/L	-		-		-		0.4	0.7	0.2	0.7
POTASSIUM	MG/L	14.00		14.00		11.7		14.8		14.8	
RA 226	PCI/L	< 2.00		< 2.00		0.	0.1	0.1	0.2	0.1	0.2
RA 228	PCI/L	< 5.00		< 2.00		0.	0.9	0.0	1.0	0.8	1.0
SELENIUM	MG/L	0.25		0.003		< 0.005		0.100		0.099	
SILICON	MG/L	10.60		-		-		-		-	
SILICA	MG/L	-		-		-		9.		9.	
SILVER	MG/L	0.01		< 0.01		-		< 0.01		< 0.01	
SODIUM	MG/L	830.00		901.00		798.		800.		800.	
STRONTIUM	MG/L	-		-		-		5.5		5.5	
SULFATE	MG/L	3260.00		3605.00		3070.		2200.		2200.	
SULFIDE	MG/L	-		-		-				-	
TEMPERATURE	C - DEGREE	26.00		16.00		45.		20.		20.	
TH 230	PCI/L	< 0.10		< 0.10		-		3.4	1.1	1.8	0.8

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		702-04 07/14/82	702-04 09/16/82	702-04 06/07/86	702-04 09/07/86	702-02 09/07/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	-	-	-	< 0.005	< 0.005
TOTAL SOLIDS	MG/L	4990.00	4870.00	5050.	5090.	5400.
URANIUM	MG/L	0.90	0.70	0.739	1.49	1.19
VANADIUM	MG/L	< 0.05	< 0.05	-	0.24	-
ZINC	MG/L	-	-	-	0.023	0.023

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE									
		702-03 09/07/86		702-04 09/07/86		702-05 09/07/86		702-01 03/13/87		702-02 03/13/87	
		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	245.		245.		245.		271.		271.	
ALUMINUM	MG/L	0.3		0.3		0.3		0.1		0.2	
AMMONIUM	MG/L	24.		24.		24.		18.		19.	
ANTIMONY	MG/L	< 0.003		< 0.003		< 0.003		-		-	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		-		-	
BALANCE	%	0.08		0.08		0.08		-		-	
BARIUM	MG/L	< 0.1		< 0.1		< 0.1		-		-	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	0.4		0.4		0.4		0.7		0.7	
CADMIUM	MG/L	< 0.001		< 0.001		< 0.001		-		-	
CALCIUM	MG/L	520.		520.		520.		475.		475.	
CHLORIDE	MG/L	100.		100.		100.		76.		76.	
CHROMIUM	MG/L	0.07		0.02		0.02		0.02		0.02	
COBALT	MG/L	< 0.05		< 0.05		< 0.05		-		-	
CONDUCTANCE	UMHO/CM	3900.		3900.		3900.		2650.		2650.	
COPPER	MG/L	0.03		0.03		0.03		-		-	
FLUORIDE	MG/L	0.9		0.9		0.9		0.7		0.7	
GROSS ALPHA	PCI/L	-		-		-		-		-	
GROSS BETA	PCI/L	-		-		-		-		-	
IRON	MG/L	< 0.03		< 0.03		< 0.03		0.05		0.04	
LEAD	MG/L	< 0.01		< 0.01		< 0.01		-		-	
MAGNESIUM	MG/L	175.		175.		175.		150.		150.	
MANGANESE	MG/L	0.47		0.47		0.47		0.43		0.42	
MERCURY	MG/L	< 0.0002		< 0.0002		< 0.0002		-		-	
MOLYBDENUM	MG/L	0.09		0.10		0.10		< 0.1		< 0.1	
NICKEL	MG/L	0.05		0.05		0.05		-		-	
NITRATE	MG/L	440.		440.		440.		142.		142.	
NITRITE	MG/L	< 0.1		< 0.1		< 0.1		-		-	
ORG. CARBON	MG/L	70.		70.		70.		-		-	
PB-210	PCI/L	4.0	1.4	4.2	1.9	5.2	1.7	-		-	
PH	SU	6.84		6.81		6.81		6.86		6.86	
PHOSPHATE	MG/L	< 0.1		< 0.1		< 0.1		-		-	
PO-210	PCI/L	0.2	1.2	0.0	0.6	0.3	0.7	-		-	
POTASSIUM	MG/L	14.8		14.8		14.8		12.4		12.5	
RA-226	PCI/L	0.1	0.2	0.1	0.2	0.2	0.2	-		-	
RA-228	PCI/L	0.0	1.0	0.0	0.8	0.0	0.8	-		-	
SELENIUM	MG/L	0.099		0.100		0.100		0.049		0.050	
SILICON	MG/L	-		-		-		-		-	
SILICA	MG/L	9.		9.		9.		-		-	
SILVER	MG/L	< 0.01		< 0.01		< 0.01		-		-	
SODIUM	MG/L	800.		800.		800.		767.		767.	
STRONTIUM	MG/L	5.5		5.5		5.5		-		-	
SULFATE	MG/L	2980.		2980.		2980.		2950.		2950.	
SULFIDE	MG/L			-		-		-		-	
TEMPERATURE	C - DEGREE	20.0		20.		20.		14.0		14.0	
TH-230	PCI/L	1.6	0.8	1.9	0.9	2.8	1.0	-		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		702-03 09/07/86	702-04 09/07/86	702-05 09/07/86	702-01 03/13/87	702-02 03/13/87
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	< 0.005	< 0.005	< 0.005	-	-
TOTAL SOLIDS	MG/L	5090.	5100.	5090.	4860.	4860.
URANIUM	MG/L	1.22	1.10	1.16	1.96	1.90
VANADIUM	MG/L	0.24	0.24	0.24	-	-
ZINC	MG/L	0.023	0.023	0.023	-	-

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		702-03 03/13/87		702-04 03/13/87		702-05 03/13/87		702-01 10/06/87		702-01 01/12/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	274.		274.		274.		265.		247.	
ALUMINUM	MG/L	0.2		0.2		0.2		< 0.1		0.39	
AMMONIUM	MG/L	49.		48.		49.		42.		24.8	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	-		-		-		< 0.01		< 0.01	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		-		-		-	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	0.7		0.7		0.7		0.4		0.44	
CADMIUM	MG/L	-		-		-		-		-	
CALCIUM	MG/L	474.		474.		475.		460.		449.	
CHLORIDE	MG/L	76.		76.		76.		110.		86.	
CHROMIUM	MG/L	0.02		0.03		0.03		< 0.01		0.02	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	2650.		2650.		2650.		4800.		4090.	
COPPER	MG/L	-		-		-		-		-	
FLUORIDE	MG/L	0.7		0.7		0.7		0.8		0.76	
GROSS ALPHA	PCI/L	-		-		-		450.	90.	690.	60.
GROSS BETA	PCI/L	-		-		-		147.	44.	340.	20.
IRON	MG/L	0.04		0.03		0.04		< 0.03		0.24	
LEAD	MG/L	-		-		-		-		-	
MAGNESIUM	MG/L	450.		451.		450.		140.		126.	
MANGANESE	MG/L	0.41		0.42		0.42		0.27		0.28	
MERCURY	MG/L	-		-		-		-		-	
MOLYBDENUM	MG/L	< 0.1		< 0.1		< 0.1		< 0.01		0.10	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	142.		142.		142.		50.		97.5	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	-		-		-		8.		79.4	
PB-210	PCI/L	-		-		-		-		-	
PH	SU	6.86		6.86		6.86		6.90		6.85	
PHOSPHATE	MG/L	-		-		-		-		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	12.5		12.5		12.5		2.7		10.4	
RA-226	PCI/L	-		-		-		0.3	0.2	0.	0.1
RA-228	PCI/L	-		-		-		2.8	1.0	0.3	0.7
SELENIUM	MG/L	0.049		0.049		0.049		0.040		0.319	
SILICON	MG/L	-		-		-		-		-	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		-		-		-	
SODIUM	MG/L	768.		767.		768.		890.		806.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	2950.		2950.		2950.		3400.		2900.	
SULFIDE	MG/L	-		-		-		-		-	
TEMPERATURE	C - DEGREE	14.0		14.0		14.0		16.0		14.7	
TH-230	PCI/L	-		-		-		-		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		702-03 03/13/87	702-04 03/13/87	702-05 03/13/87	702-01 10/06/87	702-01 01/12/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	4860.	4860.	4860.	5280.	4820.
URANIUM	MG/L	2.07	2.15	2.23	0.79	1.09
VANADIUM	MG/L	-	-	-	< 0.01	0.07
ZINC	MG/L	-	-	-	0.009	0.006

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		704-01 07/14/82		704-01 06/05/86		704-01 09/07/86		704-01 03/13/87		704-01 01/12/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	400.00		368.		390.		376.		350.	
ALUMINUM	MG/L	< 0.10		-		0.3		0.2		0.37	
AMMONIUM	MG/L	-		41.		38.		36.		32.3	
ANTIMONY	MG/L	-		-		< 0.003		-		-	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		-		< 0.01	
BALANCE	%	-		-0.21		-0.09		-		-	
BARIUM	MG/L	-		-		< 0.1		-		-	
BICARBONATE	MG/L	488.00		-		-		-		-	
BORON	MG/L	-		-		0.4		0.5		0.55	
CADMIUM	MG/L	-		-		< 0.001		-		-	
CALCIUM	MG/L	450.00		483.		531.		433.		419.	
CHLORIDE	MG/L	300.00		258.		480.		225.		220.	
CHROMIUM	MG/L	-		-		0.02		0.02		0.02	
COBALT	MG/L	-		-		0.06		-		-	
CONDUCTANCE	UMHO/CM	8160.00		2850.		6100.		4050.		6780.	
COPPER	MG/L	-		-		0.04		-		-	
FLUORIDE	MG/L	2.00		1.1		1.2		1.1		1.09	
GROSS ALPHA	PCI/L	-		200.	110.	-		-		190.	60.
GROSS BETA	PCI/L	-		180.	66.	-		-		150.	30.
IRON	MG/L	< 0.05		0.09		0.03		0.05		0.2	
LEAD	MG/L	-		-		< 0.01		-		-	
MAGNESIUM	MG/L	280.00		231.		247.		220.		205.	
MANGANESE	MG/L	-		0.98		0.48		0.52		0.34	
MERCURY	MG/L	-		-		< 0.0002		-		-	
MOLYBDENUM	MG/L	< 0.05		0.25		0.14		< 0.1		0.47	
NICKEL	MG/L	-		-		0.05		-		-	
NITRATE	MG/L	4.00		20.		350.		167.		57.	
NITRITE	MG/L	-		-		< 0.1		-		-	
ORG. CARBON	MG/L	-		104.		70.		-		112.	
PB-210	PCI/L	-		1.	0.9	1.5	1.7	-		-	
PH	SU	7.90		7.16		7.11		7.15		7.0	
PHOSPHATE	MG/L	-		-		< 0.1		-		-	
PO-210	PCI/L	-		0.4	0.6	0.0	0.6	-		-	
POTASSIUM	MG/L	16.00		18.7		20.0		32.0		11.8	
RA-226	PCI/L	< 2.00		-		0.0	0.2	-		0.	0.1
RA-228	PCI/L	-		-		0.0	1.1	-		0.1	0.7
SELENIUM	MG/L	0.012		< 0.005		0.092		< 0.002		0.223	
SILICON	MG/L	-		-		-		-		-	
SILICA	MG/L	-		-		10.		-		-	
SILVER	MG/L	-		-		< 0.01		-		-	
SODIUM	MG/L	1550.00		1290.		2010.		1840.		1690.	
STRONTIUM	MG/L	-		-		6.6		-		-	
SULFATE	MG/L	4580.00		4200.		5290.		5150.		4840.	
SULFIDE	MG/L	-		-		-		-		-	
TEMPERATURE	C - DEGREE	24.00		15.		22.		14.5		13.7	
TH-230	PCI/L	-		0.	0.2	1.1	0.7	-		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		704-01 07/11/82	704-01 06/05/86	704-01 09/07/86	704-01 03/13/87	704-01 01/12/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	-	-	(0.005	-	-
TOTAL SOLIDS	MG/L	7420.00	8580.	8490.	8090.	7840.
URANIUM	MG/L	0.70	0.487	0.288	0.254	0.441
VANADIUM	MG/L	(0.05	-	0.24	-	0.07
ZINC	MG/L	-	-	0.025	-	0.017

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		705-01 07/15/82	705-01 09/16/82	705-01 06/06/86	705-01 09/07/86	705-01 07/24/87
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	250.00	244.00	294.	298.	346.
ALUMINUM	MG/L	0.27	< 0.01	-	0.4	< 0.1
AMMONIUM	MG/L	-	-	27.	41.	8.0
ANTIMONY	MG/L	-	-	-	< 0.003	-
ARSENIC	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	-
BALANCE	%	-	-	-0.09	-0.04	-
BARIUM	MG/L	-	0.014	-	< 0.1	-
BICARBONATE	MG/L	305.00	298.00	-	-	-
BORON	MG/L	-	-	-	0.6	0.35
CADMIUM	MG/L	-	< 0.01	-	< 0.004	-
CALCIUM	MG/L	450.00	490.00	456.	483.	443.
CHLORIDE	MG/L	400.00	324.00	321.	140.	369.
CHROMIUM	MG/L	-	< 0.01	-	0.02	0.04
COBALT	MG/L	-	-	-	0.08	-
CONDUCTANCE	UMHO/CM	15400.00	8960.00	4900.	6200.	4700.
COPPER	MG/L	-	0.024	-	0.04	-
FLUORIDE	MG/L	1.00	< 1.00	0.8	0.8	0.63
GROSS ALPHA	PCI/L	-	-	-	-	-
GROSS BETA	PCI/L	-	-	-	-	-
IRON	MG/L	< 0.05	< 0.05	0.07	0.06	0.05
LEAD	MG/L	-	< 0.01	-	< 0.01	-
MAGNESIUM	MG/L	280.00	330.00	268.	346.	345.
MANGANESE	MG/L	-	-	0.02	0.03	0.03
MERCURY	MG/L	-	< 0.002	-	< 0.0002	-
MOLYBDENUM	MG/L	< 0.05	< 0.05	0.24	0.16	< 0.1
NICKEL	MG/L	-	-	-	0.10	-
NITRATE	MG/L	1.00	6.00	5.	22.	8.9
NITRITE	MG/L	-	-	-	< 0.1	-
ORG. CARBON	MG/L	-	-	-	-	-
PB-210	PCI/L	-	-	-	-	-
PH	SU	7.20	7.13	7.46	7.34	7.34
PHOSPHATE	MG/L	-	-	-	< 0.1	-
PO-210	PCI/L	-	-	-	-	-
POTASSIUM	MG/L	16.00	18.00	19.4	20.4	17.0
RA-226	PCI/L	< 2.00	< 2.00	-	-	-
RA-228	PCI/L	-	< 2.00	-	-	-
SELENIUM	MG/L	0.023	0.014	< 0.005	< 0.005	0.41
SILCON	MG/L	-	6.70	-	-	-
SILICA	MG/L	-	-	-	7.	-
SILVER	MG/L	-	< 0.01	-	< 0.01	-
SODIUM	MG/L	1680.00	1840.00	2400.	2090.	2450.
STRONTIUM	MG/L	-	-	-	6.6	-
SULFATE	MG/L	5410.00	5021.00	5930.	6425.	6590.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	18.00	19.00	45.	18.	14.
TH-230	PCI/L	-	< 0.10	-	-	-

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		705-01 07/15/82	705-01 09/16/82	705-01 06/03/86	705-01 09/07/86	705-01 02/24/87
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	-	-	-	< 0.005	-
TOTAL SOLIDS	MG/L	8390.00	8480.00	9870.	9730.	10400.
URANIUM	MG/L	0.09	0.118	0.0419	0.0485	0.0578
VANADIUM	MG/L	< 0.05	< 0.05	-	0.21	-
ZINC	MG/L	-	-	-	0.027	-

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		705-01 10/06/87		705-01 01/12/88		705-01 07/21/88		808-01 10/23/87		808-02 10/23/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	302.		335.		267.		270.		270.	
ALUMINUM	MG/L	< 0.1		0.37		0.19		< 0.1		< 0.1	
AMMONIUM	MG/L	42.		36.1		35.		19.1		18.7	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	< 0.01		0.02		0.018		< 0.01		< 0.01	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		< 0.01		-		-	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	6.4		0.55		0.47		0.4		0.4	
CADMIUM	MG/L	-		-		0.072		-		-	
CALCIUM	MG/L	420.		425.		366.		530.		520.	
CHLORIDE	MG/L	360.		370.		320.		101.		100.	
CHROMIUM	MG/L	< 0.01		0.02		0.13		< 0.01		< 0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	9800.		9070.		6500.		4500.		4500.	
COPPER	MG/L	-		-		0.01		-		-	
FLUORIDE	MG/L	0.8		0.66		0.7		0.6		0.7	
GROSS ALPHA	PCI/L	115.	68.	59.	41.	0.	73.	980.	120.	950.	130.
GROSS BETA	PCI/L	76.	57.	93.	33.	26.	40.	310.	56.	450.	88.
IRON	MG/L	< 0.03		0.22		0.09		< 0.03		< 0.03	
LEAD	MG/L	-		-		< 0.01		-		-	
MAGNESIUM	MG/L	310.		315.		248.		165.		161.	
MANGANESE	MG/L	< 0.01		0.03		0.02		0.51		0.45	
MERCURY	MG/L	-		-		< 0.0002		-		-	
MOLYBDENUM	MG/L	0.03		0.21		0.09		< 0.01		< 0.01	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	11.5		3.5		1.9		437.		143.	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	5.		97.3		74.6		12.		13.	
PB-210	PCI/L	-		-		-		-		-	
PH	SU	7.2		7.15		7.26		6.8		6.8	
PHOSPHATE	MG/L	-		-		-		-		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	16.3		17.7		19.7		10.5		10.5	
RA-226	PCI/L	0.5	0.3	0.1	0.1	0.0	0.1	0.0	0.1	0.2	0.1
RA-228	PCI/L	1.2	0.9	0.1	0.8	0.5	0.7	0.1	0.9	0.2	1.0
SELENIUM	MG/L	< 0.005		0.367		0.137		0.32		0.31	
SILCON	MG/L	-		-		-		-		-	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		0.02		-		-	
SODIUM	MG/L	2100.		2540.		1920.		720.		760.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	5200.		6890.		5950.		3000.		3000.	
SULFIDE	MG/L	-		-		< 0.1		-		-	
TEMPERATURE	C - DEGREE	14.5		15.0		16.0		17.0		17.0	
TH-230	PCI/L	-		-		-		-		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		705-01 10/06/87	705-01 01/12/88	705-01 07/21/88	808-01 10/23/87	808-02 10/23/87
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	1[illegible]00.	10800.	9230.	4980.	4960.
URANIUM	MG/L	0.084	0.0647	0.0521	1.31	1.64
VANADIUM	MG/L	< 0.01	0.07	0.07	< 0.01	< 0.01
ZINC	MG/L	< 0.005	0.007	< 0.005	0.036	0.042

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		808-03 10/23/87		808-04 10/23/87		808-05 10/23/87		808-01 01/11/88		808-02 01/11/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	270.		270.		270.		226.		226.	
ALUMINUM	MG/L	< 0.1		< 0.1		< 0.1		0.38		0.39	
AMMONIUM	MG/L	18.7		18.9		18.9		19.1		18.6	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		0.01		< 0.01	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		-		-		-	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	0.4		0.3		0.4		0.47		0.45	
CADMIUM	MG/L	-		-		-		-		-	
CALCIUM	MG/L	510.		460.		490.		460.		452.	
CHLORIDE	MG/L	99.		98.		132.		83.		78.	
CHROMIUM	MG/L	< 0.01		< 0.01		< 0.01		0.01		0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	4500.		4500.		4500.		4020.		4020.	
COPPER	MG/L	-		-		-		-		-	
FLUORIDE	MG/L	0.7		0.7		0.8		0.72		0.73	
GROSS ALPHA	PCI/L	700.	115.	1020.	160.	840.	110.	950.	60.	900.	60.
GROSS BETA	PCI/L	450.	75.	410.	180.	370.	59.	480.	20.	500.	20.
IRON	MG/L	< 0.03		< 0.03		< 0.03		0.2		0.2	
LEAD	MG/L	-		-		-		-		-	
MAGNESIUM	MG/L	157.		156.		150.		133.		130.	
MANGANESE	MG/L	0.46		0.45		0.49		0.56		0.55	
MERCURY	MG/L	-		-		-		-		-	
MOLYBDENUM	MG/L	< 0.01		< 0.01		< 0.01		0.10		0.11	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	129.		142.		131.		70.		69.	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	12.		12.		8.		76.		77.2	
PB-210	PCI/L	-		-		-		-		-	
PH	SU	6.8		6.8		6.8		7.0		7.0	
PHOSPHATE	MG/L	-		-		-		-		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	10.5		10.5		10.5		10.5		10.5	
RA-226	PCI/L	0.1	0.1	0.0	0.2	0.0	0.1	0.	0.1	0.	0.1
RA-228	PCI/L	0.0	0.9	7.5	1.6	0.0	0.9	0.1	0.8	0.4	0.8
SELENIUM	MG/L	0.35		0.30		0.35		0.502		0.428	
SILICON	MG/L	-		-		-		-		-	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		-		-		-	
SODIUM	MG/L	690.		670.		660.		702.		593.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	3000.		3000.		3000.		2550.		2560.	
SULFIDE	MG/L	-		-		-		-		-	
TEMPERATURE	C - DEGREE	17.0		17.0		17.0		14.1		14.1	
TH-230	PCI/L	-		-		-		-		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		808-03 10/23/87	808-04 10/23/87	808-05 10/23/87	808-01 01/11/88	808-02 01/11/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TIN	MG/L	-	-	-	-	-
TOTAL SOLIDS	MG/L	4970.	4990.	4960.	4610.	4640.
URANIUM	MG/L	1.23	1.67	1.67	1.67	1.80
VANADIUM	MG/L	< 0.01	< 0.01	< 0.01	0.06	0.06
ZINC	MG/L	0.029	0.028	0.035	0.016	0.014

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE							
		808-03 01/11/88		808-04 01/11/88		808-05 01/11/88			
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	226.		226.		226.			
ALUMINUM	MG/L	0.4		0.4		0.4			
AMMONIUM	MG/L	18.6		18.6		18.6			
ANTIMONY	MG/L	-		-		-			
ARSENIC	MG/L	0.01		< 0.01		< 0.01			
BALANCE	%	-		-		-			
BARIUM	MG/L	-		-		-			
BICARBONATE	MG/L	-		-		-			
BORON	MG/L	0.43		0.42		0.45			
CADMIUM	MG/L	-		-		-			
CALCIUM	MG/L	458.		455.		456.			
CHLORIDE	MG/L	78.		78.		78.			
CHROMIUM	MG/L	0.01		0.01		0.01			
COBALT	MG/L	-		-		-			
CONDUCTANCE	UMHO/CM	4020.		4020.		4020.			
COPPER	MG/L	-		-		-			
FLUORIDE	MG/L	0.72		0.7		0.7			
GROSS ALPHA	PCI/L	920.	60.	940.	60.	1200.	100.		
GROSS BETA	PCI/L	490.	20.	490.	20.	530.	20.		
IRON	MG/L	0.2		0.19		0.2			
LEAD	MG/L	-		-		-			
MAGNESIUM	MG/L	132.		131.		132.			
MANGANESE	MG/L	0.54		0.53		0.54			
MERCURY	MG/L	-		-		-			
MOLYBDENUM	MG/L	0.15		0.11		0.10			
NICKEL	MG/L	-		-		-			
NITRATE	MG/L	68.		63.		67.			
NITRITE	MG/L	-		-		-			
ORG. CARBON	MG/L	76.6		76.5		75.5			
PB-210	PCI/L	-		-		-			
PH	SU	7.0		7.0		7.0			
PHOSPHATE	MG/L	-		-		-			
PO-210	PCI/L	-		-		-			
POTASSIUM	MG/L	10.6		10.7		10.3			
RA-226	PCI/L	0.	0.1	0.2	0.1	0.	0.1		
RA-228	PCI/L	0.	0.7	0.	0.7	0.	0.8		
SELENIUM	MG/L	0.441		0.760		0.725			
SILICON	MG/L	-		-		-			
SILICA	MG/L	-		-		-			
SILVER	MG/L	-		-		-			
SODIUM	MG/L	762.		699.		691.			
STRONTIUM	MG/L	-		-		-			
SULFATE	MG/L	2570.		2560.		2570.			
SULFIDE	MG/L	-		-		-			
TEMPERATURE	C - DEGREE	14.1		14.1		14.1			
TH-230	PCI/L	-		-		-			

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE		
		808-03 01/11/88	808-04 01/11/88	808-05 01/11/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE +/-UNCERTAINTY	PARAMETER VALUE +/-UNCERTAINTY	PARAMETER VALUE +/-UNCERTAINTY
TIN	MG/L	-	-	-
TOTAL SOLIDS	MG/L	4640.	4620.	4640.
URANIUM	MG/L	1.72	1.80	1.69
VANADIUM	MG/L	0.07	0.06	0.06
ZINC	MG/L	0.014	0.012	0.014

MAPPER DATA FILE NAME: GRN01*UDPGWQ102483

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: CROSS GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE					
		708-01 09/15/82	708-01 11/23/82	708-01 09/07/86	708-01 02/25/87	708-01 01/11/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	272.00	261.00	283.	263.	206.	
ALUMINUM	MG/L	0.01	0.037	0.2	< 0.1	0.35	
AMMONIUM	MG/L	-	-	< 0.1	8.2	< 0.1	
ANTIMONY	MG/L	-	-	< 0.003	-	-	
ARSENIC	MG/L	< 0.01	0.007	< 0.01	-	0.01	
BALANCE	%	-	-	0.01	-	-	
BARIUM	MG/L	0.021	-	< 0.1	-	-	
BICARBONATE	MG/L	332.00	318.00	-	-	-	
BORON	MG/L	-	-	0.5	0.23	0.36	
CADMIUM	MG/L	< 0.01	-	< 0.001	-	-	
CALCIUM	MG/L	440.00	319.00	512.	383.	405.	
CHLORIDE	MG/L	341.00	592.00	150.	358.	320.	
CHROMIUM	MG/L	< 0.01	-	0.03	0.04	0.01	
COBALT	MG/L	-	-	0.09	-	-	
CONDUCTANCE	UMHO/CM	10400.00	9670.00	6750.	4650.	6700.	
COPPER	MG/L	0.033	-	0.03	-	-	
FLUORIDE	MG/L	< 1.00	< 1.00	0.7	0.50	0.5	
GROSS ALPHA	PCI/L	-	-	-	-	31.	37.
GROSS BETA	PCI/L	-	-	-	-	17.	27.
IRON	MG/L	< 0.05	-	0.06	0.05	0.2	
LEAD	MG/L	< 0.01	-	< 0.01	-	-	
MAGNESIUM	MG/L	325.00	319.00	320.	313.	190.	
MANGANESE	MG/L	-	-	0.03	0.03	0.02	
MERCURY	MG/L	< 0.002	-	< 0.0002	-	-	
MOLYBDENUM	MG/L	< 0.05	< 0.05	0.11	< 0.1	0.13	
NICKEL	MG/L	-	-	0.06	-	-	
NITRATE	MG/L	2.00	< 5.00	9.	1.6	1.3	
NITRITE	MG/L	-	-	< 0.1	-	-	
ORG. CARBON	MG/L	-	-	-	-	55.9	
PH	SU	6.97	6.97	7.28	7.61	7.1	
PHOSPHATE	MG/L	-	-	< 0.1	-	-	
POTASSIUM	MG/L	21.00	18.00	22.1	16.6	12.9	
RA-226	PCI/L	< 2.00	< 2.00	-	-	0.1	0.1
RA-228	PCI/L	< 2.00	-	-	-	0.0	0.8
SELENIUM	MG/L	0.013	0.014	< 0.005	0.10	0.284	
SILCON	MG/L	6.70	-	-	-	-	
SILICA	MG/L	-	-	7.	-	-	
SILVER	MG/L	< 0.01	-	< 0.01	-	-	
SODIUM	MG/L	2225.00	2100.00	1980.	2320.	1760.	
STRONTIUM	MG/L	-	-	0.8	-	-	
SULFATE	MG/L	5469.00	5684.00	6180.	6280.	4800.	
TEMPERATURE	C - DEGREE	21.00	13.00	20.	10.0	8.2	
TH-230	PCI/L	< 0.10	-	-	-	-	
TIN	MG/L	-	-	< 0.005	-	-	
TOTAL SOLIDS	MG/L	8940.00	9190.00	9310.	10407.	7809.	
URANIUM	MG/L	0.027	0.031	0.0080	0.0077	0.0375	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: ALLUVIUM
HYDRAULIC FLOW RELATIONSHIP: CROSS GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		708-01 09/15/82	708-01 11/23/82	708-01 09/07/86	708-01 02/25/87	708-01 01/11/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
VANADIUM	MG/L	< 0.05	< 0.05	0.22	-	0.06
ZINC	MG/L	-	-	0.024	-	0.016

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		806-01 10/23/87		806-01 01/10/88		806-01 07/21/88		807-01 10/06/87		807-01 01/07/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	988.		967.		986.		627.		643.	
ALUMINUM	MG/L	< 0.1		< 0.1		< 0.01		< 0.1		0.1	
AMMONIUM	MG/L	0.2		0.1		< 0.1		0.4		0.1	
ARSENIC	MG/L	< 0.01		< 0.01		0.007		< 0.01		0.021	
BARIUM	MG/L	-		-		0.01		-		-	
BORON	MG/L	0.8		0.89		0.8		0.8		0.84	
CADMIUM	MG/L	-		-		0.026		-		-	
CALCIUM	MG/L	4.9		5.20		4.73		83.		137.	
CHLORIDE	MG/L	188.		169.		200.		100.		400.	
CHROMIUM	MG/L	< 0.01		0.02		< 0.01		< 0.01		0.02	
CONDUCTANCE	UMHO/CM	2750.		2870.		2800.		8000.		8880.	
COPPER	MG/L	-		-		< 0.01		-		-	
FLUORIDE	MG/L	1.8		1.95		3.5		1.9		1.24	
GROSS ALPHA	PCI/L	0.0	23.	5.	13.	0.	19.	0.0	36.	31.	32.
GROSS BETA	PCI/L	4.5	18.	7.3	9.6	5.	11.	0.0	38.	49.	35.
IRON	MG/L	< 0.03		0.12		< 0.01		< 0.03		0.14	
LEAD	MG/L	-		-		0.01		-		-	
MAGNESIUM	MG/L	1.54		1.54		1.37		45.		54.7	
MANGANESE	MG/L	< 0.01		0.01		< 0.01		0.04		0.05	
MERCURY	MG/L	-		-		< 0.0002		-		-	
MOLYBDENUM	MG/L	< 0.01		0.02		0.02		0.07		0.11	
NITRATE	MG/L	< 1.0		< 0.1		0.3		670.		975.	
ORG. CARBON	MG/L	4.		233.		182.		19.		176.	
PH	SU	7.9		8.0		8.07		7.65		7.4	
POTASSIUM	MG/L	1.42		1.57		1.6		4.4		5.5	
RA-226	PCI/L	0.1	0.1	0.3	0.2	0.0	0.1	1.5	0.4	0.	0.1
RA-228	PCI/L	0.3	0.9	0.	0.9	0.1	0.8	1.1	0.8	0.4	0.9
SELENIUM	MG/L	< 0.005		0.048		0.022		0.17		0.25	
SILVER	MG/L	-		-		< 0.01		-		-	
SODIUM	MG/L	850.		871.		823.		2260.		2450.	
SULFATE	MG/L	570.		720.		682.		4000.		4160.	
SULFIDE	MG/L	-		-		< 0.1		-		-	
TEMPERATURE	C - DEGREE	16.0		14.8		17.0		17.5		14.3	
TOTAL SOLIDS	MG/L	2200.		2400.		2290.		7550.		9540.	
URANIUM	MG/L	< 0.003		< 0.0003		< 0.0003		0.005		0.0053	
VANADIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		0.02	
ZINC	MG/L	< 0.005		0.042		< 0.005		< 0.005		0.043	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE							
		807-01 07/21/88		816-01 10/23/87		816-01 04/07/88			
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	646.		-		485.			
ALUMINUM	MG/L	0.07		0.9		0.4			
AMMONIUM	MG/L	< 0.1		1.4		< 0.1			
ARSENIC	MG/L	0.043		< 0.01		0.014			
BARIUM	MG/L	0.01		-		-			
BORON	MG/L	0.84		0.6		0.52			
CADMIUM	MG/L	0.125		-		-			
CALCIUM	MG/L	175.		410.		436.			
CHLORIDE	MG/L	130.		165.		340.			
CHROMIUM	MG/L	0.06		< 0.01		0.05			
CONDUCTANCE	UMHO/CM	10500.		3700.		5240.			
COPPER	MG/L	< 0.01		-		-			
FLUORIDE	MG/L	1.3		0.8		0.52			
GROSS ALPHA	PCI/L	0.	67.	-		21.	25.		
GROSS BETA	PCI/L	0.	38.	-		40.	27.		
IRON	MG/L	0.04		0.43		0.4			
LEAD	MG/L	0.02		-		-			
MAGNESIUM	MG/L	63.3		300.		542.			
MANGANESE	MG/L	0.07		0.21		0.1			
MERCURY	MG/L	< 0.0002		-		-			
MOLYBDENUM	MG/L	0.07		0.02		0.05			
NITRATE	MG/L	1280.		85.		93.			
ORG. CARBON	MG/L	158.		-		84.7			
PH	SU	7.45		7.6		7.2			
POTASSIUM	MG/L	7.2		22.4		29.5			
RA-226	PCI/L	0.0	0.1	-		0.1	0.1		
RA-228	PCI/L	0.8	0.7	-		0.7	0.8		
SELENIUM	MG/L	0.322		0.72		2.5			
SILVER	MG/L	< 0.01		-		-			
SODIUM	MG/L	3240.		790.		707.			
SULFATE	MG/L	6450.		3600.		3940.			
SULFIDE	MG/L	< 0.1		-		-			
TEMPERATURE	C - DEGREE	17.5		15.0		13.3			
TOTAL SOLIDS	MG/L	11700.		6220.		7300.			
URANIUM	MG/L	0.0054		0.038		0.0074			
VANADIUM	MG/L	0.03		< 0.01		0.08			
ZINC	MG/L	0.007		0.045		0.068			

MAPPER DATA FILE NAME: GRN01*UPPGUQ102191

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		701-01 07/14/82	701-01 06/06/86	701-02 06/06/86	701-03 06/06/86	701-04 06/06/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	330.00	442.	442.	442.	442.
ALUMINUM	MG/L	< 0.10	-	-	-	-
AMMONIUM	MG/L	-	34.	30.	30.	30.
ANTIMONY	MG/L	-	-	-	-	-
ARSENIC	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
BALANCE	%	-	-1.40	-0.02	-0.02	-0.02
BARIUM	MG/L	-	-	-	-	-
BICARBONATE	MG/L	401.00	-	-	-	-
BORON	MG/L	-	-	-	-	-
CADMIUM	MG/L	-	-	-	-	-
CALCIUM	MG/L	390.00	511.	510.	510.	510.
CHLORIDE	MG/L	100.00	107.	110.	110.	110.
CHROMIUM	MG/L	-	-	-	-	-
COBALT	MG/L	-	-	-	-	-
CONDUCTANCE	UMHO/CM	7440.00	5000.	5000.	5000.	5000.
COPPER	MG/L	-	-	-	-	-
FLUORIDE	MG/L	2.00	0.9	0.9	0.9	0.9
GROSS ALPHA	PCI/L	-	-	-	-	-
GROSS BETA	PCI/L	-	-	-	-	-
IRON	MG/L	< 0.05	0.08	0.08	0.08	0.08
LEAD	MG/L	-	-	-	-	-
MAGNESIUM	MG/L	140.00	190.	190.	190.	190.
MANGANESE	MG/L	-	2.7	2.3	2.3	2.3
MERCURY	MG/L	-	-	-	-	-
MOLYBDENUM	MG/L	< 0.05	0.2	0.18	0.2	0.2
NICKEL	MG/L	-	-	-	-	-
NITRATE	MG/L	28.00	1370.	1190.	1190.	1190.
NITRITE	MG/L	-	-	-	-	-
ORG. CARBON	MG/L	-	-	-	-	-
PB-210	PCI/L	-	-	-	-	-
PH	SU	7.00	7.67	7.67	7.67	7.67
PHOSPHATE	MG/L	-	-	-	-	-
PO-210	PCI/L	-	-	-	-	-
POTASSIUM	MG/L	11.00	13.5	13.3	13.3	13.3
RA-226	PCI/L	< 2.00	0.3 0.2	-	-	-
RA-228	PCI/L	-	0.6 0.9	-	-	-
SELENIUM	MG/L	0.36	0.01	0.01	0.01	0.01
SILICA	MG/L	-	-	-	-	-
SILVER	MG/L	-	-	-	-	-
SODIUM	MG/L	1530.00	1150.	1170.	1170.	1170.
STRONTIUM	MG/L	-	-	-	-	-
SULFATE	MG/L	3610.00	3050.	3020.	3070.	3020.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	18.00	17.	17.	17.	17.
TH-230	PCI/L	-	-	-	-	-
TIN	MG/L	-	-	-	-	-

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		701-01 07/11/82	701-01 06/06/86	701-02 06/06/86	701-03 06/06/86	701-04 06/06/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
TOTAL SOLIDS	MG/L	6010.00	7110.	7160.	7100.	7120.
URANIUM	MG/L	1.40	1.11	2.91	2.99	2.98
VANADIUM	MG/L	< 0.05	-	-	-	-
ZINC	MG/L	-	-	-	-	-

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		701-05 06/04/86		701-01 09/07/86		701-01 03/13/87		701-01 10/06/87		701-01 04/12/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	442.		395.		407.		398.		253.	
ALUMINUM	MG/L	-		0.3		0.2		< 0.1		0.4	
AMMONIUM	MG/L	30.		30.		32.		47.		47.7	
ANTIMONY	MG/L	-		< 0.003		-		-		-	
ARSENIC	MG/L	< 0.01		< 0.01		-		< 0.01		< 0.01	
BALANCE	%	-0.02		0.09		-		-		-	
BARIUM	MG/L	-		0.1		-		-		-	
BICARBONATE	MG/L	-		-		-		-		-	
BORON	MG/L	-		0.6		0.6		0.6		0.69	
CADMIUM	MG/L	-		< 0.001		-		-		-	
CALCIUM	MG/L	540.		337.		366.		380.		407.	
CHLORIDE	MG/L	110.		100.		86.		96.		96.	
CHROMIUM	MG/L	-		0.05		0.03		< 0.01		0.02	
COBALT	MG/L	-		0.09		-		-		-	
CONDUCTANCE	UMHO/CM	5000.		500.		4100.		6200.		5450.	
COPPER	MG/L	-		0.03		-		-		-	
FLUORIDE	MG/L	0.9		1.0		1.0		1.0		0.92	
GROSS ALPHA	PCI/L	-		-		-		970.	120.	1100.	100.
GROSS BETA	PCI/L	-		-		-		270.	56.	620.	40.
IRON	MG/L	0.08		0.05		0.12		< 0.03		0.25	
LEAD	MG/L	-		< 0.01		-		-		-	
MAGNESIUM	MG/L	199.		139.		160.		180.		176.	
MANGANESE	MG/L	2.3		1.23		1.60		1.65		1.81	
MERCURY	MG/L	-		< 0.0002		-		-		-	
MOLYBDENUM	MG/L	0.2		0.13		< 0.1		0.04		0.14	
NICKEL	MG/L	-		0.06		-		-		-	
NITRATE	MG/L	1190.		570.		2480.		1120.		1020.	
NITRITE	MG/L	-		< 0.1		-		-		-	
ORG. CARBON	MG/L	-		96.		-		44.		110.	
PB-210	PCI/L	-		11.	2.	-		-		-	
PH	SU	7.67		7.60		7.18		6.85		6.88	
PHOSPHATE	MG/L	-		< 0.1		-		-		-	
PO-210	PCI/L	-		1.5	0.8	-		-		-	
POTASSIUM	MG/L	13.3		12.2		10.8		9.6		10.4	
RA-226	PCI/L	-		0.8	0.3	-		0.8	0.3	0.1	0.1
RA-228	PCI/L	-		0.9	1.0	-		1.0	0.8	0.8	0.7
SELENIUM	MG/L	0.01		0.121		0.150		0.37		0.546	
SILICA	MG/L	-		8.		-		-		-	
SILVER	MG/L	-		< 0.01		-		-		-	
SODIUM	MG/L	1170.		1400.		1900.		1300.		1190.	
STRONTIUM	MG/L	-		2.6		-		-		-	
SULFATE	MG/L	3030.		3420.		1170.		3400.		3000.	
SULFIDE	MG/L	-				-		-		-	
TEMPERATURE	C - DEGREE	17.		17.0		16.		16.0		14.6	
TH-230	PCI/L	-		1.7	0.8	-		-		-	
TIN	MG/L	-		< 0.005		-		-		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		701-05 04/06/86	701-01 09/07/86	701-01 03/13/87	701-01 10/06/87	701-01 01/12/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+,-UNCERTAINTY
TOTAL SOLIDS	MG/L	7420.	6550.	7070.	6460.	6130.
URANIUM	MG/L	3.05	1.06	1.59	1.71	2.23
VANADIUM	MG/L	-	0.48	-	< 0.01	0.07
ZINC	MG/L	-	0.047	-	0.038	0.011

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		701-01 05/11/88				
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	407.				
ALUMINUM	MG/L	0.23				
AMMONIUM	MG/L	51.				
ANTIMONY	MG/L	-				
ARSENIC	MG/L	0.045				
BALANCE	%	-				
BARIUM	MG/L	0.01				
BICARBONATE	MG/L	-				
BORON	MG/L	0.71				
CADMIUM	MG/L	0.003				
CALCIUM	MG/L	520.				
CHLORIDE	MG/L	94.				
CHROMIUM	MG/L	0.45				
COBALT	MG/L	0.03				
CONDUCTANCE	UMHO/CM	5410.				
COPPER	MG/L	0.02				
FLUORIDE	MG/L	0.77				
GROSS ALPHA	PCI/L	-				
GROSS BETA	PCI/L	-				
IRON	MG/L	0.16				
LEAD	MG/L	0.02				
MAGNESIUM	MG/L	197.				
MANGANESE	MG/L	2.18				
MERCURY	MG/L	0.0012				
MOLYBDENUM	MG/L	0.09				
NICKEL	MG/L	0.01				
NITRATE	MG/L	1730.				
NITRITE	MG/L	-				
ORG. CARBON	MG/L	-				
PB-210	PCI/L	-				
PH	SU	6.68				
PHOSPHATE	MG/L	0.3				
PO-210	PCI/L	-				
POTASSIUM	MG/L	20.5				
RA-226	PCI/L	-				
RA-228	PCI/L	-				
SELENIUM	MG/L	0.549				
SILICA	MG/L	18.0				
SILVER	MG/L	-				
SODIUM	MG/L	1450.				
STRONTIUM	MG/L	7.82				
SULFATE	MG/L	2870.				
SULFIDE	MG/L	< 0.1				
TEMPERATURE	C - DEGREE	16.5				
TH-230	PCI/L	-				
TIN	MG/L	-				

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE 701-01 05/11/88 PARAMETER VALUE+/-UNCERTAINTY
TOTAL SOLIDS	MG/L	6680.
URANIUM	MG/L	2.99
VANADIUM	MG/L	0.08
ZINC	MG/L	0.048

MASTER DATA FILE NAME: GRN01*UDPGW0402190

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		583-01 09/12/86		583-01 01/13/87		583-01 10/02/87		583-01 01/11/88		583-01 07/21/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	493.		670.		1030.		1220.		1563.	
ALUMINUM	MG/L	0.3		< 0.1		< 0.1		0.2		0.06	
AMMONIUM	MG/L	1.1		0.4		0.5		0.3		0.4	
ANTIMONY	MG/L	< 0.003		-		-		-		-	
ARSENIC	MG/L	< 0.01		-		< 0.01		< 0.01		0.015	
BALANCE	%	0.11		-		-		-		-	
BARIUM	MG/L	0.2		-		-		-		0.01	
BORON	MG/L	0.4		1.0		1.2		1.23		1.2	
CADMIUM	MG/L	< 0.001		-		-		-		0.048	
CALCIUM	MG/L	303.		327.		230.		248.		186.	
CHLORIDE	MG/L	710.		925.		830.		900.		1120.	
CHROMIUM	MG/L	0.02		0.02		< 0.01		0.03		0.07	
COBALT	MG/L	< 0.05		-		-		-		-	
CONDUCTANCE	UMHO/CM	4500.		7000.		7000.		6270.		6750.	
COPPER	MG/L	0.03		-		-		-		< 0.01	
FLUORIDE	MG/L	1.2		0.4		0.2		0.36		0.4	
GROSS ALPHA	PCI/L	-		-		0.8	61.	4.	27.	0.	54.
GROSS BETA	PCI/L	-		-		[illegible]	38.	0.	19.	15.	29.
IRON	MG/L	< 0.03		0.03		0.16		0.56		0.22	
LEAD	MG/L	< 0.01		-		-		-		0.02	
MAGNESIUM	MG/L	127.		136.		117.		87.7		76.2	
MANGANESE	MG/L	0.07		0.09		0.02		0.07		0.06	
MERCURY	MG/L	< 0.0002		-		-		-		< 0.0002	
MOLYBDENUM	MG/L	0.19		< 0.1		< 0.01		0.09		0.05	
NICKEL	MG/L	0.05		-		-		-		-	
NITRATE	MG/L	11.		71.		40.		48.3		4.4	
NITRITE	MG/L	< 0.1		-		-		-		-	
ORG. CARBON	MG/L	120.		-		2.		279.		404.	
PB-210	PCI/L	0.0	1.4	-		-		-		-	
PH	SU	8.19		6.79		6.60		6.7		7.10	
PHOSPHATE	MG/L	< 0.1		-		-		-		-	
PO-210	PCI/L	0.0	0.6	-		-		-		-	
POTASSIUM	MG/L	10.3		10.7		6.6		6.68		6.8	
RA-226	PCI/L	0.7	0.3	-		1.1	0.3	0.7	0.2	1.0	0.3
RA-228	PCI/L	0.1	1.2	-		2.6	1.2	2.	1.	1.4	0.9
SELENIUM	MG/L	0.111		0.002		0.049		0.104		0.062	
SILICA	MG/L	3.		-		-		-		-	
SILVER	MG/L	< 0.01		-		-		-		< 0.01	
SODIUM	MG/L	1220.		1520.		1690.		1870.		1860.	
STRONTIUM	MG/L	6.5		-		-		-		-	
SULFATE	MG/L	2630.		2580.		2340.		2290.		1440.	
SULFIDE	MG/L			-		-		-		< 0.1	
TEMPERATURE	C - DEGREE	17.5		14.		16.0		13.0		15.0	
TH-230	PCI/L	0.7	0.6	-		-		-		-	
TIN	MG/L	< 0.005		-		-		-		-	
TOTAL SOLIDS	MG/L	5360.		6100.		5840.		6200.		6190.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		583-01 09/12/86	583-01 03/13/87	583-01 10/02/87	583-01 04/11/88	583-01 07/21/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	0.0042	0.0139	0.014	0.0105	0.0036
VANADIUM	MG/L	0.23	-	< 0.01	0.93	0.03
ZINC	MG/L	0.054	-	0.005	0.013	0.007

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		584-01 09/11/86		584-01 01/13/87		584-01 10/06/87		584-01 01/12/88		584-01 05/11/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	286.		267.		252.		263.		264.	
ALUMINUM	MG/L	0.2		0.2		< 0.1		0.47		0.06	
AMMONIUM	MG/L	1.0		0.9		0.7		0.5		0.7	
ANTIMONY	MG/L	< 0.003		-		-		-		-	
ARSENIC	MG/L	< 0.01		-		< 0.01		0.01		0.008	
BALANCE	%	-0.38		-		-		-		-	
BARIUM	MG/L	0.2		-		-		-		0.01	
BORON	MG/L	0.3		0.3		0.6		0.67		0.65	
CADMIUM	MG/L	< 0.001		-		-		-		0.003	
CALCIUM	MG/L	57.5		39.7		47.		39.4		46.7	
CHLORIDE	MG/L	530.		95.4		120.		110.		130.	
CHROMIUM	MG/L	0.02		0.02		< 0.01		0.02		0.02	
COBALT	MG/L	< 0.05		-		-		-		0.01	
CONDUCTANCE	UMHO/CM	4800.		4250.		4620.		5100.		5100.	
COPPER	MG/L	< 0.02		-		-		-		< 0.01	
FLUORIDE	MG/L	1.9		1.9		1.9		1.76		1.73	
GROSS ALPHA	PCI/L	-		-		0.0	40.	45.	19.	-	
GROSS BETA	PCI/L	-		-		0.0	29.	6.	13.	-	
IRON	MG/L	< 0.03		0.11		0.08		0.22		0.06	
LEAD	MG/L	0.03		-		-		-		0.03	
MAGNESIUM	MG/L	15.2		12.8		14.7		12.9		11.4	
MANGANESE	MG/L	0.02		0.05		0.02		0.03		0.03	
MERCURY	MG/L	< 0.0002		-		-		-		< 0.0002	
MOLYBDENUM	MG/L	0.10		< 0.1		< 0.01		< 0.01		0.01	
NICKEL	MG/L	0.04		-		-		-		0.02	
NITRATE	MG/L	5.		0.4		5.8		< 0.1		1.0	
NITRITE	MG/L	< 0.1		-		-		-		-	
ORG. CARBON	MG/L	62.		-		4.		30.		-	
PB-210	PCI/L	1.5	1.3	-		-		-		-	
PH	SU	9.08		8.11		7.95		8.0		7.96	
PHOSPHATE	MG/L	< 0.1		-		-		-		0.3	
PO-210	PCI/L	0.0	0.5	-		-		-		-	
POTASSIUM	MG/L	4.78		7.60		2.7		2.94		3.27	
RA-226	PCI/L	0.2	0.2	-		0.8	0.3	0.1	0.1	-	
RA-228	PCI/L	0.0	1.0	-		2.8	1.2	0.2	0.7	-	
SELENIUM	MG/L	0.093		< 0.002		< 0.005		0.249		0.142	
SILICA	MG/L	5.		-		-		-		9.2	
SILVER	MG/L	< 0.01		-		-		-		-	
SODIUM	MG/L	1880.		1640.		1490.		1580.		1630.	
STRONTIUM	MG/L	3.1		-		-		-		1.50	
SULFATE	MG/L	3160.		3450.		3100.		2540.		3160.	
SULFIDE	MG/L	-		-		-		-		< 0.1	
TEMPERATURE	C - DEGREE	17.0		15.0		14.8		14.0		15.9	
TH-230	PCI/L	0.6	0.6	-		-		-		-	
TIN	MG/L	< 0.005		-		-		-		-	
TOTAL SOLIDS	MG/L	4870.		5130.		5040.		4930.		4930.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		584-01 09/11/86	584-01 01/13/87	584-01 10/06/87	584-01 01/12/88	584-01 05/11/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	< 0.0003	< 0.0003	0.003	0.0009	0.0007
VANADIUM	MG/L	0.27	-	< 0.01	0.02	0.01
ZINC	MG/L	0.013	-	0.024	0.007	< 0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		584-01 07/14/88		585-01 09/12/86		585-01 03/13/87		585-01 10/02/87		585-01 04/10/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	259.		1007.		938.		848.		766.	
ALUMINUM	MG/L	0.02		0.3		0.3		0.1		< 0.1	
AMMONIUM	MG/L	0.2		1.0		2.0		1.3		0.7	
ANTIMONY	MG/L	-		< 0.003		-		-		-	
ARSENIC	MG/L	0.010		< 0.01		-		< 0.01		< 0.01	
BALANCE	%	-		-0.33		-		-		-	
BARIUM	MG/L	< 0.01		0.1		-		-		-	
BORON	MG/L	0.64		1.5		0.8		1.1		1.1	
CADMIUM	MG/L	0.004		< 0.001		-		-		-	
CALCIUM	MG/L	46.3		78.6		25.8		40.		36.8	
CHLORIDE	MG/L	130.		1200.		837.		750.		740.	
CHROMIUM	MG/L	0.02		0.02		0.03		< 0.01		0.07	
COBALT	MG/L	-		< 0.05		-		-		-	
CONDUCTANCE	UMHO/CM	4650.		4900.		6500.		7000.		5960.	
COPPER	MG/L	< 0.01		0.03		-		-		-	
FLUORIDE	MG/L	1.7		0.6		0.5		0.2		0.32	
GROSS ALPHA	PCI/L	0.	30.	-		-		0.0	56.	7.	38.
GROSS BETA	PCI/L	17.	17.	-		-		9.0	46.	16.	28.
IRON	MG/L	0.11		0.05		< 0.03		< 0.03		0.35	
LEAD	MG/L	0.01		< 0.01		-		-		-	
MAGNESIUM	MG/L	14.7		14.1		7.52		8.8		8.65	
MANGANESE	MG/L	0.02		0.04		< 0.01		0.01		0.03	
MERCURY	MG/L	< 0.0002		< 0.0002		-		-		-	
MOLYBDENUM	MG/L	0.01		0.09		< 0.1		< 0.01		0.02	
NICKEL	MG/L	-		0.04		-		-		-	
NITRATE	MG/L	11.		< 1.		0.4		< 1.0		< 0.1	
NITRITE	MG/L	-		< 0.1		-		-		-	
ORG. CARBON	MG/L	67.2		140.		-		5.		36.2	
PB-210	PCI/L	-		0.6	1.3	-		-		-	
PH	SU	8.09		7.30		8.52		7.40		6.9	
PHOSPHATE	MG/L	-		< 0.1		-		-		-	
PO-210	PCI/L	-		0.0	0.5	-		-		-	
POTASSIUM	MG/L	3.5		5.71		8.61		3.6		3.59	
RA-226	PCI/L	0.3	0.2	0.6	0.3	-		0.3	0.2	0.3	0.1
RA-228	PCI/L	0.7	0.8	0.6	1.0	-		1.8	1.5	0.9	0.9
SELENIUM	MG/L	0.009		0.039		< 0.002		< 0.005		0.155	
SILICA	MG/L	-		11.		-		-		-	
SILVER	MG/L	< 0.01		< 0.01		-		-		-	
SODIUM	MG/L	1460.		2240.		1940.		1900.		1920.	
STRONTIUM	MG/L	-		1.4		-		-		-	
SULFATE	MG/L	3440.		2370.		2470.		2490.		2400.	
SULFIDE	MG/L	< 0.1		-		-		-		-	
TEMPERATURE	C - DEGREE	15.0		17.5		15.0		16.0		14.3	
TH-230	PCI/L	-		0.4	0.5	-		-		-	
TIN	MG/L	-		< 0.005		-		-		-	
TOTAL SOLIDS	MG/L	4940.		5660.		5650.		5120.		5550.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		584-01 07/16/88		585-01 09/12/86		585-01 03/13/87		585-01 10/02/87		585-01 01/10/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
URANIUM	MG/L	<	0.0003	<	0.0003	<	0.0003	<	0.003	<	0.0003
VANADIUM	MG/L	<	0.01		0.25		-	<	0.01	<	0.01
ZINC	MG/L	<	0.005		0.019		-	<	0.005		0.025

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE									
		585-01 07/18/88		585-02 07/18/88		585-03 07/18/88		585-04 07/18/88		585-05 07/18/88	
		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	873.		873.		873.		873.		873.	
ALUMINUM	MG/L	0.02		< 0.01		0.01		< 0.01		< 0.01	
AMMONIUM	MG/L	1.2		1.2		1.2		1.2		1.2	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	0.008		0.011		0.011		0.011		0.007	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	0.01		0.01		0.01		0.01		0.01	
BORON	MG/L	1.1		1.1		1.2		1.2		1.1	
CADMIUM	MG/L	0.003		0.006		0.005		0.004		0.005	
CALCIUM	MG/L	41.9		41.3		41.3		42.5		41.9	
CHLORIDE	MG/L	830.		820.		830.		830.		840.	
CHROMIUM	MG/L	0.02		< 0.01		< 0.01		< 0.01		< 0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	5000.		5000.		5000.		5000.		5000.	
COPPER	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
FLUORIDE	MG/L	0.4		0.4		0.4		0.4		0.4	
GROSS ALPHA	PCI/L	0.	49.	0.	45.	0.	48.	8.	38.	0.	47.
GROSS BETA	PCI/L	27.	26.	4.	25.	14.	26.	11.	25.	12.	26.
IRON	MG/L	0.05		0.05		0.28		0.05		0.05	
LEAD	MG/L	0.01		0.01		0.02		0.02		< 0.01	
MAGNESIUM	MG/L	9.67		9.49		9.59		9.78		9.57	
MANGANESE	MG/L	0.02		0.02		0.02		0.02		0.02	
MERCURY	MG/L	< 0.0002		< 0.0002		< 0.0002		< 0.0002		< 0.0002	
MOLYBDENUM	MG/L	< 0.01		0.02		0.01		< 0.01		0.01	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	4.1		5.6		5.7		5.6		5.4	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	232.		229.		240.		223.		228.	
PB-210	PCI/L	-		-		-		-		-	
PH	SU	7.22		7.22		7.22		7.22		7.22	
PHOSPHATE	MG/L	-		-		-		-		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	4.2		4.3		4.3		4.1		4.1	
RA-226	PCI/L	0.4	0.2	0.3	0.2	0.3	0.2	0.4	0.2	0.3	0.2
RA-228	PCI/L	0.1	0.7	0.6	0.7	0.2	0.9	0.4	0.2	0.3	0.9
SELENIUM	MG/L	0.071		0.056		0.059		0.054		0.054	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
SODIUM	MG/L	1900.		1940.		1950.		1930.		1920.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	2320.		2300.		2150.		2350.		2370.	
SULFIDE	MG/L	0.2		0.1		0.2		0.1		0.2	
TEMPERATURE	C - DEGREE	16.5		16.5		16.5		16.5		16.5	
TH-230	PCI/L	-		-		-		-		-	
TIN	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	5630.		5640.		5640.		5580.		5620.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		585-01 07/18/88		585-02 07/18/88		585-03 07/18/88		585-04 07/18/88		585-05 07/18/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
URANIUM	MG/L	<	0.0003	<	0.0003	<	0.0003		0.0003	<	0.0003
VANADIUM	MG/L	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
ZINC	MG/L	<	0.005	<	0.005		0.018	<	0.005	<	0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE 809-01 10/23/87 PARAMETER VALUE+/-UNCERTAINTY		809-01 04/07/88 PARAMETER VALUE+/-UNCERTAINTY		810-01 10/26/87 PARAMETER VALUE+/-UNCERTAINTY		810-01 04/07/88 PARAMETER VALUE+/-UNCERTAINTY		810-01 07/15/88 PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	530.		485.		369.		423.		406.	
ALUMINUM	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		0.09	
AMMONIUM	MG/L	0.6		0.7		0.3		0.1		< 0.1	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	< 0.01		0.014		< 0.01		0.01		0.042	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		-		-		0.04	
BORON	MG/L	0.5		0.64		0.6		0.59		9.71	
CADMIUM	MG/L	-		-		-		-		0.003	
CALCIUM	MG/L	33.		27.7		7.7		17.1		27.9	
CHLORIDE	MG/L	92.		100.		550.		150.		150.	
CHROMIUM	MG/L	< 0.01		0.02		< 0.01		0.07		< 0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	5500.		5240.		3200.		4110.		5000.	
COPPER	MG/L	-		-		-		-		0.02	
FLUORIDE	MG/L	1.9		1.93		5.4		3.27		2.7	
GROSS ALPHA	PCI/L	0.0	33.	0.8	1.4	0.0	28.	10.	18.	0.	25.
GROSS BETA	PCI/L	0.0	31.	0.	1.7	0.0	23.	19.	18.	0.	15.
IRON	MG/L	< 0.03		0.43		< 0.03		0.32		0.04	
LEAD	MG/L	-		-		-		-		0.01	
MAGNESIUM	MG/L	46.		44.9		4.70		6.94		43.7	
MANGANESE	MG/L	0.01		0.09		< 0.01		0.21		0.08	
MERCURY	MG/L	-		-		-		-		< 0.0002	
MOLYBDENUM	MG/L	< 0.01		0.04		< 0.01		0.04		0.03	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	< 1.0		< 0.1		1.0		< 0.1		11.	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	3.		118.		3.		99.6		101.	
PB-210	PCI/L	-		-		-		-		-	
PH	SU	8.2		8.3		8.3		8.05		8.22	
PHOSPHATE	MG/L	-		-		-		-		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	4.1		3.46		4.25		2.5		3.8	
RA-226	PCI/L	0.6	0.2	0.7	0.2	0.1	0.7	0.2	0.2	0.4	0.2
RA-228	PCI/L	0.5	1.3	0.9	0.9	1.0	1.4	1.3	0.9	0.5	0.7
SELENIUM	MG/L	< 0.005		0.124		< 0.005		0.083		0.071	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		-		-		< 0.01	
SODIUM	MG/L	1670.		1800.		840.		1280.		1420.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	3140.		3270.		620.		2140.		2790.	
SULFIDE	MG/L	-		-		-		-		< 0.1	
TEMPERATURE	C - DEGREE	15.0		14.1		16.0		14.3		21.0	
TH-230	PCI/L	-		-		-		-		-	
TIN	MG/L	-		-		-		-			
TOTAL SOLIDS	MG/L	5340.		5400.		2740.		3970.		4700.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SHALE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE 809-01 10/21/87 PARAMETER VALUE+/-UNCERTAINTY	809-01 01/07/88 PARAMETER VALUE+/-UNCERTAINTY	810-01 10/26/87 PARAMETER VALUE+/-UNCERTAINTY	810-01 01/07/88 PARAMETER VALUE+/-UNCERTAINTY	810-01 07/16/88 PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	< 0.003	0.0014	0.005	0.004	0.0042
VANADIUM	MG/L	< 0.01	0.01	< 0.01	< 0.01	< 0.01
ZINC	MG/L	< 0.005	0.009	< 0.005	0.427	0.013

MAPPER DATA FILE NAME: GRN01*UDPGUU102189

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		562-01 06/05/86	562-02 06/05/86	562-03 06/05/86	562-04 06/05/86	562-05 06/05/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	600.	600.	600.	600.	600.
ALUMINUM	MG/L	0.7	0.2	0.2	0.2	0.2
AMMONIUM	MG/L	0.1	< 0.1	< 0.1	< 0.1	< 0.1
ANTIMONY	MG/L	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
ARSENIC	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
BALANCE	%	0.22	0.25	0.25	0.26	0.23
BARIUM	MG/L	0.1	0.2	0.2	0.2	0.2
BORON	MG/L	0.9	0.4	0.4	0.5	0.4
CADMIUM	MG/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
CALCIUM	MG/L	369.	368.	368.	368.	368.
CHLORIDE	MG/L	126.	127.	127.	127.	127.
CHROMIUM	MG/L	0.04	0.04	0.04	0.04	0.04
COBALT	MG/L	0.13	0.1	0.1	0.1	0.1
CONDUCTANCE	UMHO/CM	6000.	6000.	6000.	6000.	6000.
COPPER	MG/L	0.05	0.04	0.04	0.04	0.04
FLUORIDE	MG/L	1.	0.9	0.9	0.9	0.9
GROSS ALPHA	PCI/L	-	-	-	-	-
GROSS BETA	PCI/L	-	-	-	-	-
IRON	MG/L	0.06	0.08	0.08	0.08	0.08
LEAD	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
MAGNESIUM	MG/L	150.	141.	141.	141.	141.
MANGANESE	MG/L	0.38	0.39	0.39	0.39	0.39
MERCURY	MG/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
MOLYBDENUM	MG/L	0.18	0.11	0.11	0.11	0.11
NICKEL	MG/L	0.09	0.09	0.09	0.09	0.09
NITRATE	MG/L	45.	66.	66.	65.	68.
NITRITE	MG/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
ORG. CARBON	MG/L	-	-	-	-	-
PH	SU	7.3	7.3	7.3	7.3	7.3
PHOSPHATE	MG/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
POTASSIUM	MG/L	8.44	8.83	8.81	8.83	8.83
RA-226	PCI/L	-	-	-	-	-
RA-228	PCI/L	-	-	-	-	-
SELENIUM	MG/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
SILICA	MG/L	4.	4.	4.	4.	4.
SILVER	MG/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
SODIUM	MG/L	1740.	1830.	1830.	1839.	1830.
STRONTIUM	MG/L	10.8	11.2	11.2	11.2	11.2
SULFATE	MG/L	4330.	4360.	4360.	4460.	4460.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	18.	18.	18.	18.	18.
TIN	MG/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
TOTAL SOLIDS	MG/L	7620.	7690.	7980.	7920.	7930.
URANIUM	MG/L	0.0201	0.0231	0.0254	0.0331	0.035
VANADIUM	MG/L	0.1	0.12	0.11	0.1	0.12
ZINC	MG/L	0.015	0.016	0.017	0.016	0.016

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		562-01 09/07/86		562-01 02/27/87		562-01 10/02/87		562-01 01/05/88		562-01 05/17/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	704.		745.		588.		635.		660.	
ALUMINUM	MG/L	0.2		< 0.1		< 0.1		0.2		0.24	
AMMONIUM	MG/L	0.3		< 0.1		< 0.1		< 0.1		0.2	
ANTIMONY	MG/L	< 0.003		-		-		-		-	
ARSENIC	MG/L	< 0.01		-		< 0.01		< 0.001		0.010	
BALANCE	%	-0.16		-		-		-		-	
BARIUM	MG/L	0.2		-		-		-		0.01	
BORON	MG/L	0.9		0.59		0.7		0.74		0.82	
CADMIUM	MG/L	< 0.001		-		-		-		0.005	
CALCIUM	MG/L	324.		298.		300.		270.		328.	
CHLORIDE	MG/L	60.		118.		129.		120.		150.	
CHROMIUM	MG/L	< 0.01		0.02		< 0.01		0.01		0.09	
COBALT	MG/L	0.06		-		-		-		0.02	
CONDUCTANCE	UMHO/CM	5709.		4575.		7900.		6700.		6240.	
COPPER	MG/L	0.03		-		-		-		< 0.01	
FLUORIDE	MG/L	1.0		0.73		0.9		0.81		0.85	
GROSS ALPHA	PCI/L	-		-		82.	74.	100.	40.	-	
GROSS BETA	PCI/L	-		-		0.0	40.	39.	29.	-	
IRON	MG/L	0.37		0.08		< 0.03		0.19		0.11	
LEAD	MG/L	< 0.01		-		-		-		0.02	
MAGNESIUM	MG/L	144.		150.		167.		123.		124.	
MANGANESE	MG/L	0.43		0.09		0.49		0.49		0.47	
MERCURY	MG/L	< 0.0002		-		-		-		0.0014	
MOLYBDENUM	MG/L	0.18		< 0.1		0.02		0.12		0.07	
NICKEL	MG/L	0.05		-		-		-		0.05	
NITRATE	MG/L	130.		133.		173.		62.		130.	
NITRITE	MG/L	< 0.1		-		-		-		-	
ORG. CARBON	MG/L	-		-		25.		237.		-	
PH	SU	7.03		6.93		6.9		6.9		6.88	
PHOSPHATE	MG/L	< 0.1		-		-		-		0.3	
POTASSIUM	MG/L	8.48		5.10		7.2		6.25		7.39	
RA-226	PCI/L	-		-		1.3	0.3	0.2	0.2	-	
RA-228	PCI/L	-		-		1.8	1.0	0.9	0.8	-	
SELENIUM	MG/L	< 0.005		0.12		0.020		0.164		0.160	
SILICA	MG/L	4.		-		-		-		9.7	
SILVER	MG/L	< 0.01		-		-		-		-	
SODIUM	MG/L	1900.		1910.		1750.		1570.		1870.	
STRONTIUM	MG/L	0.8		-		-		-		8.83	
SULFATE	MG/L	4480.		4510.		4400.		3550.		4330.	
SULFIDE	MG/L	-		-		-		-		< 0.1	
TEMPERATURE	C - DEGREE	18.5		16.5		16.5		15.9		16.5	
TIN	MG/L	< 0.005		-		-		-		-	
TOTAL SOLIDS	MG/L	7160.		7640.		7440.		7070.		7490.	
URANIUM	MG/L	0.0854		0.0362		0.146		0.0792		0.0402	
VANADIUM	MG/L	0.38		-		< 0.01		0.04		0.05	
ZINC	MG/L	0.020		-		0.022		0.007		0.006	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		811-01 10/22/87		811-01 01/11/88		811-01 07/21/88		813-01 10/06/87		813-01 04/07/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	1019.		937.		993.		670.		651.	
ALUMINUM	MG/L	< 0.1		< 0.1		< 0.01		< 0.1		0.2	
AMMONIUM	MG/L	0.3		< 0.1		< 0.1		0.2		< 0.1	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	< 0.01		< 0.01		0.005		0.01		0.023	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		0.10		-		-	
BORON	MG/L	0.7		0.81		0.8		0.8		0.7	
CADMIUM	MG/L	-		-		0.025		-		-	
CALCIUM	MG/L	4.1		4.17		4.60		210.		212.	
CHLORIDE	MG/L	159.		150.		170.		116.		110.	
CHROMIUM	MG/L	< 0.01		0.07		< 0.01		< 0.01		0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	2700.		2460.		2775.		7000.		6540.	
COPPER	MG/L	-		-		< 0.01		-		-	
FLUORIDE	MG/L	2.3		2.19		2.5		1.0		0.96	
GROSS ALPHA	PCI/L	27.	32.	4.3	9.7	36.	19.	44.	67.	150.	50.
GROSS BETA	PCI/L	39.	25.	3.5	6.7	21.	8.	31.	48.	52.	32.
IRON	MG/L	< 0.03		0.3		0.02		< 0.03		0.19	
LEAD	MG/L	-		-		< 0.01		-		-	
MAGNESIUM	MG/L	1.33		1.21		1.33		422.		111.	
MANGANESE	MG/L	0.01		0.02		0.02		0.17		9.15	
MERCURY	MG/L	-		-		< 0.0002		-		-	
MOLYBDENUM	MG/L	< 0.01		0.02		0.02		0.07		0.22	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	< 1.0		< 0.1		2.7		67.		12.	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	< 1.		229.		219.		15.		227.	
PH	SU	8.0		8.1		8.05		6.90		6.9	
PHOSPHATE	MG/L	-		-		-		-		-	
POTASSIUM	MG/L	1.35		1.45		1.3		6.3		6.68	
RA-226	PCI/L	0.1	0.1	0.1	0.1	.1	0.2	2.6	0.5	0.1	0.2
RA-228	PCI/L	2.1	1.1	0.	0.8	0.0	0.9	1.3	0.8	1.4	0.9
SELENIUM	MG/L	< 0.005		0.033		0.022		0.007		0.178	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		< 0.01		-		-	
SODIUM	MG/L	740.		756.		809.		1660.		48[illegible]0	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	450.		537.		637.		3900.		[illegible]	
SULFIDE	MG/L	-		-		< 0.1		-		-	
TEMPERATURE	C - DEGREE	15.5		14.3		17.5		17.0		15.7	
TIN	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	2050.		2120.		2190.		6820.		6770.	
URANIUM	MG/L	< 0.001		< 0.0003		0.0003		0.070		0.0707	
VANADIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		0.03	
ZINC	MG/L	0.006		0.009		< 0.005		0.019		0.021	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		813-01 05/10/88				
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	671.				
ALUMINUM	MG/L	0.19				
AMMONIUM	MG/L	< 0.1				
ANTIMONY	MG/L	-				
ARSENIC	MG/L	0.016				
BALANCE	%	-				
BARIUM	MG/L	0.01				
BORON	MG/L	0.83				
CADMIUM	MG/L	0.005				
CALCIUM	MG/L	253.				
CHLORIDE	MG/L	130.				
CHROMIUM	MG/L	0.08				
COBALT	MG/L	0.02				
CONDUCTANCE	UMHO/CM	6520.				
COPPER	MG/L	0.01				
FLUORIDE	MG/L	0.95				
GROSS ALPHA	PCI/L	-				
GROSS BETA	PCI/L	-				
IRON	MG/L	0.08				
LEAD	MG/L	0.02				
MAGNESIUM	MG/L	114.				
MANGANESE	MG/L	0.17				
MERCURY	MG/L	< 0.0002				
MOLYBDENUM	MG/L	0.13				
NICKEL	MG/L	0.05				
NITRATE	MG/L	56.				
NITRITE	MG/L	-				
ORG. CARBON	MG/L	-				
PH	SU	6.88				
PHOSPHATE	MG/L	0.3				
POTASSIUM	MG/L	7.24				
RA-226	PCI/L	-				
RA-228	PCI/L	-				
SELENIUM	MG/L	0.134				
SILICA	MG/L	9.2				
SILVER	MG/L	-				
SODIUM	MG/L	1910.				
STRONTIUM	MG/L	9.55				
SULFATE	MG/L	4700.				
SULFIDE	MG/L	< 0.1				
TEMPERATURE	C - DEGREE	17.5				
TIN	MG/L	-				
TOTAL SOLIDS	MG/L	6920.				
URANIUM	MG/L	0.0390				
VANADIUM	MG/L	0.01				
ZINC	MG/L	0.006				

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE									
		581-01 09/11/86		581-01 03/13/87		581-01 10/05/87		581-01 01/12/88		581-01 05/11/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	1021.		1042.		973.		961.		979.	
ALUMINUM	MG/L	0.3		0.2		< 0.1		0.09		0.04	
AMMONIUM	MG/L	2.4		0.8		0.6		0.5		0.8	
ANTIMONY	MG/L	< 0.003		-		-		-		-	
ARSENIC	MG/L	< 0.01		-		< 0.01		0.03		0.019	
BALANCE	%	-0.21		-		-		-		-	
BARIUM	MG/L	0.1		-		-		-		< 0.01	
BORON	MG/L	0.9		0.7		0.8		0.83		0.86	
CADMIUM	MG/L	< 0.001		-		-		-		0.005	
CALCIUM	MG/L	29.5		20.5		18.1		20.0		22.1	
CHLORIDE	MG/L	100.		95.1		229.		130.		180.	
CHROMIUM	MG/L	0.01		0.01		< 0.01		0.02		0.01	
COBALT	MG/L	< 0.05		-		-		-		< 0.01	
CONDUCTANCE	UMHO/CM	5000.		4100.		5500.		4900.		4920.	
COPPER	MG/L	< 0.02		-		-		-		< 0.01	
FLUORIDE	MG/L	1.3		1.2		1.2		1.13		1.12	
GROSS ALPHA	PCI/L	-		-		0.0	32.	7.	21.	-	
GROSS BETA	PCI/L	-		-		9.9	31.	12.	16.	-	
IRON	MG/L	0.05		0.04		< 0.03		0.12		< 0.01	
LEAD	MG/L	< 0.01		-		-		-		0.09	
MAGNESIUM	MG/L	10.3		9.51		9.3		9.71		8.83	
MANGANESE	MG/L	0.02		0.03		< 0.01		0.01		0.01	
MERCURY	MG/L	< 0.0002		-		-		-		0.0027	
MOLYBDENUM	MG/L	0.09		< 0.1		< 0.01		< 0.01		0.02	
NICKEL	MG/L	< 0.04		-		-		-		< 0.04	
NITRATE	MG/L	1.2		0.4		< 1.0		< 0.1		< 0.1	
NITRITE	MG/L	< 0.1		-		-		-		-	
ORG. CARBON	MG/L	120.		-		5.		218.		-	
PB-210	PCI/L	0.5	1.3	-		-		-		-	
PH	SU	7.91		7.77		7.7		7.8		7.75	
PHOSPHATE	MG/L	< 0.1		-		-		-		0.6	
PO-210	PCI/L	0.0	0.5	-		-		-		-	
POTASSIUM	MG/L	3.86		1.88		2.26		2.25		2.51	
RA-226	PCI/L	1.2	0.5	-		0.7	0.2	0.3	0.1	-	
RA-228	PCI/L	0.2	1.4	-		2.7	0.9	0.3	0.8	-	
SELENIUM	MG/L	0.124		< 0.002		< 0.005		0.157		0.095	
SILICA	MG/L	8.		-		-		-		8.8	
SILVER	MG/L	< 0.01		-		-		-		-	
SODIUM	MG/L	1680.		1540.		1570.		1610.		1680.	
STRONTIUM	MG/L	2.5		-		-		-		2.60	
SULFATE	MG/L	2520.		2380.		2290.		2570.		2460.	
SULFIDE	MG/L			-		-		-		15.4	
TEMPERATURE	C - DEGREE	17.		16.5		16.0		15.0		15.7	
TH-230	PCI/L	0.3	1.7	-		-		-		-	
TIN	MG/L	< 0.005				-		-		-	
TOTAL SOLIDS	MG/L	4770.		17900.		4520.		4630.		4430.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: ON-SITE

		LOCATION ID - SAMPLE ID AND LOG DATE				
		581-01 09/11/86	581-01 03/13/87	581-01 10/05/87	581-01 01/12/88	581-01 05/11/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	< 0.0003	< 0.0003	< 0.003	0.0010	< 0.0003
VANADIUM	MG/L	0.22	-	< 0.01	< 0.01	< 0.01
ZINC	MG/L	0.010	-	0.007	0.006	0.047

MAPPER DATA FILE NAME: GRN01*UOPGW#102187

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: CROSS GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE						
		561-01 06/04/86	561-01 09/07/86	561-01 02/27/87	561-01 10/01/87		561-01 04/10/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAIN	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	745.	707.	790.	606.		606.	
ALUMINUM	MG/L	13.4	5.3	0.8	< 0.1		0.7	
AMMONIUM	MG/L	1.2	0.8	0.6	0.2		0.7	
ANTIMONY	MG/L	< 0.003	< 0.003	-	-		-	
ARSENIC	MG/L	< 0.01	< 0.01	-	0.02		0.04	
BALANCE	%	-3.92	1.05	-	-		-	
BARIUM	MG/L	0.4	0.3	-	-		-	
BORON	MG/L	0.4	0.9	0.76	0.7		0.71	
CADMIUM	MG/L	< 0.001	< 0.001	-	-		-	
CALCIUM	MG/L	101.	49.6	4.94	4.1		4.40	
CHLORIDE	MG/L	190.	430.	198.	226.		240.	
CHROMIUM	MG/L	0.04	0.04	< 0.01	< 0.01		0.02	
COBALT	MG/L	0.09	< 0.05	-	-		-	
CONDUCTANCE	UMHO/CM	2700.	2209.	1925.	2310.		2330.	
COPPER	MG/L	0.04	< 0.02	-	-		-	
FLUORIDE	MG/L	2.9	3.2	2.92	2.7		2.87	
GROSS ALPHA	PCI/L	-	-	-	0.0	13.	0.	14.
GROSS BETA	PCI/L	-	-	-	2.9	12.	0.	11.
IRON	MG/L	9.53	2.13	0.46	< 0.03		0.32	
LEAD	MG/L	< 0.01	< 0.01	-	-		-	
MAGNESIUM	MG/L	42.2	3.01	1.32	0.90		1.03	
MANGANESE	MG/L	0.87	0.12	0.02	< 0.01		< 0.01	
MERCURY	MG/L	< 0.0002	< 0.0002	-	-		-	
MOLYBDENUM	MG/L	0.13	0.15	< 0.1	< 0.01		< 0.01	
NICKEL	MG/L	0.08	< 0.04	-	-		-	
NITRATE	MG/L	0.3	< 1.	< 0.1	< 1.0		< 0.1	
NITRITE	MG/L	< 0.1	< 0.1	-	-		-	
ORG. CARBON	MG/L	-	-	-	5.		136.	
PH	SU	8.16	8.23	8.44	8.45		8.5	
PHOSPHATE	MG/L	0.1	< 0.1	-	-		-	
POTASSIUM	MG/L	5.93	2.40	1.60	0.92		1.41	
RA-226	PCI/L	-	-	-	0.1	0.1	0.1	0.1
RA-228	PCI/L	-	-	-	2.2	0.9	0.3	0.8
SELENIUM	MG/L	< 0.005	< 0.005	0.11	< 0.005		0.051	
SILICA	MG/L	4.	4.	-	-		-	
SILVER	MG/L	< 0.01	< 0.01	-	-		-	
SODIUM	MG/L	556.	840.	723.	680.		666.	
STRONTIUM	MG/L	0.5	0.2	-	-		-	
SULFATE	MG/L	700.	484.	670.	650.		648.	
TEMPERATURE	C - DEGREE	19.	19.5	17.0	17.0		15.5	
TIN	MG/L	< 0.005	< 0.005	-	-		-	
TOTAL SOLIDS	MG/L	1910.	1890.	2120.	1870.		1900.	
URANIUM	MG/L	0.0008	< 0.0003	0.0028	< 0.003		< 0.0003	
VANADIUM	MG/L	0.1	0.18	-	< 0.01		< 0.01	
ZINC	MG/L	0.052	0.020	-	0.005		0.013	

MAPPER DATA FILE NAME: GRN01*UPPGU0102185

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE														
		845-01 10/26/87			845-01 01/05/88			845-01 07/16/88			845-02 07/16/88			845-03 07/16/88		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY			PARAMETER VALUE+/-UNCERTAINTY		
ALKALINITY	MG/L CACO3		427.			546.			432.			432.			432.	
ALUMINUM	MG/L	<	0.1		<	0.1		<	0.01		<	0.01		<	0.01	
AMMONIUM	MG/L		0.3			0.3		<	0.1		<	0.1		<	0.1	
ARSENIC	MG/L	<	0.01			0.002			0.005			0.003			0.004	
BARIUM	MG/L		-			-			0.05			0.05			0.05	
BORON	MG/L		0.6			0.57			0.69			0.67			0.67	
CADMIUM	MG/L		-			-			0.002			0.003			0.003	
CALCIUM	MG/L		7.6			8.48			7.94			7.72			7.72	
CHLORIDE	MG/L		930.			950.			930.			1020.			1020.	
CHROMIUM	MG/L	<	0.01			0.03		<	0.01		<	0.01		<	0.01	
CONDUCTANCE	UMHO/CM		3850.			3760.			3650.			3650.			3650.	
COPPER	MG/L		-			-		<	0.01		<	0.01		<	0.01	
FLUORIDE	MG/L		3.2			3.24			3.3			3.3			3.3	
GROSS ALPHA	PCI/L		0.0	37.		4.	16.		0.	29.		9.	16.		0.	21.
GROSS BETA	PCI/L		0.0	28.		17	19.		2.	19.		14.	9.		7.	11.
IRON	MG/L	<	0.03			6.44		<	0.01		<	0.01		<	0.01	
LEAD	MG/L		-			-			0.02		<	0.01			0.01	
MAGNESIUM	MG/L		2.74			2.64			2.55			72.9			2.48	
MANGANESE	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
MERCURY	MG/L		-			-		<	0.0002		<	0.0062		<	0.0002	
MOLYBDENUM	MG/L		0.01			0.05			0.03			0.03			0.03	
NITRATE	MG/L		1.0		<	0.1			12.			11.			11.	
ORG. CARBON	MG/L		10.			113.			113.			110.			113.	
PH	SU		8.45			8.20			8.27			8.27			8.27	
POTASSIUM	MG/L		1.43			4.55			4.5			4.5			4.7	
RA-226	PCI/L		0.3	0.2		0.1	0.2		0.1	0.2		0.1	0.2		0.1	0.7
RA-228	PCI/L		0.0	1.2		0.	0.8		0.1	0.8		0.2	0.8		0.0	0.7
SELENIUM	MG/L	<	0.005			0.027			0.024			0.039			0.034	
SILVER	MG/L		-			-		<	0.01		<	0.01		<	0.01	
SODIUM	MG/L		960.			1070.			1050.			1050.			1040.	
SULFATE	MG/L		480.			572.			529.			553.			548.	
SULFIDE	MG/L		-			-		<	0.1		<	0.1		<	0.1	
TEMPERATURE	C - DEGREE		15.5			14.4			16.0			16.0			16.0	
TOTAL SOLIDS	MG/L		2860.			2930.			2800.			2830.			2850.	
URANIUM	MG/L	<	0.003		<	0.003		<	0.0003		<	0.0003		<	0.0003	
VANADIUM	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	
ZINC	MG/L		0.012			0.009		<	0.005		<	0.005		<	0.005	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: CONGLOMERATE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE 845-04 07/14/88 PARAMETER VALUE+/-UNCERTAINTY		845-05 07/14/88 PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	432.		432.				
ALUMINUM	MG/L	< 0.01		< 0.01				
AMMONIUM	MG/L	< 0.1		< 0.1				
ARSENIC	MG/L	0.004		0.003				
BARIUM	MG/L	0.05		0.05				
BORON	MG/L	0.67		0.67				
CADMIUM	MG/L	0.002		0.003				
CALCIUM	MG/L	7.70		7.71				
CHLORIDE	MG/L	960.		960.				
CHROMIUM	MG/L	< 0.01		< 0.01				
CONDUCTANCE	UMHO/CM	3650.		3450.				
COPPER	MG/L	< 0.01		< 0.01				
FLUORIDE	MG/L	3.3		3.3				
GROSS ALPHA	PCI/L	0.	17.	0.	24.			
GROSS BETA	PCI/L	0.	10.	0.	17.			
IRON	MG/L	< 0.01		< 0.01				
LEAD	MG/L	< 0.01		< 0.01				
MAGNESIUM	MG/L	2.46		2.46				
MANGANESE	MG/L	< 0.01		< 0.01				
MERCURY	MG/L	< 0.0002		< 0.0002				
MOLYBDENUM	MG/L	0.03		0.03				
NITRATE	MG/L	11.		12.				
ORG. CARBON	MG/L	111.		110.				
PH	SU	8.27		8.27				
POTASSIUM	MG/L	1.7		1.7				
RA-226	PCI/L	0.1	0.2	0.1	0.4			
RA-228	PCI/L	0.3	0.7	0.3	0.7			
SELENIUM	MG/L	0.031		0.029				
SILVER	MG/L	< 0.01		< 0.01				
SODIUM	MG/L	1030.		1050.				
SULFATE	MG/L	548.		556.				
SULFIDE	MG/L	< 0.1		< 0.1				
TEMPERATURE	C - DEGREE	16.0		16.0				
TOTAL SOLIDS	MG/L	2820.		2830.				
URANIUM	MG/L	< 0.0007		< 0.0003				
VANADIUM	MG/L	0.01		0.02				
ZINC	MG/L	< 0.005		0.005				

MAPPER DATA FILE NAME: GRN01*DPGU0402188

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		586-01 09/11/86	586-01 03/13/87	586-01 10/05/87	586-01 01/07/88	587-01 09/11/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	720.	424.	569.	586.	842.
ALUMINUM	MG/L	0.5	0.1	< 0.1	< 0.1	0.8
AMMONIUM	MG/L	1.0	2.4	0.2	0.1	1.0
ANTIMONY	MG/L	< 0.003	-	-	-	< 0.003
ARSENIC	MG/L	< 0.01	-	0.01	0.03	< 0.01
BALANCE	%	-2.79	-	-	-	-7.08
BARIUM	MG/L	< 0.1	-	-	-	< 0.1
BORON	MG/L	0.6	0.7	0.6	0.65	0.4
CADMIUM	MG/L	< 0.001	-	-	-	< 0.001
CALCIUM	MG/L	8.20	6.62	12.3	12.5	3.18
CHLORIDE	MG/L	110.	142.	183.	180.	190.
CHROMIUM	MG/L	0.03	0.06	< 0.01	0.07	0.04
COBALT	MG/L	< 0.05	-	-	-	< 0.05
CONDUCTANCE	UMHO/CM	2500.	2300.	2400.	2290.	3500.
COPPER	MG/L	< 0.02	-	-	-	0.03
FLUORIDE	MG/L	2.7	3.0	2.6	0.81	3.0
GROSS ALPHA	PCI/L	-	1. 11.	0.0 20.	2.5 8.7	-
GROSS BETA	PCI/L	-	4.5 5.7	0.0 11.	9. 10.	-
IRON	MG/L	0.07	< 0.03	< 0.03	0.34	0.04
LEAD	MG/L	0.01	-	-	-	0.01
MAGNESIUM	MG/L	3.48	2.20	6.5	3.45	0.011
MANGANESE	MG/L	0.03	0.02	< 0.01	< 0.01	0.03
MERCURY	MG/L	< 0.0002	-	-	-	< 0.0002
MOLYBDENUM	MG/L	0.14	< 0.1	< 0.01	0.02	0.09
NICKEL	MG/L	< 0.04	-	-	-	< 0.04
NITRATE	MG/L	2.	0.4	< 1.0	< 0.1	< 1.
NITRITE	MG/L	< 0.1	-	-	-	< 0.1
ORG. CARBON	MG/L	-	-	6.	117.	-
PH	SU	9.97	10.51	8.1	8.05	11.49
PHOSPHATE	MG/L	< 0.1	-	-	-	< 0.1
POTASSIUM	MG/L	8.20	2.66	1.34	1.34	17.1
RA-226	PCI/L	-	0.1 0.2	0.1 0.1	0. 0.1	-
RA-228	PCI/L	-	-	1.2 0.8	0.3 0.8	-
SELENIUM	MG/L	0.036	< 0.002	< 0.005	0.021	0.106
SILICA	MG/L	10.	-	-	-	13.
SILVER	MG/L	< 0.01	-	-	-	< 0.01
SODIUM	MG/L	680.	643.	640.	682.	730.
STRONTIUM	MG/L	0.2	-	-	-	0.1
SULFATE	MG/L	699.	720.	690.	707.	546.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	16.	16.5	17.0	16.0	17.
TH-230	PCI/L	-	0.0 0.6	-	-	-
TIN	MG/L	< 0.005	-	-	-	< 0.005
TOTAL SOLIDS	MG/L	1929.	1970.	1830.	1870.	1929.
URANIUM	MG/L	0.0049	0.0036	< 0.003	0.0017	< 0.0003
VANADIUM	MG/L	0.19	-	< 0.01	< 0.01	0.22

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		586-01 09/11/86	586-01 03/13/87	586-01 10/05/87	586-01 01/07/88	587-01 09/11/86
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	0.045	-	0.007	0.042	< 0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		587-01 03/13/87		587-01 10/05/87		587-01 01/10/88		588-01 09/11/86		588-01 03/13/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	546.		449.		593.		565.		644.	
ALUMINUM	MG/L	1.1		< 0.1		0.1		0.3		0.3	
AMMONIUM	MG/L	1.0		0.2		0.1		0.9		0.6	
ANTIMONY	MG/L	-		-		-		< 0.003		-	
ARSENIC	MG/L	-		0.01		0.006		< 0.01		-	
BALANCE	%	-		-		-		-2.87		-	
BARIUM	MG/L	-		-		-		< 0.1		-	
BORON	MG/L	0.9		0.8		0.78		0.6		0.6	
CADMIUM	MG/L	-		-		-		< 0.004		-	
CALCIUM	MG/L	7.28		3.1		6.78		9.96		5.49	
CHLORIDE	MG/L	79.1		93.		76.		240.		349.	
CHROMIUM	MG/L	0.03		< 0.01		0.03		0.06		0.02	
COBALT	MG/L	-		-		-		< 0.05		-	
CONDUCTANCE	UMHO/CM	3000.		2700.		2820.		2350.		2500.	
COPPER	MG/L	-		-		-		0.03		-	
FLUORIDE	MG/L	5.5		5.1		5.3		3.2		3.4	
GROSS ALPHA	PCI/L	1.	13.	0.9	5.9	21.	42.	-		1.	13.
GROSS BETA	PCI/L	13.	8.	0.0	16.	0.	10.	-		0.0	9.4
IRON	MG/L	< 0.03		< 0.03		0.49		0.14		0.04	
LEAD	MG/L	-		-		-		< 0.01		-	
MAGNESIUM	MG/L	0.03		0.78		1.73		1.78		1.30	
MANGANESE	MG/L	< 0.01		< 0.01		< 0.01		0.02		0.03	
MERCURY	MG/L	-		-		-		< 0.0002		-	
MOLYBDENUM	MG/L	< 0.1		0.03		0.07		0.09		< 0.1	
NICKEL	MG/L	-		-		-		< 0.04		-	
NITRATE	MG/L	0.8		< 1.0		< 0.1		3.		< 0.1	
NITRITE	MG/L	-		-		-		< 0.1		-	
ORG. CARBON	MG/L	-		7.		138.		-		-	
PH	SU	11.61		9.35		9.0		8.65		8.30	
PHOSPHATE	MG/L	-		-		-		< 0.1		-	
POTASSIUM	MG/L	4.09		1.27		1.29		1.51		1.21	
RA-226	PCI/L	0.0	0.2	0.1	0.1	0.1	0.1	-		0.2	0.2
RA-228	PCI/L	-		2.9	1.0	0.	0.8	-		-	
SELENIUM	MG/L	< 0.002		< 0.005		0.043		0.096		< 0.002	
SILICA	MG/L	-		-		-		8.		-	
SILVER	MG/L	-		-		-		< 0.01		-	
SODIUM	MG/L	803.		740.		864.		677.		734.	
STRONTIUM	MG/L	-		-		-		0.4		-	
SULFATE	MG/L	1170.		950.		1193.		645.		635.	
SULFIDE	MG/L	-		-		-		-		-	
TEMPERATURE	C - DEGREE	15.0		16.0		16.1		19.		11.0	
TH-230	PCI/L	0.0	0.4	-		-		-		0.3	0.5
TIN	MG/L	-		-		-		< 0.005		-	
TOTAL SOLIDS	MG/L	2400.		2200.		2430.		2000.		2470.	
URANIUM	MG/L	0.0016		0.003		0.0027		< 0.0003		0.0040	
VANADIUM	MG/L	-		< 0.01		< 0.01		0.22		-	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		587-01 03/13/87	587-01 10/05/87	587-01 04/10/88	588-01 09/11/86	588-01 03/13/87
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	-	0.005	< 0.005	0.010	-

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		588-01 10/02/87		588-01 01/10/88		588-01 07/21/88		817-01 10/22/87		817-02 10/22/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	555.		545.		531.		655.		655.	
ALUMINUM	MG/L	< 0.1		< 0.1		0.02		< 0.1		< 0.1	
AMMONIUM	MG/L	0.2		< 0.1		< 0.1		0.2		0.2	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	0.01		0.01		0.042		< 0.01		< 0.01	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		0.02		-		-	
BORON	MG/L	0.7		0.69		0.6		0.6		0.6	
CADMIUM	MG/L	-		-		0.020		-		-	
CALCIUM	MG/L	1.2		1.43		6.90		2.7		2.7	
CHLORIDE	MG/L	220.		240.		660.		320.		340.	
CHROMIUM	MG/L	< 0.01		0.02		0.02		< 0.01		< 0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	2390.		2460.		3100.		1950.		1950.	
COPPER	MG/L	-		-		< 0.01		-		-	
FLUORIDE	MG/L	2.6		2.67		3.1		5.6		5.4	
GROSS ALPHA	PCI/L	0.0	22.	0.	17.	0.	20.	30.	22.	0.0	20.
GROSS BETA	PCI/L	0.0	20.	0.	9.	5.	13.	25.	17.	0.0	15.
IRON	MG/L	< 0.03		0.1		< 0.01		< 0.03		< 0.03	
LEAD	MG/L	-		-		0.01		-		-	
MAGNESIUM	MG/L	0.90		0.87		1.48		0.74		0.73	
MANGANESE	MG/L	< 0.01		< 0.01		< 0.01		0.02		0.02	
MERCURY	MG/L	-		-		< 0.0002		-		-	
MOLYBDENUM	MG/L	< 0.01		0.02		< 0.01		0.03		0.04	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	< 1.0		< 0.1		< 0.1		< 1.0		< 1.0	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	4.		34.8		127.		< 1.		< 1.	
PH	SU	8.15		8.25		8.34		8.2		8.2	
PHOSPHATE	MG/L	-		-		-		-		-	
POTASSIUM	MG/L	0.92		0.97		1.4		1.11		1.11	
RA-226	PCI/L	0.4	0.2	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
RA-228	PCI/L	1.1	1.1	0.4	0.8	0.4	0.8	0.5	0.9	3.8	1.3
SELENIUM	MG/L	0.007		0.027		0.024		< 0.005		< 0.005	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		< 0.01		-		-	
SODIUM	MG/L	690.		683.		901.		550.		550.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	660.		674.		571.		134.		133.	
SULFIDE	MG/L	-		-		5.6		-		-	
TEMPERATURE	C - DEGREE	16.0		16.2		16.5		17.0		17.0	
TH-230	PCI/L	-		-		-		-		-	
TIN	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	1000.		1930.		2330.		1500.		1490.	
URANIUM	MG/L	< 0.003		< 0.0003		< 0.0003		< 0.003		< 0.003	
VANADIUM	MG/L	< 0.01		< 0.01		0.01		< 0.01		< 0.01	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		588-01 10/02/87	588-01 01/10/88	588-01 07/21/88	817-01 10/22/87	817-02 10/22/87
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	< 0.005	0.007	< 0.005	< 0.005	< 0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		B17-03 10/22/87		B17-04 10/22/87		B17-05 10/22/87		B17-01 01/10/88		B17-02 01/10/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	655.		655.		655.		688.		688.	
ALUMINUM	MG/L	0.1		< 0.1		< 0.1		< 0.1		0.2	
AMMONIUM	MG/L	0.2		0.2		0.2		< 0.1		< 0.1	
ANTIMONY	MG/L	–		–		–		–		–	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	
BALANCE	%	–		–		–		–		–	
BARIUM	MG/L	–		–		–		–		–	
BORON	MG/L	0.6		0.7		0.7		0.73		0.77	
CADMIUM	MG/L	–		–		–		–		–	
CALCIUM	MG/L	2.7		2.6		2.7		2.57		2.58	
CHLORIDE	MG/L	320.		320.		320.		310.		320.	
CHROMIUM	MG/L	< 0.01		< 0.01		< 0.01		0.03		0.03	
COBALT	MG/L	–		–		–		–		–	
CONDUCTANCE	UMHO/CM	1950.		1950.		1950.		1960.		1960.	
COPPER	MG/L	–		–		–		–		–	
FLUORIDE	MG/L	4.3		3.3		3.0		4.94		5.1	
GROSS ALPHA	PCI/L	0.0	20.	0.0	15.	0.0	17.	0.	6.6	5.	12.
GROSS BETA	PCI/L	0.0	15.	0.0	10.	22.	15.	0.	4.9	2.2	8.
IRON	MG/L	< 0.03		< 0.03		< 0.03		0.15		0.15	
LEAD	MG/L	–		–		–		–		–	
MAGNESIUM	MG/L	0.73		0.73		0.73		0.61		0.61	
MANGANESE	MG/L	0.02		0.01		0.01		< 0.01		< 0.01	
MERCURY	MG/L	–		–		–		–		–	
MOLYBDENUM	MG/L	0.04		0.04		0.04		0.06		0.07	
NICKEL	MG/L	–		–		–		–		–	
NITRATE	MG/L	< 1.0		< 1.0		< 1.0		< 0.1		< 0.1	
NITRITE	MG/L	–		–		–		–		–	
ORG. CARBON	MG/L	< 1.		< 1.		2.		154.		151.	
PH	SU	8.2		8.2		8.2		8.4		8.4	
PHOSPHATE	MG/L	–		–		–		–		–	
POTASSIUM	MG/L	1.09		1.07		1.08		0.87		0.83	
RA-226	PCI/L	0.1	0.1	0.9	0.1	0.0	0.4	0.1	0.2	0.1	0.2
RA-228	PCI/L	0.1	1.4	0.5	1.1	0.4	1.8	0.	0.8	0.	0.8
SELENIUM	MG/L	< 0.005		< 0.005		< 0.005		0.007		0.009	
SILICA	MG/L	–		–		–		–		–	
SILVER	MG/L	–		–		–		–		–	
SODIUM	MG/L	590.		570.		580.		557.		556.	
STRONTIUM	MG/L	–		–		–		–		–	
SULFATE	MG/L	140.		138.		132.		137.		137.	
SULFIDE	MG/L	–		–		–		–		–	
TEMPERATURE	C - DEGREE	17.0		17.0		17.0		15.5		15.5	
TH-230	PCI/L	–		–		–		–		–	
TIN	MG/L	–		–		–		–		–	
TOTAL SOLIDS	MG/L	1490.		1370.		1400.		1500.		1500.	
URANIUM	MG/L	0.003		< 0.003		< 0.003		< 0.0003		< 0.0003	
VANADIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		817-03 10/22/87		817-04 10/22/87		817-05 10/22/87		817-01 01/10/88		817-02 01/10/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ZINC	MG/L	<	0.005	<	0.005	<	0.005		0.009		0.011

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		817-03 01/10/88		817-04 01/10/88		817-05 01/10/88		817-01 07/18/88		819-01 10/20/87	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	688.		688.		688.		662.		541.	
ALUMINUM	MG/L	< 0.1		< 0.1		< 0.1		0.01		< 0.1	
AMMONIUM	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		0.2	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	< 0.01		< 0.01		< 0.01		0.002		0.01	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		-		0.13		-	
BORON	MG/L	0.77		0.79		0.8		0.8		0.7	
CADMIUM	MG/L	-		-		-		0.002		-	
CALCIUM	MG/L	2.54		2.54		2.51		2.47		6.4	
CHLORIDE	MG/L	330.		320.		330.		360.		450.	
CHROMIUM	MG/L	0.03		0.03		0.03		< 0.01		< 0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	1960.		1960.		1960.		2000.		2900.	
COPPER	MG/L	-		-		-		< 0.01		-	
FLUORIDE	MG/L	5.08		5.16		5.22		6.1		2.6	
GROSS ALPHA	PCI/L	6.	11.	4.6	9.3	3.	10.	0.	16.	0.0	2.1
GROSS BETA	PCI/L	6.	8.6	11.	9.	5.3	9.1	9.	11.	0.2	2.4
IRON	MG/L	0.15		0.15		0.15		< 0.01		< 0.03	
LEAD	MG/L	-		-		-		0.01		-	
MAGNESIUM	MG/L	0.60		0.62		0.61		0.53		1.39	
MANGANESE	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		0.03	
MERCURY	MG/L	-		-		-		< 0.0002		-	
MOLYBDENUM	MG/L	0.06		0.07		0.07		0.05		< 0.01	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		< 1.0	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	155.		163.		160.		165.		6.	
PH	SU	8.4		8.4		8.4		8.39		8.3	
PHOSPHATE	MG/L	-		-		-		-		-	
POTASSIUM	MG/L	0.85		0.16		0.86		2.6		1.41	
RA-226	PCI/L	0.	0.1	0.	0.1	0.1	0.1	0.1	0.2	0.3	0.1
RA-228	PCI/L	0.1	0.9	0.	0.8	0.	0.7	0.0	0.7	0.6	1.4
SELENIUM	MG/L	0.008		0.008		0.007		0.008		0.007	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		-		< 0.01		-	
SODIUM	MG/L	564.		560.		558.		589.		840.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	139.		137.		139.		135.		620.	
SULFIDE	MG/L	-		-		-		< 0.1		-	
TEMPERATURE	C - DEGREE	15.5		15.5		15.5		17.0		18.0	
TH-230	PCI/L	-		-		-		-		-	
TDS	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	1490.		1490.		1490.		1440.		2170.	
URANIUM	MG/L	< 0.0003		< 0.0003		< 0.0003		< 0.0003		0.005	
VANADIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		817-03 01/10/88	817-04 01/10/88	817-05 01/10/88	817-04 07/18/88	818-04 10/20/87
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	< 0.005	< 0.005	0.006	< 0.005	0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE 818-02 10/20/87 PARAMETER VALUE+/-UNCERTAINTY			818-03 10/20/87 PARAMETER VALUE+/-UNCERTAINTY			818-04 10/20/87 PARAMETER VALUE+/-UNCERTAINTY			818-05 10/20/87 PARAMETER VALUE+/-UNCERTAINTY			818-01 01/05/88 PARAMETER VALUE+/-UNCERTAINTY		
ALKALINITY	MG/L CACO3		541.			541.			541.			541.			546.	
ALUMINUM	MG/L	<	0.1		<	0.1		<	0.1		<	0.1		<	0.1	
AMMONIUM	MG/L		0.2			0.2			0.2			0.2			0.3	
ANTIMONY	MG/L		-			-			-			-			-	
ARSENIC	MG/L		0.01			0.01			0.01			0.01			0.01	
BALANCE	%		-			-			-			-			-	
BARIUM	MG/L		-			-			-			-			-	
BORON	MG/L		0.7			0.7			0.7			0.6			0.61	
CADMIUM	MG/L		-			-			-			-			-	
CALCIUM	MG/L		6.5			6.4			6.4			6.4			8.59	
CHLORIDE	MG/L		450.			400.			400.			440.			600.	
CHROMIUM	MG/L	<	0.01		<	0.01		<	0.01		<	0.01			0.03	
COBALT	MG/L		-			-			-			-			-	
CONDUCTANCE	UMHO/CM		2900.			2900.			2900.			2900.			3160.	
COPPER	MG/L		-			-			-			-			-	
FLUORIDE	MG/L		2.1			2.4			2.7			2.7			2.9	
GROSS ALPHA	PCI/L		0.0	28.		0.0	27.		32.	29.		0.0	23.		2.	14.
GROSS BETA	PCI/L		5.6	22.		8.1	23.		2.0	18.		0.0	21.		23.	16.
IRON	MG/L	<	0.03		<	0.03		<	0.03		<	0.03			0.15	
LEAD	MG/L		-			-			-			-			-	
MAGNESIUM	MG/L		1.40			1.40			1.43			1.41			1.65	
MANGANESE	MG/L		0.04			0.04			0.04			0.04			0.02	
MERCURY	MG/L		-			-			-			-			-	
MOLYBDENUM	MG/L	<	0.01		<	0.01		<	0.01		<	0.01			0.04	
NICKEL	MG/L		-			-			-			-			-	
NITRATE	MG/L	<	1.0		<	1.0		<	1.0		<	1.0		<	0.1	
NITRITE	MG/L		-			-			-			-			-	
ORG. CARBON	MG/L		10.		<	1.		<	1.			1.			146.	
PH	SU		8.3			8.3			8.3			8.3			8.35	
PHOSPHATE	MG/L		-			-			-			-			-	
POTASSIUM	MG/L		1.40			1.40			1.40			1.42			2.1	
RA-226	PCI/L		0.3	0.1		0.3	0.1		0.2	0.1		0.4	0.1		0.1	0.1
RA-228	PCI/L		0.1	1.4		1.0	1.3		1.5	2.1		1.5	1.7		0.8	0.8
SELENIUM	MG/L	<	0.005		<	0.005		<	0.005		<	0.005			0.018	
SILICA	MG/L		-			-			-			-			-	
SILVER	MG/L		-			-			-			-			-	
SODIUM	MG/L		780.			790.			800.			730.			906.	
STRONTIUM	MG/L		-			-			-			-			-	
SULFATE	MG/L		590.			620.			580.			590.			599.	
SULFIDE	MG/L		-			-			-			-			-	
TEMPERATURE	C - DEGREE		18.0			18.0			18.0			18.0			16.2	
TH-230	PCI/L		-			-			-			-			-	
TIN	MG/L		-			-			-			-			-	
TOTAL SOLIDS	MG/L		2160.			2140.			2170.			2170.			2420.	
URANIUM	MG/L		0.003			0.003			0.004			0.005			0.0011	
VANADIUM	MG/L	<	0.01		<	0.01		<	0.01		<	0.01		<	0.01	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Contirued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		848-02 10/20/87	848-03 10/20/87	848-04 10/20/87	848-05 10/20/87	848-01 01/05/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

LOCATION ID - SAMPLE ID AND LOG DATE

		848-02 01/05/88		848-03 01/05/88		848-04 01/05/88		848-05 01/05/88		848-01 07/16/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	546.		546.		546.		546.		513.	
ALUMINUM	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		< 0.01	
AMMONIUM	MG/L	0.1		0.1		0.1		0.2		< 0.1	
ANTIMONY	MG/L	-		-		-		-		-	
ARSENIC	MG/L	0.01		0.01		0.01		0.007		0.151	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		-		-		0.03	
BORON	MG/L	0.61		0.59		0.61		0.61		0.69	
CADMIUM	MG/L	-		-		-		-		< 0.001	
CALCIUM	MG/L	8.56		8.47		8.72		8.54		12.5	
CHLORIDE	MG/L	600.		640.		640.		640.		880.	
CHROMIUM	MG/L	0.03		0.03		0.03		0.03		< 0.01	
COBALT	MG/L	-		-		-		-		-	
CONDUCTANCE	UMHO/CM	3160.		3160.		3160.		3160.		3800.	
COPPER	MG/L	-		-		-		-		< 0.01	
FLUORIDE	MG/L	2.98		2.92		2.93		2.94		2.9	
GROSS ALPHA	PCI/L	9.	17.	2.	13.	8.	16.	17.	16.	0.	27.
GROSS BETA	PCI/L	7.	18.	0.	18.	15.	18.	8.	16.	0.	18.
IRON	MG/L	0.15		0.15		0.15		0.15		0.01	
LEAD	MG/L	-		-		-		-		0.17	
MAGNESIUM	MG/L	1.63		1.61		1.65		1.62		2.31	
MANGANESE	MG/L	0.02		0.02		0.02		0.02		0.02	
MERCURY	MG/L	-		-		-		-		< 0.0002	
MOLYBDENUM	MG/L	0.08		0.09		0.08		0.09		0.01	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	< 0.1		< 0.1		< 0.1		< 0.1		6.3	
NITRITE	MG/L	-		-		-		-		-	
ORG. CARBON	MG/L	146.		111.		135.		147.		120.	
PH	SU	8.35		8.35		8.35		8.35		8.45	
PHOSPHATE	MG/L	-		-		-		-		-	
POTASSIUM	MG/L	1.42		1.35		1.56		2.01		2.4	
RA-226	PCI/L	0.2	0.2	0.2	0.2	0.4	0.2	0.5	0.3	0.2	0.2
RA-228	PCI/L	0.6	1.0	0.	0.9	0.5	0.9	0.4	0.8	0.5	0.8
SELENIUM	MG/L	0.018		0.016		0.017		0.016		< 0.001	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		-		-		< 0.01	
SODIUM	MG/L	904.		900.		904.		902.		1040.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	589.		594.		604.		600.		535.	
SULFIDE	MG/L	-		-		-		-		11.	
TEMPERATURE	C - DEGREE	16.2		16.2		15.2		16.2		18.0	
TH-230	PCI/L	-		-		-		-		-	
TIN	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	2420.		2420.		2440.		2440.		2800.	
URANIUM	MG/L	0.0042		0.0043		0.0042		0.0043		0.0003	
VANADIUM	MG/L	< 0.01		< 0.01		< 0.01		< 0.01		< 0.01	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		818-02 01/05/88	818-03 01/05/88	818-04 01/05/88	818-05 01/05/88	818-01 07/16/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	0.009	0.007	< 0.005	0.005	< 0.005

MAPPER DATA FILE NAME: GRN01*UDPGUQ102193

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE									
		582-01 09/12/86		582-01 01/13/87		582-01 10/02/87		582-01 01/10/88		582-01 07/18/88	
		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	530.		560.		521.		521.		529.	
ALUMINUM	MG/L	0.3		0.2		< 0.1		< 0.1		< 0.01	
AMMONIUM	MG/L	0.7		0.3		0.3		< 0.1		< 0.1	
ANTIMONY	MG/L	< 0.003		-		-		-		-	
ARSENIC	MG/L	< 0.01		-		< 0.01		< 0.01		0.022	
BALANCE	%	-0.88		-		-		-		-	
BARIUM	MG/L	0.2		-		-		-		< 0.01	
BORON	MG/L	0.8		0.5		0.7		0.7		0.7	
CADMIUM	MG/L	< 0.001		-		-		-		0.001	
CALCIUM	MG/L	7.32		1.83		1.1		1.54		5.96	
CHLORIDE	MG/L	640.		307.		300.		300.		569.	
CHROMIUM	MG/L	0.01		< 0.01		< 0.01		0.02		< 0.01	
COBALT	MG/L	< 0.05		-		-		-		-	
CONDUCTANCE	UMHO/CM	2500.		2550.		2500.		2400.		2900.	
COPPER	MG/L	< 0.02		-		-		-		< 0.01	
FLUORIDE	MG/L	4.4		1.3		1.2		3.65		4.3	
GROSS ALPHA	PCI/L	-		-		0.0	18.	2.	13.	0.	23.
GROSS BETA	PCI/L	-		-		1.9	15.	0.	11.	5.	14.
IRON	MG/L	< 0.03		0.05		< 0.03		0.12		< 0.01	
LEAD	MG/L	< 0.01		-		-		-		0.10	
MAGNESIUM	MG/L	1.20		0.99		0.94		0.88		1.13	
MANGANESE	MG/L	0.02		0.01		< 0.01		< 0.01		< 0.01	
MERCURY	MG/L	< 0.0002		-		-		-		< 0.0002	
MOLYBDENUM	MG/L	0.10		< 0.1		< 0.01		0.02		< 0.01	
NICKEL	MG/L	< 0.04		-		-		-		-	
NITRATE	MG/L	5.6		0.4		< 1.0		< 0.1		2.1	
NITRITE	MG/L	< 0.1		-		-		-		-	
ORG. CARBON	MG/L	62.		-		< 1.		125.		74.3	
PB-210	PCI/L	0.0	1.7	-		-		-		-	
PH	SU	8.84		8.34		8.0		8.4		8.21	
PHOSPHATE	MG/L	< 0.1		-		-		-		-	
PO-210	PCI/L	0.0	0.5	-		-		-		-	
POTASSIUM	MG/L	2.01		0.90		0.92		1.07		1.1	
RA-226	PCI/L	0.1	0.1	-		0.4	0.2	0.3	0.1	0.5	0.3
RA-228	PCI/L	0.0	1.1	-		1.2	1.0	0.	0.9	0.0	0.7
SELENIUM	MG/L	0.076		< 0.002		< 0.005		0.027		0.007	
SILICA	MG/L	5.		-		-		-		-	
SILVER	MG/L	< 0.01		-		-		-		< 0.01	
SODIUM	MG/L	936.		712.		700.		698.		834.	
STRONTIUM	MG/L	0.6		-		-		-		-	
SULFATE	MG/L	649.		618.		630.		624.		577.	
SULFIDE	MG/L	-		-		-		-		9.9	
TEMPERATURE	C - DEGREE	18.		16.5		16.0		14.3		16.5	
TH-230	PCI/L	0.3	0.5	-		-		-		-	
TIN	MG/L	< 0.005		-		-		-		-	
TOTAL SOLIDS	MG/L	2000.		2130.		1930.		1930.		2240.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: UP GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		848-02 01/05/88	848-03 01/05/88	848-04 01/05/88	848-05 01/05/88	848-01 07/16/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
ZINC	MG/L	0.009	0.007	< 0.005	0.005	< 0.005

MAPPER DATA FILE NAME: GRN01*UOPGW0402493

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		582-01 09/12/86		582-01 01/13/87		582-01 10/02/87		582-01 01/10/88		582-01 07/18/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	530.		560.		571.		571.		579.	
ALUMINUM	MG/L	0.3		0.2		< 0.1		< 0.1		< 0.01	
AMMONIUM	MG/L	0.7		0.3		0.3		< 0.1		< 0.1	
ANTIMONY	MG/L	< 0.003		-		-		-		-	
ARSENIC	MG/L	< 0.01		-		< 0.01		< 0.01		0.022	
BALANCE	%	-0.88		-		-		-		-	
BARIUM	MG/L	0.7		-		-		-		< 0.01	
BORON	MG/L	0.8		0.5		0.7		0.7		0.7	
CADMIUM	MG/L	< 0.001		-		-		-		0.001	
CALCIUM	MG/L	7.12		1.83		1.1		1.54		5.96	
CHLORIDE	MG/L	640.		307.		390.		300.		560.	
CHROMIUM	MG/L	0.01		< 0.01		< 0.01		0.02		< 0.01	
COBALT	MG/L	< 0.05		-		-		-		-	
CONDUCTANCE	UMHO/CM	2500.		2550.		2500.		2400.		2900.	
COPPER	MG/L	< 0.02		-		-		-		< 0.01	
FLUORIDE	MG/L	4.4		4.3		1.2		3.65		1.3	
GROSS ALPHA	PCI/L	-		-		0.0	18.	2.	13.	0.	23.
GROSS BETA	PCI/L	-		-		1.9	15.	0.	11.	5.	14.
IRON	MG/L	< 0.03		0.05		< 0.03		0.12		< 0.01	
LEAD	MG/L	< 0.01		-		-		-		0.10	
MAGNESIUM	MG/L	1.20		0.99		0.94		0.88		1.13	
MANGANESE	MG/L	0.02		0.01		< 0.01		< 0.01		< 0.01	
MERCURY	MG/L	< 0.0002		-		-		-		< 0.0002	
MOLYBDENUM	MG/L	0.10		< 0.1		< 0.01		0.02		< 0.01	
NICKEL	MG/L	< 0.04		-		-		-		-	
NITRATE	MG/L	5.6		0.4		< 1.0		< 0.1		2.1	
NITRITE	MG/L	< 0.1		-		-		-		-	
ORG. CARBON	MG/L	62.		-		< 1.		125.		74.3	
PB-210	PCI/L	0.0	1.7	-		-		-		-	
PH	SU	8.84		8.14		8.0		8.4		8.21	
PHOSPHATE	MG/L	< 0.1		-		-		-		-	
PO-210	PCI/L	0.0	0.5	-		-		-		-	
POTASSIUM	MG/L	2.01		0.90		0.92		1.02		1.1	
RA-226	PCI/L	0.1	0.1	-		0.4	0.2	0.3	0.1	0.5	0.3
RA-228	PCI/L	0.0	1.1	-		1.2	1.0	0.	0.9	0.0	0.7
SELENIUM	MG/L	0.076		< 0.002		< 0.005		0.027		0.007	
SILICA	MG/L	5.		-		-		-		-	
SILVER	MG/L	< 0.01		-		-		-		< 0.01	
SODIUM	MG/L	936.		742.		700.		698.		834.	
STRONTIUM	MG/L	9.6		-		-		-		-	
SULFATE	MG/L	642.		615.		630.		674.		577.	
SULFIDE	MG/L	-		-		-		-		9.9	
TEMPERATURE	C - DEGREE	10.		16.5		16.0		14.3		16.5	
TH-230	PCI/L	0.3	0.5	-		-		-		-	
TIN	MG/L	< 0.005		-		-		-		-	
TOTAL SOLIDS	MG/L	2000.		2130.		1930.		1930.		2240.	

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE				
		582-01 09/12/86	582-01 03/13/87	582-01 10/02/87	582-01 01/10/88	582-01 07/18/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	< 0.0003	0.0026	< 0.003	< 0.0003	< 0.0003
VANADIUM	MG/L	0.19	-	< 0.01	< 0.01	< 0.01
ZINC	MG/L	0.008	-	< 0.005	0.01	< 0.005

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Continued)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE									
		849-01 10/26/87		849-01 01/05/88							
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	500.		547.							
ALUMINUM	MG/L	< 0.1		< 0.1							
AMMONIUM	MG/L	0.4		0.3							
ANTIMONY	MG/L	-		-							
ARSENIC	MG/L	< 0.01		0.002							
BALANCE	%	-		-							
BARIUM	MG/L	-		-							
BORON	MG/L	0.5		0.62							
CADMIUM	MG/L	-		-							
CALCIUM	MG/L	24.		6.63							
CHLORIDE	MG/L	146.		630.							
CHROMIUM	MG/L	< 0.01		0.02							
COBALT	MG/L	-		-							
CONDUCTANCE	UMHO/CM	3300.		3450.							
COPPER	MG/L	-		-							
FLUORIDE	MG/L	2.9		5.58							
GROSS ALPHA	PCI/L	0.0	18.	0.	9.						
GROSS BETA	PCI/L	0.0	19.	9.	14.						
IRON	MG/L	< 0.03		0.11							
LEAD	MG/L	-		-							
MAGNESIUM	MG/L	11.6		1.31							
MANGANESE	MG/L	< 0.01		0.01							
MERCURY	MG/L	-		-							
MOLYBDENUM	MG/L	0.01		0.04							
NICKEL	MG/L	-		-							
NITRATE	MG/L	6.5		< 0.1							
NITRITE	MG/L	-		-							
ORG. CARBON	MG/L	12.		108.							
PB-210	PCI/L	-		-							
PH	SU	8.0		8.2							
PHOSPHATE	MG/L	-		-							
PO-210	PCI/L	-		-							
POTASSIUM	MG/L	2.6		1.3							
RA-226	PCI/L	0.3	0.2	0.7	0.2						
RA-228	PCI/L	0.0	1.1	0.6	0.9						
SELENIUM	MG/L	< 0.005		0.019							
SILICA	MG/L	-		-							
SILVER	MG/L	-		-							
SODIUM	MG/L	1160.		908.							
STRONTIUM	MG/L	-		-							
SULFATE	MG/L	2470.		578.							
SULFIDE	MG/L	-		-							
TEMPERATURE	C - DEGREE	16.0		14.3							
TH-230	PCI/L	-		-							
TIN	MG/L	-		-							
TOTAL SOLIDS	MG/L	3820.		2480.							

Table D.5.15 Chemical analyses of groundwater, Green River, Utah, tailings site (Concluded)

FORMATION OF COMPLETION: SANDSTONE
HYDRAULIC FLOW RELATIONSHIP: DOWN GRADIENT

		LOCATION ID - SAMPLE ID AND LOG DATE	
		819-01 10/26/87	819-01 01/05/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY	PARAMETER VALUE+/-UNCERTAINTY
URANIUM	MG/L	0.009	< 0.0003
VANADIUM	MG/L	< 0.01	< 0.01
ZINC	MG/L	< 0.005	0.02

MAPPER DATA FILE NAME: GRN01*UDPGW0102492

Table D.5.16 Background groundwater quality summary for the top hydrostratigraphic unit, Green River, Utah, tailings site

Constituent[a]	Number of analyses[b]	Arithmetic mean ($\bar{X}$)	Standard deviation x2 (2s)	Statistical concentration range ($\bar{X}\pm 2s$)	Observed concentration range	Proposed EPA groundwater MCL
Chromium (mg/l)	11	0.04	0.07	<0.01-0.11	0.03-0.14	0.05
Molybdenum (mg/l)	11	0.11	0.13	<0.01-0.24	<0.01-0.20	0.10
Nitrate (NO_3) (mg/l)	11	45	84	<1-129	9-140	44
Selenium (mg/l)	11	0.147	0.272	<0.005-0.419	<0.005-0.380	0.010
Radium-226 and 228 (pci/l)	6	0.9	1.4	0.0-2.3	0.0-1.7	5.0
Uranium-234 and 238 (mg/l)	11	0.0118	0.0051	0.0067-0.0169	0.0081-0.0167	0.0440
Gross alpha (pCi/l)	5	9.6	31.8	0.0-41.4	0.0-41.0	15

[a] All constituents listed are included in the proposed EPA groundwater standards (40 CFR 142) and have EPA National and State of Utah Primary Drinking Water Standards, with the exception of molybdenum, which does not have a maximum concentration limit in Utah. Arsenic, barium, cadmium, lead, mercury, and silver are also included in the proposed EPA groundwater standards, and the EPA National and State of Utah Primary Drinking Water Standards. However, because these constituents were found to be below detection limits for the first two rounds of water sampling in June, 1986, and September, 1986, they were excluded from subsequent sampling rounds and are not considered to be present as contamination at the Green River site

[b] The background wells included in the analyses are GRN01-563 and 707. The analyses may include the results from one or more of the following rounds of sampling: 6/86; 9/86; 3/87; 10/87; 1/88; 5/88; and 7/88; depending on if the well(s) were in existence at the time of sampling.

Table D.5.17 Background groundwater quality summary for the upper-middle hydrostratigraphic unit, Green River, Utah, tailings site

Constituent[a]	Number of analyses[b]	Arithmetic mean[c] ($\bar{X}$)	Standard deviation x2[c] (2s)	Statistical concentration range[c] ($\bar{X}\pm 2s$)	Observed concentration range	Proposed EPA groundwater MCL[d]
Chromium (mg/l)	5	0.02	0.03	<0.01-0.05	<0.01-0.05	0.05
Molybdenum (mg/l)	5	0.02	0.03	<0.01-0.05	<0.01-0.05	0.1
Nitrate (NO_3) (mg/l)	5	36	86	<1-122	<1-93	44
Selenium (mg/l)	5	0.66	1.92	<0.005-2.58	<0.005-2.50	0.01
Radium-226 and 228 (pCi/l)	4	ND	ND	ND	0.1-0.8	5.0
Uranium-234 and 238 (mg/l)	5	0.0109	0.0274	<0.003-0.0383	<0.003-0.0380	0.044
Gross alpha (pCi/l)	4	ND	ND	ND	0.0-21.0	15

[a] All constituents listed are included in the proposed EPA groundwater standards (40 CFR 192) and have EPA National and State of Utah Primary Drinking Water Standards, with the exception of molybdenum, which does not have a maximum concentration limit in Utah. Arsenic, barium, cadmium, lead, mercury, and silver are also included in the proposed EPA groundwater standards, and the EPA National and State of Utah Primary Drinking Water Standards. However, because these constituents were found to be below detection limits for the first two rounds of water sampling in June, 1986, and September, 1986, they were excluded from subsequent sampling rounds and are not considered to be present as contamination at the Green River site.

[b] The background wells included in the analyses are GRN01-816 and 806. The analyses may include the results from one or more of the following rounds of sampling: 6/86; 9/86; 3/87; 10/87; 1/88; 5/88; and 7/88; depending on if the well(s) were in existence at the time of sampling. If less than five analyses were available, a statistical analysis was not performed.

[c] ND = not determined because number of analyses is less than five.

[d] MCLs are the same for EPA National and State of Utah Primary Drinking Water Standards.

Table D.5.18 Background groundwater quality summary for the lower-middle hydrostratigraphic unit, Green River, Utah, tailings site

Constituent[a]	Number of analyses[b]	Arithmetic mean ($\bar{X}$)	Standard deviation x2 (2s)	Statistical concentration range ($\bar{X} \pm 2s$)	Observed concentration range	Proposed EPA groundwater MCL[c]
Chromium (mg/l)	12	0.03	0.06	<0.01-0.09	<0.01-0.09	0.05
Molybdenum (mg/l)	12	0.10	0.14	<0.01-0.24	<0.01-0.22	0.1
Nitrate (NO_3) (mg/l)	12	68	116	<1-184	1-173	44
Selenium (mg/l)	12	0.088	0.196	<0.005-0.284	<0.005-0.320	0.01
Radium-226 and 228 (pCi/l)	7	1.7	2.6	0.0-4.3	0.1-3.9	5.0
Uranium-234 and 238 (mg/l)	12	0.046	0.080	<0.003-0.126	<0.003-0.146	0.044
Gross alpha (pCi/l)	7	70	110	0-180	4-150	15

[a] All constituents listed are included in the proposed EPA groundwater standards (CFR 40 192) and have EPA National and State of Utah Primary Drinking Water Standards, with the exception of molybdenum, which does not have a maximum concentration limit in Utah. Arsenic, barium, cadmium, lead, mercury, and silver are also included in the proposed EPA groundwater standards, and the EPA National and State of Utah Primary Drinking Water Standards. However, because these constituents were found to be below detection limits for the first two rounds of water sampling in June, 1986, and September, 1986, they were excluded from subsequent sampling rounds and are not considered to be present as contamination at the Green River site.

[b] The background wells included in the analyses are GRN01-562, 811, and 813. The analyses may include the results from one or more of the following rounds of sampling: 6/86; 9/86; 3/87; 10/87; 1/88; 5/88; and 7/88; depending on if the well(s) were in existence at the time of sampling.

[c] MCLs are the same for EPA National and State of Utah Primary Drinking Water Standards.

Table D.5.19 Background groundwater quality summary for the bottom hydrostratigraphic unit, Green River, Utah, tailings site

Constituent[a]	Number of analyses[b]	Arithmetic mean ($\bar{X}$)	Standard deviation x2 (2s)	Statistical concentration range ($\bar{X} \pm 2s$)	Observed concentration range	Proposed EPA groundwater MCL[c]
Chromium (mg/l)	19	0.03	0.04	<0.01-0.07	<0.01-0.07	0.05
Molybdenum (mg/l)	19	0.05	0.08	<0.01-0.13	<0.01-0.14	0.1
Nitrate (NO_3) (mg/l)	19	1	2	<1-3	<1-6	44
Selenium (mg/l)	19	0.022	0.060	<0.005-0.082	<0.005-0.106	0.01
Radium-226 and 228 (pCi/l)	16	0.7	1.5	0.0-2.2	0.0-3.0	5.0
Uranium-234 and 238 (mg/l)	19	0.0019	0.0032	<0.003-0.0051	<0.003-0.0049	0.044
Gross alpha (pCi/l)	16	3.7	16.8	0.0-20.5	0.0-30.0	15

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[a] All constituents listed are included in the proposed EPA groundwater standards (UMTRA, 52 FR36000) and have EPA National and State of Utah Primary Drinking Water Standards, with the exception of molybdenum, which does not have a maximum concentration limit in Utah. Arsenic, barium, cadmium, lead, mercury, and silver are also included in the proposed EPA groundwater standards, and the EPA National and State of Utah Primary Drinking Water Standards. However, because these constituents were found to be below detection limits for the first two rounds of water sampling in June, 1986, and September, 1986, they were excluded from subsequent sampling rounds and are not considered to be present as contamination at the Green River site.

[b] The background wells included in the analyses are GRN01-586, 587, 588, 817, and 818. The analyses may include the results from one or more of the following rounds of sampling: 6/86; 9/86; 3/87; 10/87; 1/88; 5/88; and 7/88; depending on if the well(s) were in existence at the time of sampling.

[c] MCLs are the same for EPA National and State of Utah Primary Drinking Water Standards.

Table D.5.20 Summary of maximum and minimum observed concentrations in the top hydrostratigraphic unit from tailings seepage, Green River, Utah, tailings site

Constituent	Number of analyses[a]	Observed maximum	Observed minimum	Proposed EPA standard
Chromium (mg/l)	12	0.040	0.005	0.050
Molybdenum (mg/l)	17	0.270	0.005	0.100
Nitrate (NO_3) (mg/l)	17	440	1	44
Selenium (mg/l)	17	0.410	0.001	0.010
Radium-226 and 228 (pCi/l)	11	3.8	0.0	5.0
Uranium-234 and 238 (mg/l)	17	2.23	0.0419	0.0440
Gross alpha (pCi/l)	5	950	20	15

[a] Includes analyses from on-site monitor wells 702, 704, 705, and 808.

Table D.5.21 Summary of maximum and minimum observed concentrations in the upper-middle hydrostratigraphic unit from tailings seepage, Green River, Utah, tailings site

Constituent	Number of analyses[a]	Observed maximum	Observed minimum	Proposed EPA standard
Chromium (mg/l)	5	0.050	0.005	0.050
Molybdenum (mg/l)	8	0.200	0.010	0.100
Nitrate (NO_3) (mg/l)	8	2480	2	44
Selenium (mg/l)	8	0.370	0.0025	0.010
Radium-226 and 228 (pCi/l)	7	2.0	0.9	5.0
Uranium-234 and 238 (mg/l)	8	3.110	0.437	0.044
Gross alpha (pCi/l)	1	980	980	15

[a] Includes analyses from on site monitor well 701.

Table D.5.22 Permeability test results and physical properties from tailings samples, Green River, Utah, tailings site[a]

Test pit or borehole number	Sample interval (feet)	USCS class[b]	Tailings type	In situ moisture content (percent)	Dry density (pcf)[c]	Saturated hydraulic conductivity (cm/s)	Type of test
542	0.5-1.5	SP-SM	Sand	--	--	5.8×10^{-4}	C[d]
572	3.5-4.5	SP-SC	Sand	1.6	--	--	--
	6.5-7.5	SP-SC	Sand	4.0	--	--	--
	9.5-10.5	SP-SM	Sand	5.6	--	--	--
	12.8-13.5	SP-SM	Sand	15.5	--	--	--
574	2.5-3.5	SP-SM	Sand	1.2	103.6	--	--
	7.0-7.5	SP-SM	Sand	4.7	86.7	--	--
575	2.5-3.0	SP-SM	Sand	1.3	97.6	--	--
	7.0-8.0	SM	Sand	4.7	--	--	--
	13.0-14.0	SP-SM	Sand	5.0	--	--	--
578	2.5-3.0	SP-SM	Sand	2.2	90.1	--	--
	5.5-6.5	SP-SM	Sand	3.4	--	--	--
	7.0-8.0	SM	Sand	6.1	--	--	--
	10.0-11.0	SC	Sand	5.3	--	--	--
T-01	--	SP-SM	Sand	--	--	2.7×10^{-5}	T[e]
T-02	--	SP-SM	Sand	--	--	2.8×10^{-4}	T
T-03	--	SP-SM	Sand	--	--	1.3×10^{-4}	T

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[a] Borehole locations are shown on Figure D.5.1. Blanks indicate the properties were not determined.

[b] Unified Soil Classification System; SP is poorly graded sands, gravelly sands; SM is silty sands, sand-silt mixtures; SC is clayey sands, sand-clay mixtures.

[c] pcf = pounds per cubic foot.

[d] C = constant-head test; the sample was remolded to average 92 percent of standard Proctor density.

[e] T = triaxial permeability tests; sample was remolded to 95 percent of standard Proctor density.

Table D.5.23 Chemical analyses for lysimeter GRN01-714[a]

Parameter	9/11/86	3/12/87
Aluminum	6300	1840
Ammonium	14	11
Antimony	-	0.003
Arsenic	-	0.03
Barium	-	0.1
Boron	0.5	0.1
Cadmium	-	0.032
Calcium	457	385
Chloride	113	2900
Chromium	2.61	1.14
Cobalt	-	30.9
Copper	-	45.8
Fluoride	0.1	0.2
Iron	2200	267
Lead	-	0.02
Magnesium	2640	1090
Manganese	360	122
Mercury	-	0.
Molybdenum	0.2	0.10
Nickel	-	25.3
Nitrate	4500	2
Nitrite	-	0.1
Phosphate	-	0.1
Potassium	0.19	16.0
Selenium	0.092	0.208
Silica	-	60
Silver	-	0.01
Sodium	89.2	111
Strontium	-	0.1
Sulfate	56200	16000
Tin	-	0.005
Total dissolved solids	80800	26100
Uranium	675	221
Vanadium	-	178
Zinc	-	259

[a] All values in mg/l. See Figure D.5.1 for the location of lysimeter 714.

Table D.5.24 Analyses of Cedar Mountain Formation groundwater, Green River, Utah[a]

Species and parameter	Monitor well 562	Monitor well 581	Monitor well 584	Monitor well 701	Monitor well 813
Magnesium	124	883	134	197	114
Calcium	328	221	467	520	253
Sodium	1870	1680	1680	1115	1910
Potassium	7.39	2.51	3.27	20.50	7.24
Sulfate	4330	2460	3160	2870	4200
Chlorine	150	180	130	94	130
Alkalinity (as calcium carbonate)	660	979	266	407	671
Silica	9.70	8.8	9.2	18.0	9.2
Sulphur	<0.10	45.4	<0.1	<0.1	<0.1
Iron^{2+}	<0.03	<0.03	<0.03	<0.03	<0.03
Iron^{3+}	0.045	<0.01	0.045	0.045	0.040
Nitrate	103	0.2	0.2	1570	22.7
Ammonium	<0.1	0.8	0.6	45.2	<0.1
Nitrite	0.66	<0.03	<0.03	0.07	1.48
Molybdenum	0.07	0.02	0.01	0.09	0.13
Selenium	0.16	0.09	0.11	0.55	0.13
Arsenic	0.01	0.02	0.01	0.02	0.02
Total dissolved solids	7190	4630	4930	6680	6920
Temperature(°C)	16.5	15.7	15.9	16.5	17.5
pH	6.88	7.25	7.96	6.68	6.88
Eh (field, V)	+0.274	-0.133	-0.080	+0.272	+0.274

[a] All concentrations are in mg/l unless noted otherwise. °C = degrees Celsius; V = volts.

Table D.5.25 Field measured and theoretical redox potentials (Eh) controlling uraninite precipitation within the Cedar Mountain Formation, Green River, Utah

Monitor well	pH	Field Eh (volts)	Uraninite S.I.[a]	Calculated Eh (volts)	Uraninite S.I.[a]	Log PCO_2
581	7.25	-0.133	2.19	-0.107	0	-2.0
584	7.96	-0.080	0.02	-0.106	0	-2.0

Speciation of dissolved uranium (mg/l)

	Total U	$U(OH)_5^-$	$UO_2CO_3^0$	$UO_2(CO_3)_2^{2-}$	$UO_2(CO_3)_3^{4-}$
581	0.001	0.0007	6.14×10^{-7}	0.0001	0.0001
584	0.001	0.001	2.04×10^{-6}	0.003	0.0005

[a] S.I. refers to saturation index. $\text{S.I.} = \text{Log } 10 \frac{\text{activity product}}{\text{solubility product}}$.

Table D.5.26 Field pH, field Eh, total uranium, and saturation indices for Cedar Mountain Formation, Green River, Utah[a]

Well number	Field pH	Field Eh (volts)	Total uranium (mg/l)	Dominant Form	Saturation index Uraninite	Coffinite	Calcite	Gypsum	Pyrite	Amorphous $Fe(OH)_3$	CO_2
584	7.96	-0.080	<0.001	$UO_2(CO_3)_3^{4-}$ $U(OH)_5^-$	+0.02	-0.89	-0.02	-0.85	+0.01	-0.68	-2.0
581	7.25	-0.133	<0.001	$U(OH)_5^-$	+1.83	+1.34	-0.42	-4.63	+0.01	-3.82	-2.0
701	6.68	+0.272	2.690	$UO_2(CO_3)_2^{2-}$	-5.75	-6.08	+0.03	+0.28	-94.60	+2.71	-2.0
562	6.88	+0.274	0.076	$UO_2(CO_3)_3^{4-}$	-8.85	-9.43	+0.06	+0.35	-98.20	+3/65	-2.0
813	6.88	+0.274	0.079	$UO_2(CO_3)_3^{4-}$	-8.76	-9.26	+0.06	+0.13	-98.50	+3/62	-2.0

[a] Calculated by PHREEQE Model (Parkhurst et al., 1980). Saturation indices = log (IAP/K_T).

Table D.5.27 Chemical analysis of batch leach and column extraction solutions from tailings, buffer material, and windblown soil samples, Green River, Utah

		LOCATION ID - SAMPLE ID AND LOG DATE			
		825-01 04/10/89 (a)	826-01 04/10/89 (a)	827-01 04/10/89 (a)	828-01 04/10/89 (a)
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY
ALUMINUM	MG/L	-	0.06	< 0.05	< 0.05
AMMONIUM	MG/L	0.25	0.22	0.09	0.17
ANTIMONY	MG/L	0.009	0.004	0.002	0.010
ARSENIC	MG/L	0.033	0.043	0.040	0.032
BARIUM	MG/L	0.06	0.07	0.08	0.06
BERYLLIUM	MG/L	< 0.005	< 0.005	< 0.005	0.06
CADMIUM	MG/L	0.0030	< 0.0001	< 0.0001	< 0.005
CALCIUM	MG/L	71.	57.	59.	< 0.0001
CHLORIDE	MG/L	8.	7.	7.	60.
CHROMIUM	MG/L	< 0.01	< 0.01	< 0.01	6.
COBALT	MG/L	< 0.02	< 0.02	< 0.02	< 0.01
COPPER	MG/L	0.04	0.02	0.04	< 0.02
FLUORIDE	MG/L	0.4	0.3	0.3	0.06
IRON	MG/L	0.02	0.03	< 0.02	0.4
LEAD	MG/L	0.003	< 0.001	< 0.001	< 0.02
MAGNESIUM	MG/L	9.	8.	8.	< 0.001
MANGANESE	MG/L	< 0.01	< 0.01	< 0.01	8.
MERCURY	MG/L	< 0.0001	< 0.0001	< 0.0001	< 0.01
MOLYBDENUM	MG/L	0.007	0.004	0.003	< 0.0001
NICKEL	MG/L	< 0.02	< 0.02	< 0.02	0.002
NITRATE	MG/L	1.8	0.2	0.3	< 0.02
POTASSIUM	MG/L	8.	7.	8.	2.0
SELENIUM	MG/L	0.011	0.010	0.009	7.
SILICA	MG/L	13.3	11.4	11.7	0.011
SODIUM	MG/L	29.	24.	23.	11.1
STRONTIUM	MG/L	0.71	0.60	0.62	22.
SULFATE	MG/L	187.	152.	156.	0.63
THALLIUM	MG/L	< 0.001	< 0.001	< 0.001	169.
TIN	MG/L	< 0.001	< 0.001	< 0.001	< 0.001
TOTAL SOLIDS	MG/L	388.	302.	295.	0.001
URANIUM	MG/L	0.182	0.177	0.168	315.
VANADIUM	MG/L	0.24	0.25	0.24	0.172
ZINC	MG/L	0.02	0.02	< 0.01	0.22
					0.02

Table D.5.27 Chemical analysis of batch leach and column extraction solutions from tailings, buffer material, and windblown soil samples, Green River, Utah

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE			
		829-01 04/28/89 (b)	830-01 04/28/89 (c)	831-01 04/28/89 (c)	832-01 04/28/89 (c)
		PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMFTER VALUE +/- UNCERTAINTY
ALUMINUM	MG/L	< 0.05	< 0.05	< 0.05	< 0.05
AMMONIUM	MG/L	0.42	0.14	0.12	0.35
ANTIMONY	MG/L	0.004	0.001	0.002	0.007
ARSENIC	MG/L	0.011	0.004	0.003	0.003
BARIUM	MG/L	0.02	0.02	0.02	0.02
BERYLLIUM	MG/L	< 0.005	< 0.005	< 0.005	< 0.005
CADMIUM	MG/L	< 0.0001	0.0001	< 0.0001	< 0.0001
CALCIUM	MG/L	661.	550.	560.	511.
CHLORIDE	MG/L	4.	19.	16.	25.
CHROMIUM	MG/L	< 0.01	< 0.01	< 0.01	< 0.01
COBALT	MG/L	< 0.02	< 0.02	< 0.02	< 0.02
COPPER	MG/L	0.01	0.01	0.26	0.03
FLUORIDE	MG/L	0.5	1.5	1.6	1.6
IRON	MG/L	< 0.02	< 0.02	< 0.02	< 0.02
LEAD	MG/L	< 0.001	< 0.001	< 0.001	< 0.001
MAGNESIUM	MG/L	33.	138.	128.	150.
MANGANESE	MG/L	0.08	< 0.01	< 0.01	< 0.01
MERCURY	MG/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
MOLYBDENUM	MG/L	0.082	0.063	0.063	0.058
NICKEL	MG/L	< 0.02	< 0.02	< 0.02	< 0.02
NITRATE	MG/L	12.8	12 5	12.3	12.4
POTASSIUM	MG/L	5.	< 1.	< 1.	1.
SELENIUM	MG/L	0.170	0.091	0.091	0.074
SILICA	MG/L	6.4	22.8	21.7	23.0
SODIUM	MG/L	18.	150.	126.	209.
STRONTIUM	MG/L	1.00	3.70	4.00	5.00
SULFATE	MG/L	1720.	2231.	2165.	2437.
THALLIUM	MG/L	< 0.001	< 0.001	< 0.001	< 0.001
TIN	MG/L	0.017	0.022	0.018	0.027
TOTAL SOLIDS	MG/L	2412.	3126.	3052.	3520.
URANIUM	MG/L	2.800	0.168	0.398	0.077
VANADIUM	MG/L	0.07	0.02	0.02	0.04
ZINC	MG/L	0.03	0.03	0.04	0.02

Table D.5.27 Chemical analysis of batch leach and column extraction solutions from tailings, buffer material, and windblown soil samples, Green River, Utah

		LOCATION ID - SAMPLE ID AND LOG DATE			
		833-01 05/08/89 (d)	834-01 05/08/89 (d)	835-01 05/08/89 (d)	836-01 05/08/89 (b)
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY
ALUMINUM	MG/L	< 0.05	< 0.05	< 0.05	< 0.05
AMMONIUM	MG/L	0.57	0.22	0.62	0.30
ANTIMONY	MG/L	0.008	0.002	0.009	0.008
ARSENIC	MG/L	0.012	0.02	0.005	0.002
BARIUM	MG/L	0.02	0.02	0.02	0.04
BERYLLIUM	MG/L	< 0.005	< 0.005	< 0.005	< 0.005
CADMIUM	MG/L	0.0031	0.0033	0.0028	< 0.0001
CALCIUM	MG/L	607.	656.	655.	135.
CHLORIDE	MG/L	5.	5.	5.	6.
CHROMIUM	MG/L	< 0.01	< 0.01	< 0.01	< 0.01
COBALT	MG/L	< 0.02	< 0.02	< 0.02	< 0.02
COPPER	MG/L	0.03	0.02	0.03	0.03
FLUORIDE	MG/L	0.6	0.6	0.7	1.0
IRON	MG/L	< 0.02	< 0.02	< 0.02	< 0.02
LEAD	MG/L	< 0.001	< 0.001	< 0.001	< 0.001
MAGNESIUM	MG/L	32.	32.	26.	22.
MANGANESE	MG/L	0.02	0.01	0.01	< 0.01
MERCURY	MG/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
MOLYBDENUM	MG/L	0.083	0.088	0.091	0.006
NICKEL	MG/L	< 0.02	< 0.02	< 0.02	< 0.02
NITRATE	MG/L	14.7	16.2	16.5	0.4
POTASSIUM	MG/L	4.	4.	4.	1.
SELENIUM	MG/L	0.167	0.183	0.187	0.005
SILICA	MG/L	7.0	6.9	5.5	8.9
SODIUM	MG/L	20.	22.	21.	31.
STRONTIUM	MG/L	0.99	1.00	1.09	1.97
SULFATE	MG/L	1655.	1712.	1712.	521.
THALLIUM	MG/L	< 0.001	< 0.001	< 0.001	< 0.001
TIN	MG/L	0.017	0.015	0.018	0.007
TOTAL SOLIDS	MG/L	2325.	2305.	2350.	750.
URANIUM	MG/L	0.296	0.306	0.316	0.010
VANADIUM	MG/L	0.07	0.07	0.07	0.01
ZINC	MG/L	0.04	0.02	0.02	0.01

Table D.5.27 Chemical analysis of batch leach and column extraction solutions from tailings, buffer material, and windblown soil samples, Green River, Utah

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE 837-01 05/08/89 (b) PARAMETER VALUE +/- UNCERTAINTY	838-01 05/08/89 (b) PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY
ALUMINUM	MG/L	0.26	< 0.05		
AMMONIUM	MG/L	0.39	0.21		
ANTIMONY	MG/L	0.001	0.007		
ARSENIC	MG/L	0.002	0.003		
BARIUM	MG/L	0.06	0.04		
BERYLLIUM	MG/L	< 0.005	< 0.005		
CADMIUM	MG/L	0.0004	< 0.0001		
CALCIUM	MG/L	139.	127.		
CHLORIDE	MG/L	9.	6.		
CHROMIUM	MG/L	< 0.01	< 0.01		
COBALT	MG/L	< 0.02	< 0.02		
COPPER	MG/L	0.04	0.02		
FLUORIDE	MG/L	1.1	1.1		
IRON	MG/L	0.18	< 0.02		
LEAD	MG/L	< 0.001	< 0.001		
MAGNESIUM	MG/L	25.	22.		
MANGANESE	MG/L	< 0.01	< 0.01		
MERCURY	MG/L	< 0.0001	< 0.0001		
MOLYBDENUM	MG/L	0.003	0.005		
NICKEL	MG/L	< 0.02	< 0.02		
NITRATE	MG/L	0.4	0.3		
POTASSIUM	MG/L	1.	< 1.		
SELENIUM	MG/L	0.004	0.006		
SILICA	MG/L	9.4	9.5		
SODIUM	MG/L	38.	31.		
STRONTIUM	MG/L	2.10	1.91		
SULFATE	MG/L	512.	480.		
THALLIUM	MG/L	< 0.001	< 0.001		
TIN	MG/L	0.006	0.007		
TOTAL SOLIDS	MG/L	705.	675.		
URANIUM	MG/L	0.060	0.040		
VANADIUM	MG/L	0.01	0.01		
ZINC	MG/L	0.02	< 0.01		

MAPPER DATA FILE NAME: GRN01*UDPSUR100236

[a] 825-828: batch leach solution, windblown soils

[b] 829, 836-838: batch leach solution, tailings

[c] 830-832: column extract solution, buffer material; feed solution from 829

[d] 833-838: batch leach solution, buffer material

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APPENDIX E

WATER RESOURCES PROTECTION STRATEGY

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E.1 WATER RESOURCES PROTECTION STRATEGY SUMMARY

The U.S. Department of Energy (DOE) must demonstrate compliance with the U.S. Environmental Protection Agency (EPA) standards for groundwater protection at inactive uranium mill tailings sites. These standards are contained in proposed revisions to Subparts A through C of 40 CFR 192 under Title I of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), as amended. Remedial action taken by the DOE must comply with the proposed standards until EPA promulgates them in final form (UMTRCA, Section 108). This section summarizes the water resources protection strategy for the Uranium Mill Tailings Remedial Action (UMTRA) Project site in Green River, Utah, and the elements of the strategy that demonstrate compliance with the proposed groundwater protection standards. Details of the water resources protection strategy are presented in Sections E.2 and E.3. Characterization of groundwater and hydrogeology at the Green River site is presented in detail in Section D.5 of Appendix D, and is summarized in Section 3.5 of the text of this remedial action plan.

The DOE will comply with the disposal standard (40 CFR 192.02(a)(3)) by constructing a disposal cell that will prevent any tailings leachate from mixing with groundwater within the required 1000-year design life of the cell. Specifically, either designated maximum concentration limits (MCLs) or background concentrations (whichever is greater) will not be exceeded in the uppermost aquifer (the upper- and lower-middle hydrostratigraphic units of the Cedar Mountain Formation) at the point of compliance (POC). The POC is the downgradient edges of the engineered disposal unit.

The following sections summarize the major elements of the groundwater protection strategy.

E.1.1 DESIGN CONSIDERATIONS

The tailings will be placed in a mostly below-grade cell. The base of the excavation will be at an elevation of about 4098 feet, which is nearly 40 feet below existing grade. Groundwater is 10 to 12 feet below the base of the excavation. The bottom six feet of the cell will be filled with a compacted, select clean fill soil to retard the movement of contaminants to groundwater from the overlying contaminated materials. Above the buffer will be a layer of compacted windblown tailings (which will be mixed with clean soils) and a layer of compacted tailings.

A cover system will be constructed over the tailings. From bottom to top, the cover system will consist of three feet of compacted radon barrier, six inches of clean, compacted filter bedding, and one foot of rock for erosion protection. Collectively, the cover layers will limit infiltration of precipitation to 2×10^{-8} cubic centimeters per square centimeters per second (cm^3/cm^2s) or less, will protect from catastrophic erosion by the Probable Maximum Flood (PMF), and will control the release of radon from the cell. Degradation of the infiltration/radon barrier from freezing (via reduced density) will not occur because it is expected that the barrier will never be saturated.

However, approximately 15 inches of the infiltration/radon barrier will lie beneath the calculated frost depth of 39 inches.

The disposal cell components (buffer, windblown materials, and tailings) will be placed at a moisture content that will result in an unsatuated hydraulic conductivity of 8×10^{-9} centimeters per second (cm^2/s), which is less than the calculated saturated hydraulic conductivity (2×10^{-8} cm^2/s) of the infiltration/radon barrier. By minimizing the amount of water used for compaction and dust control during construction, drainage of excess water from the cell will not be a concern (see Section E.2.1.2).

In terms of groundwater protection, the proposed disposal cell and protection strategy at the Green River site make maximum use of the following favorable natural conditions:

- An arid climate (average annual precipitation is six inches per year; estimated ratio of yearly precipitation to actual evapotranspiration is one).
- Consistent, uniform fracturing of the foundation bedrock to prevent any perching of water in the cell and to promote drainage of runoff from the toe of the cell.
- Abundant, desirable secondary minerals on the fracture faces to attenuate any tailings seepage (although tailings seepage into the bedrock is not expected).
- Strong, upward vertical hydraulic gradients in the saturated bedrock downgradient of the disposal site to minimize the downward migration of contamination (although contamination of the groundwater by tailings seepage is not expected).
- A flow direction of groundwater beneath the disposal site toward the existing contamination from the old tailings pile.

In addition, the mostly below-grade disposal will maximize surface runoff and minimize infiltration into the disposal cell.

E.1.2 GROUNDWATER PROTECTION STANDARDS FOR DISPOSAL

There are three basic requirements for complying with the groundwater protection standard (40 CFR 192.02): (1) identification of the hazardous constituents within the disposal cell; (2) proposal of a concentration limit for each hazardous constituent; and (3) specification of the point of compliance.

Ten hazardous constituents (from Appendix IX of 40 CFR 264) within the tailings at the Green River site were identified from analyses of tailings pore water. These are cadmium, chromium, molybdenum, nickel, nitrate, selenium, uranium, vanadium, radium-226 and -228, and gross alpha activity. The proposed concentration limits for the ten hazardous constituents are listed in Table E.1.1, along with the U.S. Nuclear

Table E.1.1 Hazardous constituents and concentration limits for disposal at the Green River UMTRAP site[a]

Constituent	DOE proposed limits	Interim concentration limits
Arsenic	-	0.05 (MCL)
Cadmium	0.01 (MCL)	0.01 (MCL)
Chromium	0.09 (Background)	0.05 (MCL)
Lead	-	0.05 (MCL)
Methylene chloride	-	0.005 (Background)
Molybdenum	0.24 (Background)	0.1 (MCL)
Nickel	0.09 (Background)	0.06 (Background)
Nitrate	180 (Background)	60 (Background)
Selenium	2.50 (Background)	0.66 (Background)
Uranium-234/238	0.146 (Background)	0.044 (MCL)
Vanadium pentoxide	0.38 (Background)	0.09 (Background)
Radium-226/228	5.0 pCi/l (MCL)	5.0 pCi/l (MCL)
Gross alpha (excluding uranium and radon)	195 pCi/l (Background)	24.5 pCi/l (Background)

[a] Units are in milligrams per liter unless noted otherwise; pCi/l = picocuries per liter.

Regulatory Commission's (NRC) proposed interim concentration limits for hazardous constituents at the disposal site. Also, three additional hazardous constituents were included in the DOE's and NRC's list of constituents for the disposal unit. These constituents are arsenic, lead, and methylene chloride.

The concentration limits proposed by the DOE reflect the natural variability of the contaminant concentrations in background water quality samples from beneath the new disposal site. They are equal to one of the following: (1) the MCL for that constituent (established by the EPA); or (2) the maximum observed or statistical maximum background concentration for that constituent. The NRC's proposed interim concentration limits (see Table E.1.1) are statistical mean values rather than maximum values. The proposed interim concentration limits do not account for natural variability of the constituents as they presently occur in groundwater.

Natural variability in groundwater must be accounted for when sampling and analyzing for construction and performance monitoring, and in an assessment of what threshold concentration constitutes an excursion and subsequent corrective action. Therefore, the DOE will collect and analyze representative samples of groundwater from all monitor wells on a quarterly basis during construction of the disposal unit and collect and analyze representative samples of groundwater from the monitor wells and new wells at the point of compliance and background locations on a quarterly basis for two years after completion of the disposal unit. An excursion will therefore not be considered until the two years of quarterly monitoring have been completed. The details of the monitoring program will be presented in the surveillance and maintenance (S&M) plan or another appropriate document upon NRC concurrence with the S&M plan or other document.

The point of compliance at the Green River site will be the entire northwest and northeast edges of the engineered cell. Approximately 60 feet of rock riprap and select fill material will lie between the compacted tailings and the point of compliance.

E.1.3 PERFORMANCE ASSESSMENT

The proposed disposal cell design is intended to prevent the introduction of contaminants into groundwater by providing for leachate travel times from the base of the contaminated soil to groundwater in excess of the design life (1000 years) of the cell.

The NRC UNSAT2 computer model (NRC, 1983) was used to estimate the redistribution of moisture within the disposal cell with time. Examination of the moisture distribution with time allows conclusions to be drawn regarding the steady state moisture conditions within the disposal cell, the travel time of contaminants through the disposal cell, and the flux at the bottom of the disposal cell. Based on the modeling, the travel time for contaminants exiting the bottom of the disposal cell is over 1100 years. (A more detailed discussion of the disposal cell performance is presented in Section E.3.2.) Because leachate percolating from the disposal cell is not expected to reach groundwater within the design life of the cell, no degradation of groundwater quality as a result of the remedial action is anticipated.

E.1.4 CLOSURE PERFORMANCE ASSESSMENT

The DOE must demonstrate compliance with the closure performance standard (40 CFR 192.02(a)(4)) by showing that the need for further maintenance of the disposal site and cell has been minimized and that the disposal unit minimizes or eliminates releases of hazardous constituents to groundwater.

Natural, durable materials will be used to construct the cell so that long-term performance is ensured. Safety factors and conservative design assumptions have been considered in the design so that the cell should operate for longer than the required 1000-year design life.

The previous section (E.1.3) discussed how the disposal cell will prevent the release of hazardous constituents from affecting groundwater at the Green River site.

E.1.5 GROUNDWATER PERFORMANCE MONITORING PROGRAM

The DOE is required to describe an integrated monitoring program to be conducted before, during, and after completion of the remedial action to demonstrate that the initial performance of the cell complies with the groundwater protection standard and the closure performance standards.

The DOE will present a detailed groundwater monitoring program in the S&M plan for the Green River site. The main features of the monitoring program will include moisture monitoring in the tailings, windblown material and buffer layers, and saturated zone monitoring at the point of compliance. There is nothing that would physically preclude this program from being implemented.

An array of four neutron access holes for neutron logging will be used to monitor moisture within the tailings at different depths. The time-integrated moisture versus depth data will be used to estimate the unsaturated hydraulic conductivity of the tailings and the operative flux of moisture through the cell. The neutron access holes will also penetrate the windblown material and buffer layers. The schedule for neutron logging will be included in the Green River Surveillance and Maintenance Plan.

The compliance monitoring wells will be sampled quarterly during the first year following completion of the remedial action, semiannually for years two through six, and annually thereafter until the end of the performance monitoring period. Monitoring during the remedial action will take place semi-annually using wells placed during site characterization. The constituents to be analyzed from monitor well samples shall include all of the hazardous constituents presented in Section E.1.2, major anions and cations, and the standard suite of field parameters (alkalinity, pH, temperature, and specific conductance).

E.1.6 CORRECTIVE ACTION PLAN

The DOE is required to evaluate alternative corrective actions that could be implemented if the disposal monitoring program indicates that the disposal cell is not performing adequately (40 CFR 192.02(c)). The DOE should consider reasonable failure scenarios of the disposal cell and demonstrate that corrective actions could be implemented no later than 18 months after finding an exceedance of the groundwater protection standards.

The DOE has demonstrated that the disposal cell at Green River has been designed (and will be constructed) to perform for the mandated design life of 1000 years (see Section E.2.2.2). The design has incorporated standard safety factors and should therefore perform for at least 1000 years with minimal maintenance. There is therefore no "reasonable" failure scenario that would be related to catastrophic structural failure.

A potential "failure" of the cover system, in terms of groundwater protection, would be if the infiltration/radon barrier was not limiting infiltration to the design flux rate of 2×10^{-8} cm^3/cm^2s. The best-case corrective action for this condition at Green River would be first to assess the potential impacts to groundwater at the flux rate, and then to assess the risks to human health and the environment should there be a potential impact. A preliminary risk assessment conducted for the Green River site (DOE, 1989a) indicated minimal pathways for human exposure to the potentially affected aquifers because of already poor quality groundwater within the aquifers. It is unlikely that any corrective action would be required at the Green River site such as reconstructing the cover system or active restoration of the affected aquifer(s) because of the minimal risk to human health or the environment. To finalize the preliminary risk assessment to include a specific failure scenario would take only a few months; this plus any other necessary corrective action (applying for alternate concentration limits (ACLs) for any hazardous constituents predicted to exceed the proposed concentrations limits) could be done within the 18-month action time frame. The worst-case corrective action scenario would require removal and replacement of the cover and possible groundwater cleanup.

An exceedance of the proposed concentration limit for any hazardous constituent at the point of compliance (as determined from saturated zone monitoring during the early stages of performance monitoring) would likely be a result of drainage of construction water. This would be verified by examining the moisture monitoring system in the tailings to be sure that excess moisture is not passing through the cell barrier. Since every effort will be made during construction of the cell to limit the amount of water added for compaction (per specific construction specifications) and dust suppression, an excursion at the point of compliance is considered highly unlikely, particularly when travel time of any contaminants through the bottom six feet of buffer (and foundation bedrock) is considered. Any excursion at the point of compliance detected by saturated zone monitoring would result in resampling and analysis at least once to verify the excursion. Details of these procedures will be presented in the S&M plan for Green River.

E.1.7 CLEANUP AND CONTROL OF EXISTING CONTAMINATION

The DOE and NRC consider that evaluation of groundwater cleanup of existing contamination (Subpart B of 40 CFR 192) at the Green River processing site should be deferred until after the EPA promulgates final groundwater protection standards, provided the DOE demonstrates that disposal may proceed independently of cleanup (Subpart B of the standards can be "decoupled" from Subpart A).

By defining existing and background water quality at both the processing and disposal sites, the DOE has demonstrated that the present water quality is distinguishable and any adverse impacts from the remedial action can be identified. In addition, construction of the disposal cell in no way precludes any future aquifer restoration activities from taking place, should active restoration be deemed necessary. Finally, because the period of construction is relatively short at Green River and the extent of existing contamination is almost entirely within the site boundaries (land owned by the State of Utah), there is very little or no risk that human health or the environment could be impacted by leaving the contamination in place during the interim period between remedial action and evaluation of groundwater cleanup.

There are several methods of restoring the affected aquifers at the Green River processing site if it ever becomes necessary to do so. Because the source of contamination will be removed when the tailings are placed and stabilized at the disposal site, and background quality of groundwater in the affected aquifers is poor, the most appropriate method of restoring the aquifers is probably to allow the contamination to flush naturally and disperse downgradient from the site. Natural flushing may be used as the sole method for restoration, or it may be used in conjunction with any of a number of active restoration methods.

E.2 DISPOSAL CELL FEATURES TO PROTECT WATER RESOURCES

This section discusses natural site features and design considerations important in the performance of a disposal cell for protecting water resources at Green River. Details of the proposed disposal cell cover are presented in Section E.2.2. Design details and specifications are presented in Appendix F.

E.2.1 DESIGN CONSIDERATIONS

The disposal site is in a topographically high area 600 to 1200 feet south of the present tailings pile (see Figure D.5.1 of Appendix D). The present tailings surface is in the floodplain of Brown's Wash (elevation 4080 feet) and the proposed disposal site is 4140 feet in elevation at the existing grade. The tailings will be placed in a mostly below-grade disposal cell; the base of the excavation will be at an elevation of about 4098 feet. The disposal cell foundation (unsaturated bedrock) consists of moderately to highly fractured shale, mudstone, and limestone of the upper Cedar Mountain Formation to a depth of about 15 feet below the base of the excavation. Below this depth, the Cedar Mountain Formation is saturated and it consists of an additional 10 to 40 feet of moderately to highly fractured silty sandstone and sandstone conglomerate. A diagrammatic cross section of the proposed disposal cell and foundation is shown on Figure E.2.1. Figure E.2.2 shows the components of the cover system.

In terms of groundwater protection, the cell design makes maximum use of favorable natural conditions at the site. Some of the design and disposal site features and considerations include the following:

- Mostly below-grade disposal of the tailings to limit the exposed area of the pile, and thereby minimize percolation of precipitation through the tailings.

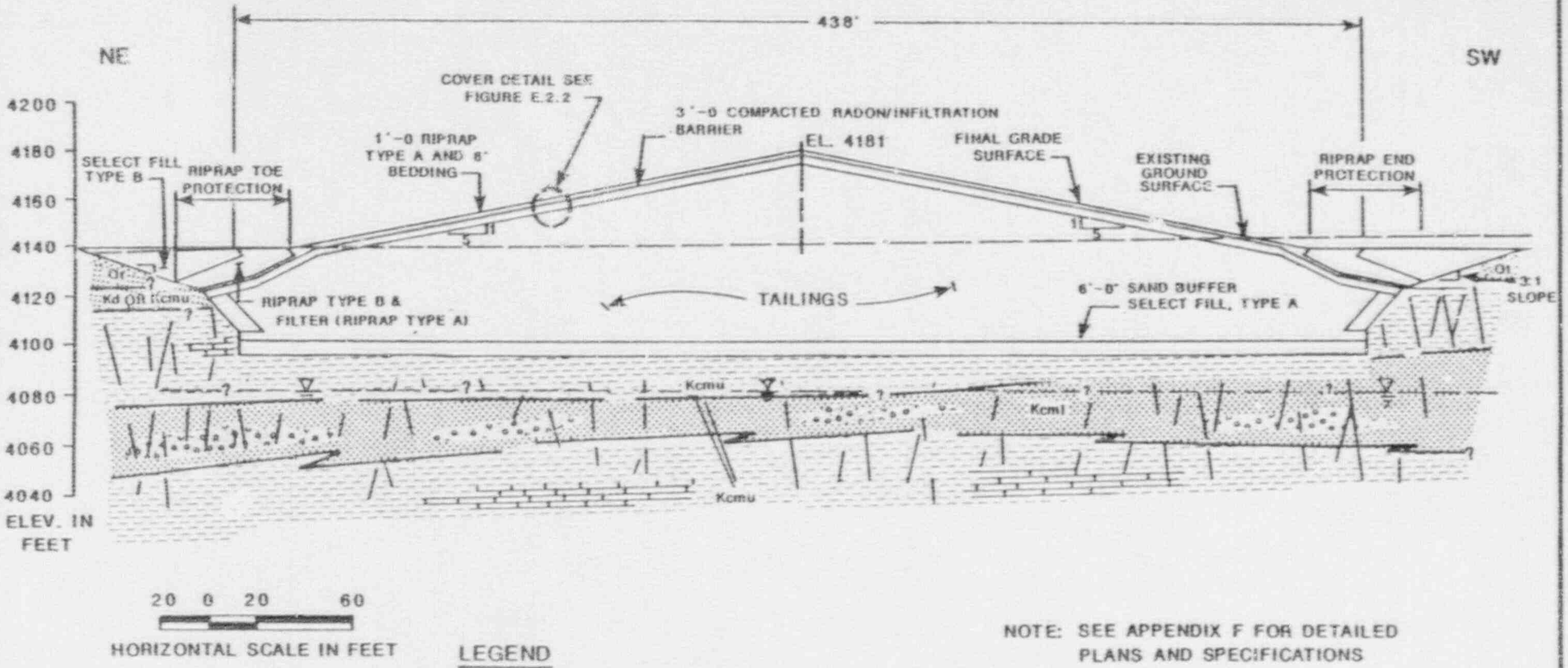
- Consistent, uniform, vertical fracturing of the foundation bedrock to prevent ponding ("bathtubbing") in the tailings, and promote drainage of runoff water from the toe of the cell.

- Abundant, desirable, secondary minerals on the foundation fracture surfaces to attenuate tailings seepage in the unlikely event that seepage leaves the cell.

- Strong, upward, vertical hydraulic gradients in the saturated bedrock downgradient of the disposal site to inhibit downward migration of contamination.

- Flow direction in the shallow groundwater beneath the disposal site that is toward the present tailings pile and existing contamination.

- Inclusion of a buffer layer to absorb contamination exiting the contaminated material and to separate contaminants further from groundwater.



NOTE: SEE APPENDIX F FOR DETAILED PLANS AND SPECIFICATIONS

LEGEND

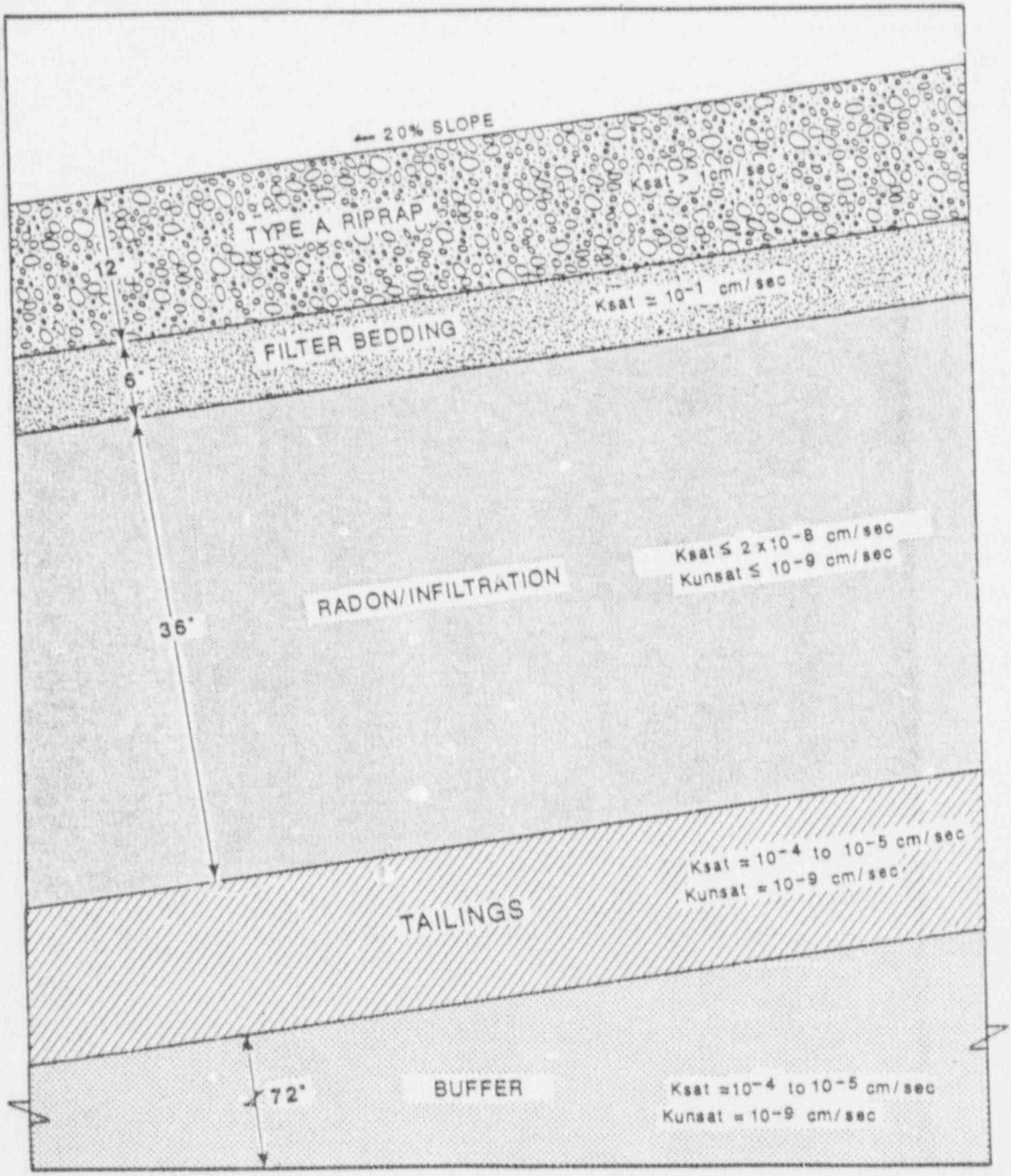
	FORMATION	MATERIAL	SYMBOL
Qt	TERRACE SEDIMENTS	SOILS	▨
Kd	DAKOTA SANDSTONE	BEDROCK	▨ SANDSTONE OR SILTSTONE
Kcmu	CEDAR MOUNTAIN FORMATION UPPER-MIDDLE UNIT		☐ SHALE OR MUDSTONE
Kcml	CEDAR MOUNTAIN FORMATION LOWER-MIDDLE UNIT		⊞ LIMESTONE
			⁛ CONGLOMERATE

// FRACTURES

—▽— POTENTIOMETRIC SURFACE

FIGURE E.2.1

DIAGRAMMATIC CROSS SECTION OF PROPOSED DISPOSAL CELL AND FOUNDATION GREEN RIVER, UTAH, TAILINGS SITE



NOTE: SEE SECTION E.2.2 FOR DETAILED DESCRIPTION OF COVER COMPONENT PROPERTIES; Ksat = SATURATED HYDRAULIC CONDUCTIVITY; Kunsat = UNSATURATED HYDRAULIC CONDUCTIVITY; cm/sec = CENTIMETER PER SEC; SEE FIGURE E.2.1 FOR LOCATION OF THIS DETAIL IN RELATION TO THE DISPOSAL CELL.

FIGURE E.2.2
DISPOSAL CELL COVER SYSTEM
GREEN RIVER, UTAH, TAILINGS SITE

- Limiting the placement moisture content of the contaminated materials in order to prevent drainage of construction water.

- Placement of a tight clay cap and surface drainage layers that promote runoff and limit infiltration.

The following sections describe in more detail the site-specific natural features and design considerations important in the optimum performance of the proposed cell design to protect groundwater.

E.2.1.1 Climate

Climate is an important design consideration because of its effects on the quantity of water available to percolate through the tailings and potentially move contaminants to groundwater. The Green River site is semiarid and is therefore well-suited for tailings disposal.

Climate at the Green River site is discussed in detail in the environmental assessment (DOE, 1988c). The average annual precipitation at Green River was six inches for the period 1951 through 1980. Other climatological data as excerpted from the environmental assessment are: the average annual pan evaporation (60 inches per year); the average annual temperature (52°F); and the average snowfall (10 inches per year).

C. W. Thornthwaite Associates (1964) and the DOE (1983) have calculated the net infiltration of annual precipitation to groundwater (deep percolation) for Green River, Utah. Both studies independently calculated the ratio of yearly precipitation to yearly actual evapotranspiration to be unity; that is, no water percolates to the groundwater from precipitation. In reality, there is some very small discrete quantity of water that reaches the groundwater system when climate conditions allow deep percolation (i.e., sustained rainfalls or melting snow cover; Walton, 1970). This natural recharge occurs in topographically low areas where soils remain saturated for long periods (Freeze and Cherry, 1979).

Rush et al. (1982) estimated that one percent or less of the average annual precipitation in the Green River, Utah, area recharges the upper groundwater system. Rush et al. (1982) note that the recharge estimate is conservatively high because all of the soils within the study area were assumed to be coarse-textured and, therefore, to have a high potential for deep percolation. In addition, this nominal recharge was estimated to occur in low-lying areas within the basin, principally in drainages. One percent of the average annual precipitation at Green River is equal to 1.4×10^{-9} inch per second (4.8×10^{-9} centimeters per second, or cm/s).

The consumptive use of precipitation by vegetation is nominal in the Green River area because of the lack of rainfall and consequent lack of vegetation. For this reason, the rock cover proposed for the Green River disposal cell is appropriate. It is reasonable to believe that the disposal cell will limit infiltration through the tailings to a rate that is equal to or less than the conservative estimate of basin recharge by Rush et al. (1982). Additional discussion regarding cover infiltration and performance is presented in Section E.3.2.

E.2.1.2 Drainage of surface runoff and tailings water

Drainage of surface runoff

Precipitation that falls directly on the disposal cell will either evaporate, infiltrate into the tailings, or run off the cell through the rock riprap or filter bedding. The disposal cell and foundation must act to prevent leachate generation by the runoff water that could potentially accumulate at the contact of the disposal cell cover with the foundation embankment.

A conservative estimate of the quantity of runoff from the disposal cell cover system is 15.2 centimeters per year (cm/yr) (equal to the average annual precipitation) multiplied by the total area of the cell (4.4 acres; 1.8×10^8 cm^2). Theoretically, this runoff could create a ring of ponding (below-grade) around the toe of the pile (see Figure E.2.1). Should ponding occur, the minimum infiltration (drainage) rate will be proportional to the vertical hydraulic conductivity of the bedrock, under a gradient of unity. For drainage considerations, a value of 0.2 foot/day (7.1×10^{-5} cm/s) was chosen to be a conservative value of the bulk (fractured) vertical hydraulic conductivity of the fractured foundation bedrock beneath the disposal site. This value is equal to the lowest calculated bulk horizontal hydraulic conductivity of the upper-middle hydrostratigraphic unit (see Table D.5.8 of Appendix D). Therefore, the minimum drainage rate would equal 7.1×10^{-5} cm/s. Making allowances for the geometry of the cell and the porosity of the bedding layer (assumed to be 0.25), the maximum potential ponding depth around the periphery of the cell would equal 74 cm (29 inches), or about 23 inches (maximum) ponding into the Type A riprap. The width of this ponding ring around the perimeter of the cell is very small (approximately one percent of the area of the tailings) and thus the ponding would have no affect on infiltration or leachate generation.

This estimate of maximum potential ponding is very conservative because it assumes (1) the buffer layer beneath the tailings is non-existent, when in reality the buffer layer will help drain any runoff from the toe of the cell and prevent preferential flow paths from developing; (2) a minimum calculated bedrock hydraulic conductivity; (3) no evaporation;

and (4) no infiltration. A more likely condition is that a significant portion of the precipitation that falls on the cell will evaporate back to the atmosphere or infiltrate into the foundation rock and/or surrounding soil.

Drainage of tailings construction water

Tailings materials and windblown and other contaminated materials will be placed in the disposal cell in as dry of a moisture condition as practicable in order to minimize the potential impact of drainage of construction water. The discussion of analyses presented in Section E.3.2 shows that the actual placement moisture content of these materials will compare to the residual moisture contents determined from laboratory capillary retention data. Therefore, the drainage of tailings construction water has been considered in the overall groundwater compliance strategy.

E.2.2 DISPOSAL CELL DESIGN

The Green River disposal cell cover will consist of a series of layers on top of the compacted contaminated materials. Prior to placement of contaminated material, a layer of uncontaminated silty to clayey sand will be placed to cover the fractured bedrock surface of the excavation. The various layers, including the windblown and other contaminated materials and the unsaturated bedrock below the disposal cell, will act as a system that prevents contamination of the uppermost aquifer. The system is designed to limit the movement of moisture through the disposal embankment to less than the saturated hydraulic conductivity of the infiltration/radon barrier operating under a unit gradient.

In addition, the cover components prevent erosion of the disposal cell by stormwater runoff, limit the radon emanation into the atmosphere, and prevent ponding of water on the disposal cell surface by promoting rapid runoff of precipitation.

Figure E.2.1 shows a cross section of the tailings disposal cell. Details of the cover are shown in Figure E.2.2. The reasons for incorporating the individual components of the disposal cell and the design specification for each are discussed in this section. The performance of each component and the system are described in Section E.2.2.2.

E.2.2.1 Cell components

Cell geometry

The disposal cell surface area has been minimized by providing the deepest burial depth (below-grade) without compromising the depth from contaminated material to groundwater. Also, the steepest sideslope geometry that optimizes rock sizes for erosion control has been used. The topslope area has been minimized to the extent allowed by conventional construction equipment. All of this results in an optimized pile geometry that will minimize the amount of time that precipitation remains on the cell.

Erosion barrier (riprap)

The rock riprap will protect the disposal cell from erosion up to Probable Maximum Precipitation (PMP) surface water flows. No other design feature except possibly vegetated earthen covers can perform this task. At Green River the amount of rainfall is insufficient to support a vegetated cover (see Section E.2.1.1). The riprap will also serve the following functions:

- To prevent deep drying of the underlying infiltration/radon barrier and thus potential cracking.
- To limit the amount of vegetation that can establish itself on the pile.
- To provide frost protection to the underlying layers.

The quality of rock specified will meet NUREG/CR-4620 (Nelson et al., 1986) for durability and the layer will be sufficiently thick (12 inches) to provide adequate erosion protection (DOE, 1988b). Specifications for rock quality placement criteria and placement details are contained in Section 2278 of the Final Design, Appendix F.

Bedding layer

The bedding layer will consist of six inches of clean sand and gravel. It will perform in three ways: (1) by acting as a separator between the infiltration/radon barrier and the rock riprap during construction; (2) by allowing rapid runoff of surface water from rainfall over the radon barrier; and (3) by providing frost protection for the underlying layers. The material will have a design hydraulic conductivity of greater than one cm/s and be specified to meet NUREG/CR-4620 (Nelson, et al., 1986) durability criteria. Specifications for grading and placement are contained in Section 2278 of the Final Design in Appendix F.

Infiltration/radon barrier

The infiltration/radon barrier will consist of three feet of bentonite-amended, compacted clay soil obtained from the Elgin borrow source. The soils will be modified with six percent sodium bentonite and placed so that a minimum laboratory saturated hydraulic conductivity of 2×10^{-8} cm/s will be obtained. The upper portion of the infiltration/radon barrier along with the riprap and bedding material will act as frost protection to the lower portion. At least one foot of the infiltration/radon barrier will be maintained below the design frost depth. Specifications and details of the radon barrier processing, placement, and compaction are presented in Section 2200 of the Final Design, Appendix F.

Tailings

Tailings placed in the disposal cell will be compacted at a moisture content that is near the specific retention moisture content of the material. Compaction and environmental (dust control) water will be controlled so that the final in-place moisture content of the tailings is as near or below this value as practicable. The Final Design, Appendix F, provides specifications in Section 2200 for placement, compaction, and moisture control of contaminated materials.

Windblown and other contaminated material

The windblown and other contaminated material will be placed and compacted at a moisture content as near to the specific retention moisture content as practicable. These materials contain minor radioactive contamination but, as indicated by the laboratory batch and column leach tests, they do not provide significant contamination to the percolating water.

Buffer layer

Particle gradation of the buffer layer will be finer (as measured by the percent passsing the No. 200 sieve) than the tailings. The upper eight to ten feet of disposal cell excavation is considered a suitable source for this buffer layer. The moisture content at placement for this layer is 11 to 17 percent, which is also the predicted long-term steady state moisture content. Placement and compaction specifications are contained in Section 2200 of the Final Design, Appendix F.

E.2.2.2 Disposal cell longevity

The EPA standards (40 CFR 192) require that the disposal cell be designed for 1000 years where reasonably achievable, and in any case for at least 200 years. Natural, stable materials will be used in construction so that the long-term performance is ensured. Design techniques will be used that are suitable for periods much longer than the 1000 years required.

Rock erosion protection has been sized and suitable, durable material selected that will perform adequately over the design life of the disposal cell. Bedding material has been selected using the same durability criteria as that of the rock. The material is sized to drain water rapidly, and oversizing is employed to provide a margin of safety from plugging by wind-blown silts. Also, the bedding is bounded on top by larger diameter riprap; should some plugging occur, it will enhance runoff in the rock riprap layer.

The radon barrier clays will be protected from erosion by the rock erosion protection and the bedding layer. Uniformity of hydraulic conductivity will be ensured by the addition of a small percentage of sodium montmorillonite (bentonite). All material placement and compaction has been specified to ensure that the disposal cell will be constructed as designed.

The final Remedial Action Plan (RAP), construction documents, and associated calculations are all prepared as documentation of the disposal cell performance. The effect of freezing and thawing was not documented in these supporting calculations. The following discussion demonstrates that the disposal cell cover will provide adequate protection from freezing and thawing cycles. A separate calculation has been performed to support this discussion and is retained at the DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

In order to determine the effect of frost penetration upon the cover design, it is necessary to determine the depth of frost penetration for the site and cover materials. Data necessary to determine depth of freezing include the minimum and maximum temperatures at the site, the geometry of the cover (specifically the thickness of each component), the dry density of each component, and the moisture content(s) at which the cover is performing.

Weather data

Historical weather data are available for Green River, Utah, from the National Oceanographic and Atmospheric Administration (NOAA). The Green River weather station is 1.5 miles west-northwest of the disposal site and at 4070 feet above mean sea level. The original grade at the site is 4154 feet above mean sea level. Based on the topography of the area, it is reasonable to assume that the site and the weather reporting station are in similar climatic areas and are not influenced by microclimatic (topographic) effects. Thirty-eight years of temperature data are available, of which 20 years provide sufficient annual data to be usable for analysis.

Cover geometry and material properties

The cover geometry analyzed was presented in Section E.2.2.1. The 12-inch-thick erosion protection layer has a dry density of 140 pounds per cubic foot, and being free-draining, will have a low moisture content estimated at five percent. The sand and gravel bedding material is also free-draining. The estimated dry density is 130 pounds per cubic foot and the moisture content is five percent. Since these are estimates based on typical values for soil and rock, sensitivity analyses are performed to observe the effect of cover geometry and material properties on frost depth. The infiltration/radon barrier will be placed at a dry density of not less than 110 pounds per cubic foot and will operate unsaturated near the optimum moisture content of 15 percent. Since some variation in the long-term moisture content of this material is anticipated, sensitivity analyses are performed varying the moisture content of the radon barrier material. Since the cover will be designed to maintain at least one foot of radon barrier below the calculated frost depth, no other soil properties are required for the analysis.

Analytical techniques

Published literature on frost depth provides various regional frost depth maps of the United States. One such map shows a frost depth of 32 inches for the Green River vicinity (U.S. Navy, 1982). Discussions with the Green River city engineer indicate that foundations and pipes are typically buried 36 inches below ground. For detailed analyses of the disposal cell cover design, a computer program developed by the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory was used. The program listing, along with the methodology employed in performing the analyses, is presented in "The Effect of Freezing and Thawing on UMTRA Covers" (DOE, 1988b). Results of the analyses are on file at the UMTRA Project office in Albuquerque, New Mexico.

Statistical curve-fitting techniques were used to extrapolate the historic recorded temperatures to obtain a 200-year return interval for the required weather data. The least squares linear regression was used because it provides a good "fit" for the data. This resulted in a predicted nonexceedance freezing index value of 1080 degree days, a 47.5°F mean annual temperature, and a 137-day duration of freeze.

Additional conservatism was added to the analyses by assuming that the coldest and longest freezing period occurs simultaneously with a dry period. Thus, insulating factors such as snow and ice accumulations in riprap were ignored.

Results

Based upon the information and data presented in the previous sections, a frost depth of 38.7 inches was calculated for the Green River site. Variations of material properties for the rock riprap, bedding, and infiltration/radon barrier layers resulted in less than seven percent variance in the depth of freezing. Variations in climatic conditions as input parameters also resulted in less than seven percent variance in the depth of freezing.

The value selected for the depth of freezing is deeper than that used by local building officials and is considered a reasonable and conservative value for use at the Green River site. Although weather data are extrapolated for only 200 years, the calculated frost depth will have a longer return interval than 200 years since the insulating effect of snow was conservatively ignored.

E.3 DISPOSAL AND CONTROL OF RADIOACTIVE MATERIALS AND NONRADIOACTIVE CONTAMINANTS

E.3.1 GROUNDWATER PROTECTION STANDARD FOR DISPOSAL

For the Green River disposal site, three basic factors for complying with the groundwater protection standards are required (40 CFR 192.02). These are (1) determination of hazardous constituents within the disposal cell, (2) proposal of a concentration limit for each hazardous constituent, and (3) specification of the point of compliance. The following sections discuss these requirements.

E.3.1.1 Hazardous constituents

Appendix IX of 40 CFR 264 is a list of hazardous compounds and elements used in screening suspected contamination at land-based hazardous waste treatment, storage, and disposal facilities under the EPA's Resource Conservation and Recovery Act (RCRA) Program. The list in Appendix IX is also used to screen for contamination due to uranium mill tailings and ore processing. However, most of the hazardous compounds in Appendix IX are not normally associated with uranium mill tailings because they were intended primarily for screening RCRA hazardous waste sites. The proposed EPA groundwater standards for uranium mill tailings disposal at inactive sites (40 CFR 192) incorporate Appendix VIII of 40 CFR 264 by reference; Appendix VIII has been superseded by Appendix IX. In addition to the Appendix IX suite, molybdenum, nitrate, radium 226 and 228, uranium 234 and 238, and gross alpha activity are potentially hazardous constituents within uranium mill tailings, and should be considered during characterization (40 CFR 192.02(3)(i,ii)).

The hazardous constituents within the Green River tailings are related to both the uranium ore and the chemicals used in the milling process. Section D.5.2.8 of Appendix D, Site Characterization, discusses the milling process at Green River and the physical and chemical characteristics of the tailings. The following discussion of hazardous constituents within the Green River tailings is subdivided into inorganic and organic components. Table E.3.1 is a summary of the hazardous constituents identified within the Green River tailings.

Inorganic constituents

The inorganic constituents within the tailings at Green River are mostly metal and metalloid elements associated with the uranium ore. Those elements that should be considered include antimony, arsenic, barium, beryllium, cadmium, chromium, lead, mercury, selenium, silver, thallium, tin, and vanadium (40 CFR 264, Appendix IX). Of these elements, only

Table E.3.1 Summary of hazardous constituents within uranium mill tailings at Green River, Utah[a]

Constituent	Concentration pore water[b]	Concentration subpile[c]	Detection limit[d]	EPA MCL[e]	Standard[f]
Cadmium	0.032	<0.001	0.0	0.010	Title I
Chromium	1.88	0.03	0.0	0.05	Title I
Molybdenum	0.15	0.27	0.01	[illegible]	Title I
Nickel	25.3	0.05	0.04	none	Title I
Nitrate	2251	440	1	44	Title I
Selenium	0.15	0.76	0.005	0.01	Title I
Uranium	448.0	2.23	0.003	0.044	Title I
Vanadium	178.0	0.24	0.01	none	Title I
Radium-226 and -228	NM	7.5 pCi/l	2.0 pCi/l	5.0 pCi/l	Title I
Gross alpha	NM	1200.0 pCi/l	0.2 pCi/l	15.0 pCi/l	Title I

[a] All concentrations are in mg/l unless noted otherwise.

[b] Data from lysimeter 714 (see Figure D.5.1 and Table D.5.22 of Appendix D). Values are arithmetic mean where two analyses are reported in Table D.5.22. "NM" means not measured.

[c] Maximum reported value from Table D.5.14 of Appendix D for on-site alluvial monitor wells 702 and 808.

[d] Laboratory method detection limit.

[e] "None" means there is no MCL for that constituent.

[f] "Title I" refers to EPA proposed standards for remedial action at inactive (Title I) uranium processing sites (40 CFR 192). The MCLs established by 40 CFR 143 are the same as those in the State of Utah Drinking Water Standards for community water systems.

arsenic (0.05 milligrams per liter, or mg/l), barium (1.0 mg/l), cadmium (0.01 mg/l), chromium (0.05 mg/l), lead (0.05 mg/l), mercury (0.002 mg/l), and selenium (0.01 mg/l) have associated MCLs (see Table D.5.1). Other inorganic elements and associated MCLs include: (from 40 CFR 192.02(3)(i,ii)) molybdenum (0.10 mg/l); nitrate as NO_3 (44 mg/l); radium-226 and -228 activity (5.0 picocuries per liter, or pCi/l); uranium-234 and -238 (30 pCi/l activity or 0.044 mg/l); and gross alpha activity (15 pCi/l). Based on acidic (low pH) pore water samples of the Green River tailings (see Table D.5.22 of Appendix D), values of the following inorganic hazardous constituents are higher than the proposed MCLs (see Table E.3.1):

- o Cadmium.
- o Chromium.
- o Molybdenum.
- o Nitrate.
- o Selenium.
- o Uranium.

Concentrations for the following inorganic hazardous constituents without MCLs are higher than laboratory method detection limits (see Table E.3.1):

- o Nickel.
- o Vanadium.

Originally, beryllium and thallium were not analyzed for in groundwater, tailings, windblown soils, or buffer materials at the Green River site. Both of these elements exist in trace quantities in nature. However, recently the DOE has evaluated whether beryllium and thallium are hazardous constituents in the contaminated materials (see Table D.5.27 of Appendix D). Representative samples of tailings, windblown soils, and buffer materials were collected and analyzed for these constituents. Laboratory analyses indicate that neither beryllium nor thallium is present in the contaminated materials. Consequently, these two constituents will not be included in the list of hazardous constituents at the disposal site.

Ammonium contamination was identified in the top hydrostratigraphic unit beneath the present tailings pile (see Section D.5.2.7 of Appendix D). Ammonium was used in the milling process (see Section D.5.2.8 of Appendix D) and may be present in the groundwater beneath the tailings by the chemical reduction of nitrate within the tailings to ammonium. Ammonium is present in much lower concentrations within the tailings pore fluid (see Table D.5.22 of Appendix D) than in concentrations presently in groundwater beneath the tailings (see Figure D.5.19 of Appendix D). Ammonium is not considered a hazardous constituent per Appendix IX of 40 CFR 264 or 40 CFR 143 and it has no associated MCL.

Organic constituents

Any organic compounds within the tailings would be present from processing activities. As discussed in Section D.5.2.8 of Appendix D, the sand tailings at Green River were leached with acid, and excess acid was neutralized with ammonia.

As discussed in detail in Section D.5.2.7 of Appendix D, a priority organic pollutant scan and analyses specifically for volatile and semi-volatile organic compounds were conducted on a sample from a lysimeter and several monitor wells at the tailings site. The analytical results showed no compounds to be present in confirmable concentrations (TAC, 1988). However, methylene chloride will be included in the hazardous constituents list because it is the breakdown product of several organic compounds, and has the potential to exist at the disposal site. Therefore, the DOE has added methylene chloride to the hazardous constituents list. The priority pollutant scan results and the other organic analyses are on file in the DOE UMTRA Project Office in Albuquerque, New Mexico.

E.3.1.2 Proposed concentration limits

The DOE intends to comply with the proposed EPA groundwater standards by meeting MCLs or background concentrations for those constituents identified in Section E.3.1.1 and summarized in Table E.3.1. Specifically, the proposed concentrations are as shown in Table E.1.1. Section E.3.2 will demonstrate that the disposal cell will perform adequately to prevent any long-term adverse impacts to groundwater beneath, or peripheral to, the disposal site.

Arsenic and lead have not been identified as hazardous constituents of concern at the Green River site, but they can be derived from the uranium milling process and have been evident at other UMTRA Project sites in excess of their respective MCLs. Consequently, the DOE will include these elements on the hazardous constituents list.

The proposed concentrations listed in Table E.1.1 were selected with consideration of the distribution of constituents in the upper-middle and lower-middle hydrostratigraphic units, both of which subcrop beneath the proposed disposal site (see Sections D.5.2.3 and D.5.2.5 of Appendix D). The quality of water in these two units beneath the disposal area is similar (see Section D.5.2.6 of Appendix D). Table E.3.2 is a summary of the descriptive statistical parameters for the background water quality at the disposal site. Monitor wells used to define the background water quality beneath the disposal site include 816 in the upper-middle unit and 562 and 813 in the lower-middle unit (see Figure D.5.1 of Appendix D for

Table E.3.2 Descriptive statistical parameters for background water quality at the Green River UMTRA Project disposal site, Green River, Utah[a]

Constituent	Number of samples, n	Arithmetic mean, $\bar{X}$	$\bar{X}$ + 2s[b]	Observed maximum	Skewness
Cadmium	4	0.003	0.007	0.005	0
Chromium	11	0.03	0.09	0.09	1.057
Molybdenum	11	0.11	0.24	0.22	0.290
Nickel	4	0.06	0.09	0.09	1.155
Nitrate	11	90	180	173	0.161
Selenium	11	0.383	1.779	2.50	2.478
Uranium	11	0.0538	0.1252	0.1460	1.303
Vanadium	10	0.08	0.30	0.38	2.326
Radium-226 and -228	5	2.1 pCil	4.5 pCi/l	3.9 pCi/l	0.436
Gross alpha	5	89 pCi/l	195 pCi/l	150 pCi/l	0.041

[a] All concentrations are in mg/l unless noted otherwise. See Table E.1.1 for proposed concentration limits. Samples include water quality analyses from monitor wells 562, 813, and 816 from sample rounds 6/86; 9/86; 2/87; 10/87; 1/88; 5/88; and 7/88. See Figure D.5.1 of Appendix D for location of wells.
[b] Mean value plus two standard deviations from the mean.

locations of the monitor wells). The following are detailed explanations of how the proposed concentration limits were determined.

Arsenic

The DOE does not propose a concentration limit for arsenic. Instead, the NRC's proposed interim concentration limit of 0.05 mg/l (MCL) will be utilized. This interim limit may be revised based on new monitoring data to be collected during and following construction of the disposal unit.

Cadmium

The DOE proposes an MCL of 0.01 mg/l for cadmium. Cadmium has been measured three times in monitor well 562, and once in well 813. The concentrations ranged from <0.001 to 0.005 mg/l.

Chromium

The DOE proposes a concentration of 0.09 mg/l for chromium. Chromium has been measured twice in the upper-middle unit and nine times in the lower-middle unit. The observed concentration range was <0.01 to 0.09 mg/l.The mean was 0.03 mg/l. The value of the mean plus two standard deviations from the mean was 0.09 mg/l.

Lead

The DOE does not propose a concentration limit for lead. Instead, the NRC's proposed interim concentration limit of 0.05 mg/l (MCL) will be utilized. This interim limit may be revised based on new monitoring data to be collected during and following construction of the disposal unit.

Methylene chloride

The DOE does not propose a concentration limit for methylene chloride. Instead, the NRC's proposed interim concentration limit of 0.005 mg/l (background) will be utilized. This interim limit may be revised based on new monitoring data to be collected during and following construction of the disposal unit.

Molybdenum

The DOE proposes a concentration of 0.24 mg/l for molybdenum, which is the mean concentration of 11 analyses plus two standard deviations from the mean. Molybdenum has been measured twice in the upper-middle unit and nine times in the lower-middle unit. The observed concentration range for these was 0.02 to 0.22 mg/l.

Nickel

Nickel has neither a proposed MCL (per 40 CFR 192), an EPA secondary drinking water limit, nor a state of Utah drinking water maximum concentration limit. Nickel has been measured three times in monitor well 562 and once in well 813. The arithmetic mean of the four values was 0.06 mg/l. The observed values ranged from 0.05 to 0.09 mg/l. The DOE proposes a concentration of 0.09 mg/l for nickel, which is the mean value plus two standard deviations from the mean; it is also the maximum observed value from the four analyses.

Nitrate

Nitrate has been measured twice in the upper-middle unit and nine times in the lower-middle unit. The observed concentration range for these analyses was 12 to 173 mg/l. The arithmetic mean of the eleven analyses was 90 mg/l. The DOE proposes a concentration of 180 mg/l for nitrate, which is the mean value plus two standard deviations from the mean.

Selenium

Selenium has been measured twice in the upper-middle unit and nine times in the lower-middle unit. Selenium concentrations have been highly variable in both of the units; the observed concentration range for the available analyses was <0.005 to 2.5 mg/l. The arithmetic mean of the eleven analyses was 0.383 mg/l. The DOE proposes a concentration of 2.5 mg/l for selenium, which is the maximum observed value from the 11 analyses.

Uranium

Uranium has been measured twice in the upper-middle unit and nine times in the lower-middle unit. The observed concentration range for the available analyses was 0.0074 to 0.146 mg/l. The arithmetic mean of the eleven analyses was 0.0538 mg/l. The mean value plus two standard deviations from the mean was equal to 0.125 mg/l. The DOE proposes a concentration for uranium of 0.1460 mg/l, which is the maximum observed concentration for uranium in the 11 background analyses.

Vanadium

Vanadium has been measured twice in the upper-middle unit and eight times in the lower-middle unit. The range of the available analyses was <0.01 to 0.38 mg/l. The arithmetic mean of the analyses was 0.08 mg/l. The mean value plus two standard deviations from the mean was equal to 0.30 mg/l. The DOE proposes a concentration for vanadium of 0.38 mg/l, which is the maximum observed concentration of the 10 background analyses.

Radium-226 and -228

The DOE proposes an MCL of 5.0 pCi/l for radium -226 and -228. Radium activity has been measured once in the upper-middle unit and four times in the lower-middle unit. The observed activity range for radium was 0.8 to 3.9 pCi/l for the five analyses.

Gross alpha

Gross alpha activity has been measured once in the upper-middle unit and four times in the lower-middle unit. Gross alpha activity ranged from 21.0 to 150.0 pCi/l for the five analyses. The arithmetic mean value of the analyses was 89.0 pCi/l. The DOE proposes an activity of 195 pCi/l for gross alpha, which is the mean value plus two standard deviations from the mean.

Natural variation

The DOE-proposed concentration limits and NRC-proposed interim concentration limits discussed in this section will be reviewed and updated following the two-year interim monitoring period following completion of the remedial action as necessary to reflect the additional background data. The measured concentrations have a natural variability associated with them and must be adequately assessed for planning purposes. Construction and performance monitoring will be discussed in more detail in Section E.3.4. A corrective action plan for the disposal site will be discussed briefly in Section E.3.5. Final details of performance monitoring and corrective action plans will be presented in a separate document (surveillance and maintenance plan) for the Green River site.

E.3.1.3 Point of compliance

The point of compliance at the Green River disposal site will be the entire northwest and northeast edges of the engineered cell as shown in Figures E.3.1 (plan view) and E.3.2 (cross section). Details of the number of monitor wells at this location and the frequency of sampling will be discussed briefly in Section E.3.4 and in detail in the forthcoming surveillance and maintenance plan for the Green River disposal site.

E.3.2 PERFORMANCE ASSESSMENT

The proposed disposal cell design as described in Section E.2 will prevent the introduction of contaminants into the groundwater by providing for leachate travel times from the base of tailings to the bottom of the disposal cell of between 450 to in excess of 1100 years. Due to the lack of understanding of the behavior of seepage in the vadose zone below rock-covered areas, as well as limitations of currently available groundwater (infiltration) models, a conservative approach to evaluating the pile performance was taken.

Travel time was estimated from the base of the tailings through the windblown and other contaminated material, and through the buffer layer. Credit for travel through the windblown and other contaminated material was taken because laboratory batch and column leaching tests on these materials indicate that they contain no significant leachable contamination (see the set of calculations accompanying this RAP). Travel time through the foundation bedrock cannot be accurately estimated due to fracturing. Because any leachate percolating through the tailings is not expected to reach groundwater within the design life of this cell, no degradation of groundwater quality as a result of remedial action is anticipated.

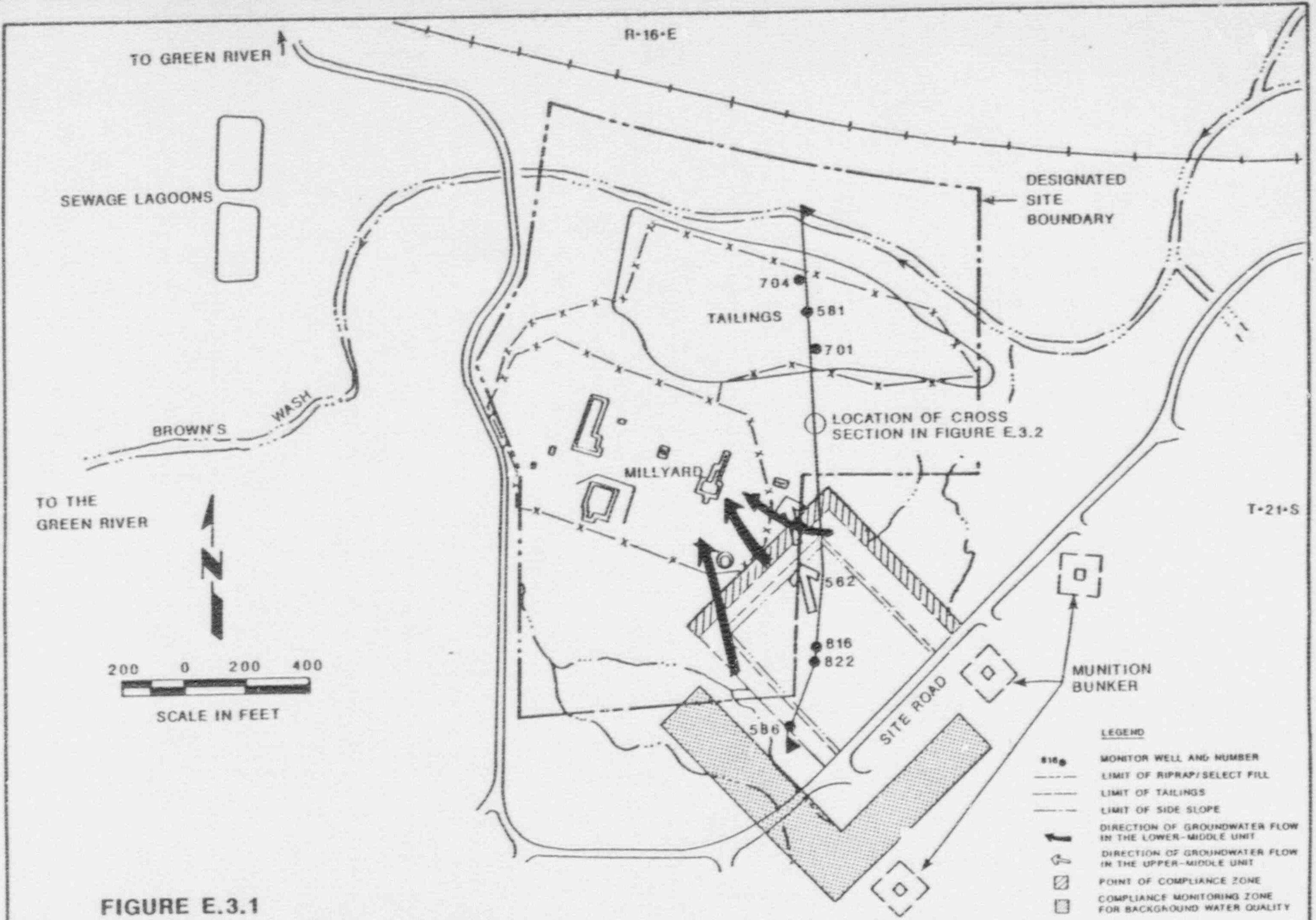


FIGURE E.3.1
PLAN VIEW OF POINT OF COMPLIANCE
AND RELATED DISPOSAL CELL AND COMPLIANCE MONITORING FEATURES
GREEN RIVER, UTAH, UMTRA PROJECT DISPOSAL SITE

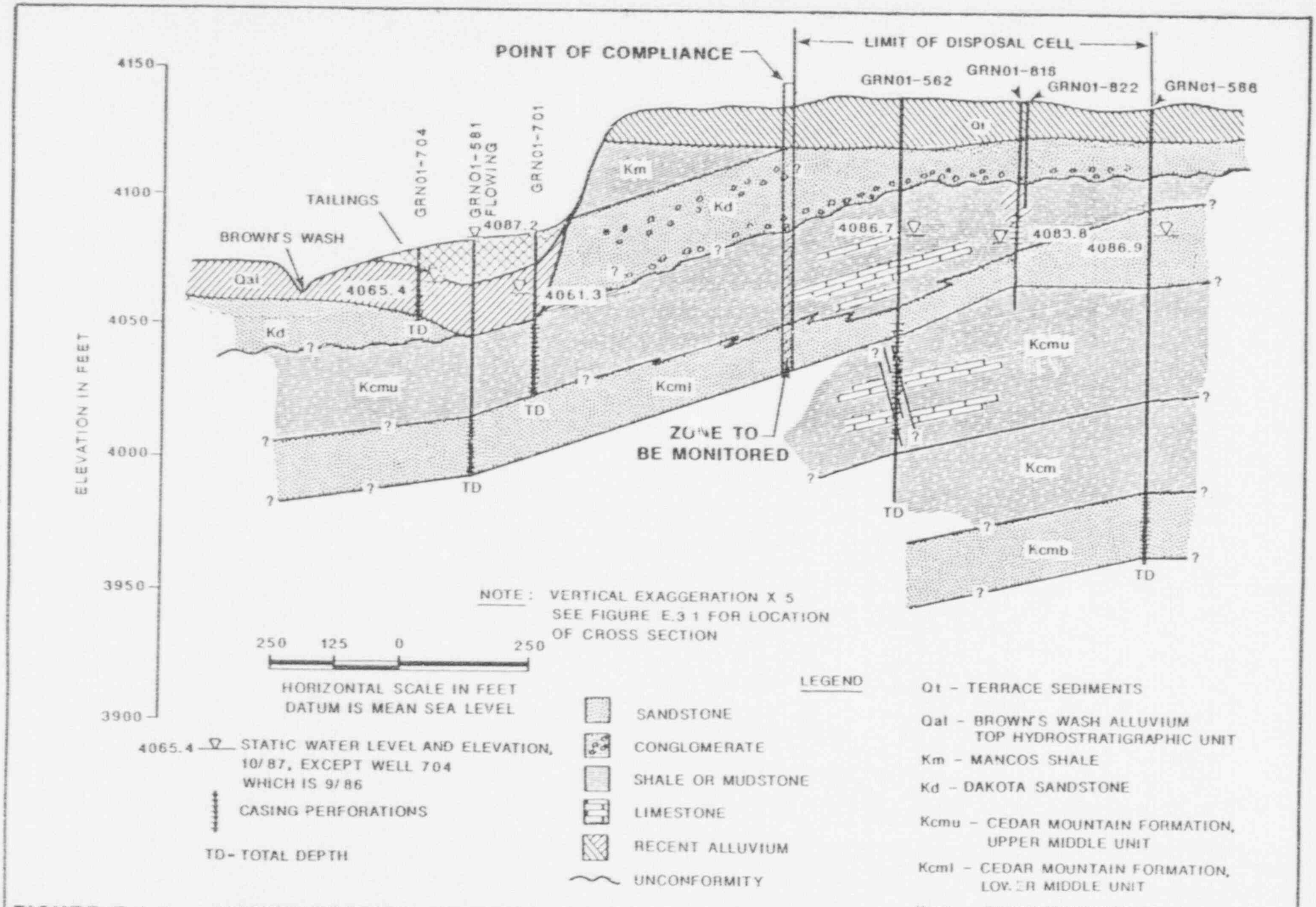


FIGURE E.3.2 CROSS SECTION OF POINT OF COMPLIANCE, GREEN RIVER, UTAH, UMTRA PROJECT DISPOSAL SITE

This section describes the analyses performed to evaluate seepage through the disposal cell and summarizes the impacts on disposal cell performance. The calculations performed for these analyses are retained in the DOE UMTRA Project Office, in Albuquerque, New Mexico.

E.3.2.1 Conceptual model assessment

In order to estimate the travel time of contaminated water to the groundwater and to evaluate the sensitivity of these analyses and associated assumptions, several approaches were used to predict the cell performance. Analyses of the redistribution of moisture through the cell were performed using UNSAT2 computer code (NRC, 1983). In addition, simplifying assumptions were made by assuming that the steady state travel time will be controlled by the least permeable layer (in this case the cover) and that the materials will operate at a flux equivalent to this saturated hydraulic conductivity under a unit gradient.

System geometry and boundary conditions

Figures E.2.1 and E.2.2 are diagrammatic cross sections depicting the cell cover, tailings, windblown, and other contaminated material, buffer layer, and foundation soils and bedrock. Detailed information about each of those components is provided in Section E.2.2 and D.4 of Appendix D.

It is assumed that moisture redistribution occurs in a vertical direction or one dimensional flow, due to the relative homogeneity of the materials and the large lateral extent of the cell in relation to its thickness. The cover layering consists of three feet of compacted infiltration/radon barrier, over 25 feet of compacted tailings, which in turn overlies 25 feet of compacted windblown and other contaminated material. Under this material is a six-foot-thick compacted buffer layer overlying 14 feet of bedrock between the base of the cell and the uppermost aquifer. Other aspects of the cover system and cell geometry are discussed in detail in Appendix B.

Other boundary conditions used for the UNSAT2 modeling include the presence of continuously available free water to the top of the infiltration/radon barrier. This is conservative, since historical meteorological data indicate that water from precipitation is only available four percent of the the time. This includes time for water to run off the cell following a rainfall event. Therefore, the upper boundary assumption is conservative. A lower boundary suction equivalent to 14 feet of suction was applied to the bottom of the cell, representing maximum capillary forces as influenced by the saturated condition in the uppermost aquifer. Since the bedrock is fractured between the cell base and the water table it is doubtful that full capillary forces will be developed. Varying this lower boundary between zero and minus 21 feet pressure head resulted in no significant change in the cell performance. The use of full capillary force due to the proximity of the uppermost aquifer is a conservative assumption.

For the simplified analysis it was assumed that water is continuously available to the top of the infiltration/radon barrier, that the infiltration/radon barrier operates in a fully saturated condition, and that the flux below the radon barrier is equivalent to the saturated hydraulic conductivity of the infiltration/radon barrier operating at a unit gradient.

Material properties

The results of capillary retention tests, saturated hydraulic conducitivity tests, and mechanical properties tests for the compacted infiltration/radon barrier, compacted tailings, compacted windblown and other contaminated material, and buffer are presented in Appendix D and Appendix G. Material properties were selected that are considered representative of the materials used to construct the disposal cell. Variations of material properties were assessed in selecting values used in the analyses. These material assessment calculations are retained in the DOE UMTRA Project Office, Albuquerque, New Mexico.

The measured retention data for each soil were used to estimate coefficients for van Genuchten's retention function using the RETC program (van Genuchten, 1984). The fitted retention function was then used to predict the unsaturated hydraulic conductivity as a function of moisture content. Results of the application of the RETC program to the retention data discussed above are on file at the DOE UMTRA Project Office, in Albuquerque, New Mexico. The parameters used to describe each soil are presented in Table E.3.3.

Part of this travel-time-related compliance strategy involves use of the windblown and other contaminated materials as part of the storage capacity of the percolating contaminated water. Therefore, this material should not be capable of producing contaminants when leached. In order to verify that this is indeed the condition of the windblown and other contaminated material, a series of batch and column leach tests were performed on samples considered representative of this material (see Appendix H). The results and interpretation of these tests are on file at the DOE UMTRA Project Office, Albuquerque, New Mexico. These tests confirm that the windblown and other contaminated material are not capable of producing significant amounts of contaminated leachate.

Table E.3.3 Hydrologic properties and parameters of the van Genuchten retention function used to describe the disposal cell soils, Green River UMTRA Project site

Parameter	Soil description			
	Infiltration/ radon barrier	Tailings	Windblown and other contaminated material	Buffer
Compaction density, pcf (% of optimum)	100	90	95	96
Saturated water content (%)	32.0	45.0	33.0	33.0
Residual water content (Vol. %)	26.9	3.0	2.5	2.5
α (fitted parameter) (1/cm)	0.0060	0.0050	0.0034	0.0034
N (fitted parameter)	2.313	2.326	2.250	2.250
Saturated hydraulic conductivity (cms)	2×10^{8}	6×10^{4}	1×10^{4}	1×10^{4}

Analytical procedures

Immediately after construction, capillary gradients created by contrasts in pore size and differences in initial moisture content between the foundation, buffer, and tailings would produce flux between these soils, and redistribution of moisture within each soil type. At some time after cell closure, moisture contents within the tailings, buffer layer, and foundation soils will be in equilibrium with the average flux through the infiltration/radon barrier. A combination of capillary and gravitational forces would produce a constant flux throughout the disposal cell profile. By placing the tailings at or near the steady state moisture content of the material, the drainage of contaminated water added due to construction will be minimized. However, it is not practical to specify the exact moisture content of the material as the residual moisture content is a low value (three percent) for the tailings and some water may be required for control of fugitive dust or other health concerns during construction.

One method of analyzing the cell performance that accounts for such transient seepage is the use of the UNSAT2 computer code (NRC, 1983). Boundary conditions and material properties used for the analysis are discussed in the previous two subsections. Analyses were peformed setting the initial suctions of the tailings at values equivalent to volumetric moisture content of five percent (residual moisture content) and 7.1 percent (that obtained during construction). For the buffer and windblown and other contaminated material, the initial suction was set at an equivalent volumetric moisture content equal to 10.6 percent (that obtained during construction). The radon barrier initial suction was set equal to a moisture content equivalent to that of optimum plus three percent. The results of these analyses indicate that the flux from the bottom of the cell reaches steady state at 8×10^{-9} cm^3/cm^2s after 100 years for the tailings placed at a higher higher moisture content. Equilibrium was not reached for the lower moisture content material. However, there is little difference in flux rate between the two placement moisture contents for flux rates greater than 8×10^{-9} cm^3/cm^2s.

A closer examination of the modeling indicates that the higher flux rate exiting the bottom of the cell, which occurs during the first 30 to 40 years, is a result of drainage of excess moisture from the buffer. The tailings do not show a change in moisture content from placement conditions until long after the equilibrium flux from the bottom of the cell has been established. Therefore, the rate of contaminant movement prior to equilibrium can be considered equal to the unsaturated hydraulic conductivity of the lowermost tailings material operating at a head equal to the suction imposed in the material. For the Green River tailings placed at 7.1 percent volumetric moisture content this corresponds to 5 X 10^{-9} cm/s at a gradient of near unity. Thus, the placement of tailings materials at or slightly above the long-term moisture content will result in no significant movement of contaminants from the tailings above those predicted for steady state conditions.

Based on the steady state flux rate predicted by UNSAT2 (8 X 10^{-9} cm^3/cm^2s) and the flux rate equivalent to the saturated hydraulic conductivity of the radon barrier acting under a unit gradient (2 X 10^{-8} cm^3/cm^2s), the travel time through the windblown material and buffer is calculated to be 1130 and 450 years, respectively. The details and analyses described above are retained in the DOE UMTRA Project Office, Albuquerque, New Mexico.

Discussion

The steady state groundwater travel time through the buffer is estimated to exceed 1000 years and in any case more than 450 years. Because this estimate assumes that the bedrock foundation drains freely, it is considered to be a conservative lower bound. As discussed above, lack of data on the unsaturated hydraulic properties of the bedrock precludes a better estimate of lower boundary pressure, or an accurate estimate of travel time through the four meters of bedrock separating the buffer from the water table. However, assuming an effective porosity of five percent, transport of any hazardous constituents from the base of the buffer to the water table under a flux of 2 X 10^{-8} cm/s will require an additional 120 years.

Because the placement moisture contents for each soil will be equal to or less than those used in the analyses, transient redistribution of water within the cell will not create downward flow of contaminants which exceed the steady state rate. Steady state velocities will therefore provide a conservative estimate of travel time. Furthermore, the conservative upper boundary assumptions made for the analyses cause the predicted travel times to be greatly overestimated. If no downward flow is assumed during periods when water is not present atop the pile, the travel time can be extended by a factor of 25.

E.3.2.2 Impacts summary

No degradation of groundwater quality will occur as a result of the proposed remedial action for at least 450 years and probably in excess of 1000 years at the Green River UMTRA Project site.

E.3.3 CLOSURE PERFORMANCE ASSESSMENT

The DOE must demonstrate compliance with the closure performance standard (40 CFR 192.02(a)(4)) by showing that the need for further maintenance of the disposal site and cell has been minimized and that the disposal unit minimizes or eliminates releases of hazardous constituents to the groundwater.

The durability and longevity of the cell has been demonstrated and discussed in Section E.2.2.2. Section E.3.2 demonstrates and discusses the adequacy of the disposal cell design to protect groundwater resources at the Green River site.

E.3.4 GROUNDWATER PERFORMANCE MONITORING PROGRAM

The DOE will present a detailed groundwater monitoring program in the S&M plan for the Green River site. This section briefly describes the program and demonstrates that implementing such a program is feasible at the Green River site. The main features of a performance monitoring program include tailings moisture monitoring and saturated zone monitoring. These features are described as follows.

E.3.4.1 Disposal cell moisture monitoring

A disposal cell moisture monitoring program will be implemented to demonstrate that the net flux of moisture through the tailings, windblown materials, and buffer is near 2×10^{-8} cm/s, as described in detail in Section E.3.2. Details of such a system will be presented in the S&M plan.

A higher cell moisture flux at the Green River site would pose a low relative risk to humans or the environment. Four neutron access holes for neutron moisture logging will be used to monitor moisture within the tailings, windblown materials, and buffer layer at different depths. The time-integrated moisture versus depth data will be used to estimate the unsaturated hydraulic conductivity of the materials. This type of monitoring equipment has been used successfully at the Shiprock UMTRA Project site (DOE, 1989a; Section E.3.2) to relate moisture content (percent saturation) of the infiltration/radon barrier to unsaturated hydraulic conductivity of the radon barrier.

E.3.4.2 Saturated zone monitoring

The upper- and lower-middle hydrostratigraphic units of the Cedar Mountain Formation will be monitored using standard monitor wells at the designated point of compliance (see Section E.3.1.3). There is nothing at the Green River site that would physically preclude wells from being installed at the designated point of compliance.

The pattern of monitor wells (or well pairs) will be presented in the S&M plan. Because of the fractured nature of the Cedar Mountain Formation, wells or well pairs shall be spaced closer together than if the aquifer was homogeneous and isotropic. Well or well pair spacing likely will be on the order of 80 to 100 feet apart at the point of compliance. This relatively greater density of wells is consistent with the procedures outlined in the "Guidance for UMTRA Project Surveillance and Maintenance" (DOE, 1986).

Performance monitoring frequency is also outlined in the guidance document (DOE, 1986). Compliance wells shall be sampled quarterly the first year following completion of remedial action activities, semi-annually for years two through six, and annually thereafter until the end of the performance monitoring period.

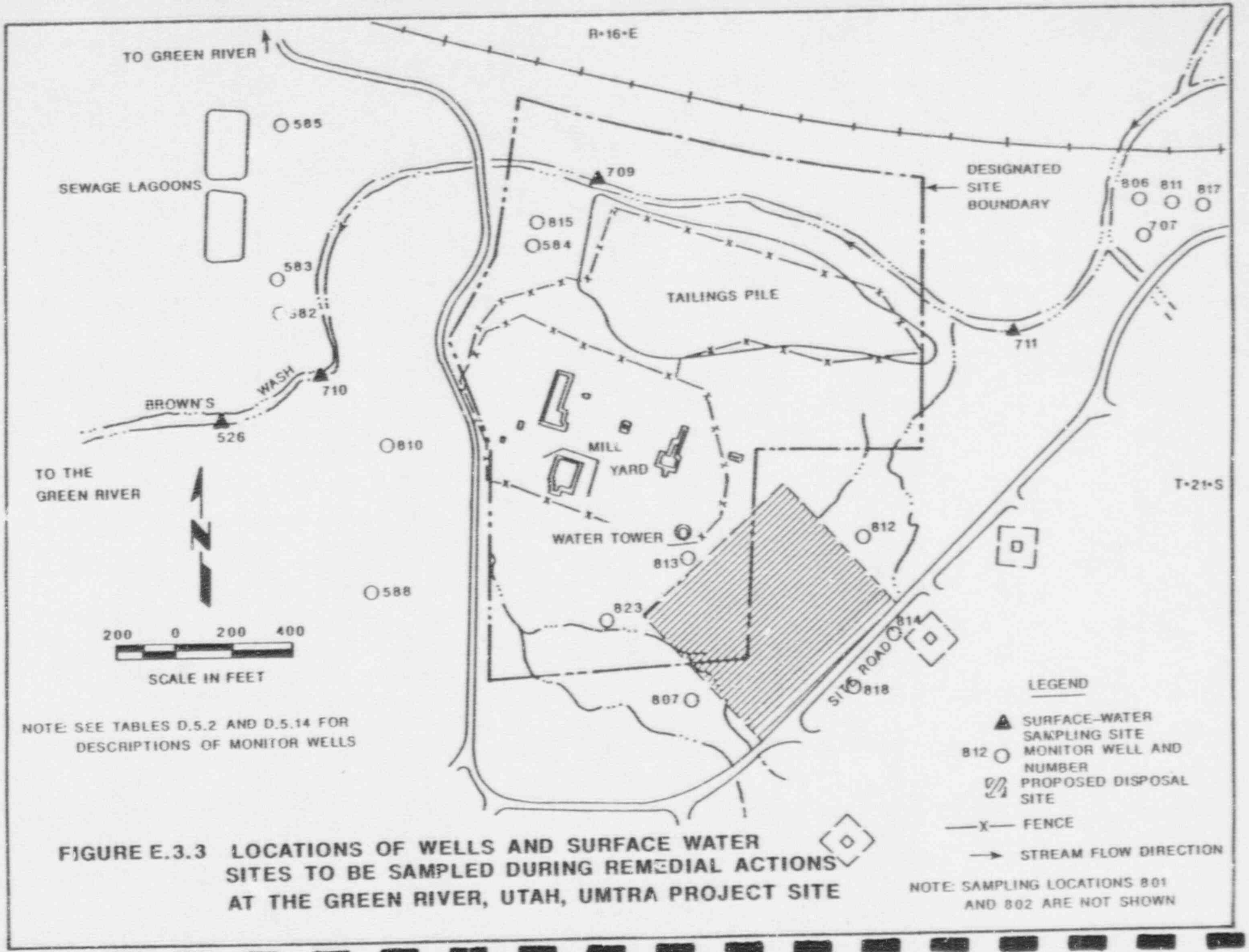
Monitoring during remedial action activities shall take place semi-annually. Samples shall be taken from the wells shown in Figure E.3.3. The wells shown in Figure E.3.3 will be retained for post-closure monitoring, but they will not be sampled as frequently as the proposed performance monitoring wells at the point of compliance. Figure E.3.3 also shows surface water sites to be sampled.

The constituents to be analyzed shall include all of the hazardous constituents listed in Table E.3.1 and E.1.1. In addition to these, major anions and cations will be analyzed together with the standard suite of field parameters. A detailed list of constituents will be presented in the S&M plan.

As discussed in Section E.3.1.2, a natural variability is associated with the proposed concentration limits for the hazardous constituents at the Green River site. This natural variability must be considered when defining excursions, and should be updated as more background water quality data become available. This approach is consistent with the S&M guidance document (DOE, 1986). Details on the variability of concentrations for each hazardous constituent will be presented in the S&M plan. Also, more background water quality data will be available at that time, and will be considered in the analysis of variability.

E.3.5 CORRECTIVE ACTION PLAN

The DOE is required by 40 CFR 192.02(c) to provide an evaluation of alternative corrective actions that could be implemented if the disposal monitoring program indicates that the disposal unit is not performing adequately. The DOE should consider reasonable failure scenarios of the disposal unit and demonstrate that corrective actions could be implemented no later than 18 months after finding an exceedence of the groundwater protection standard.



NOTE: SEE TABLES D.5.2 AND D.5.14 FOR DESCRIPTIONS OF MONITOR WELLS

NOTE: SAMPLING LOCATIONS 801 AND 802 ARE NOT SHOWN

FIGURE E.3.3 LOCATIONS OF WELLS AND SURFACE WATER SITES TO BE SAMPLED DURING REMEDIAL ACTIONS AT THE GREEN RIVER, UTAH, UMTRA PROJECT SITE

As discussed previously in Section E.2.2, the Green River disposal cell has been designed and will be constructed to perform for the mandated design life of 1000 years. The design of the cell has incorporated standard safety factors, and should therefore perform for a period of greater than 1000 years with minimal maintenance. With this in mind, there is no "reasonable" failure scenario for the Green River cell that would be related to structural instability or failure. It is conceivable, however very unlikely, that the net flux of moisture through the cell could exceed the anticipated steady state flux of 2×10^{-8} cm/s (see Section E.3.2). The disposal cell moisture monitoring program planned at Green River (see Section E.3.4.1) is designed to provide early warning of this condition. If it is determined that the moisture profile within the tailings is wetter than anticipated (within some reasonable bounds to be specified in the S&M plan), an assessment of the projected flux rate through the cell at that higher moisture content will be made to determine the potential effects on groundwater, if any.

If it is determined that there are potential adverse effects to groundwater quality, a risk assessment will be performed to determine the potential threat to human health and the environment, if any. A preliminary risk assessment has already been done for the Green River site (DOE, 1989b). The risk assessment could be finalized to include any specific constituents or pathways into the analysis in two to three months. Based on the findings of the preliminary risk assessment, the ambient water quality upgradient and peripheral to the disposal site is not usable. Therefore it is likely that any exceedences of the proposed concentration limits (see Section E.3.1.2) will not constitute an additional threat to human health and the environment. In addition, the disposal site lies immediately upgradient of the present tailings pile and existing contamination. Institutional control of existing contamination from uranium milling processes at Green River, or active restoration of the contaminated aquifers, would necessarily include any potential contamination releases from the disposal cell. The need for aquifer restoration at the Green River site will be addressed in a separate process to comply with Subpart B of the final EPA groundwater standards. Section E.3.6 addresses this subject in greater detail.

Finally, geochemical conditions in the potentially affected aquifers at the Green River site immediately downgradient of the disposal cell are favorable for attenuating redox-sensitive contaminants. This condition is presently reducing uranium and nitrate concentrations in the upper-middle unit beneath the existing tailings pile. Geochemical conditions are discussed in detail in Section D.5.2.9 of Appendix D.

In summary, a corrective action plan for the Green River disposal site contains the following main elements:

(1) Monitor moisture flux through disposal cell.

(2) If moisture content exceeds the acceptable value (to be specified in the S&M plan), assess the potential impacts of the higher cell moisture flux.

(3) Request ACLs for any constituents predicted to exceed the proposed concentration limits (based on a risk assessment) or provide for corrective actions such as cover redesign and construction (e.g., with a CLAYMAX infiltration barrier) if a positive health risk is assessed.

Any exceedence of the proposed concentration limits at the point of compliance, as determined from saturated zone monitoring during the early stages of performance monitoring, would likely be a result of the drainage of water applied to the tailings during construction. Since every effort is being made to minimize this condition (see Section E.2.1.2), an excursion at the point of compliance is considered unlikely, especially when the travel time through the buffer material and foundation bedrock are considered (see Section E.3.2). If there is an excursion at the point of compliance, the corrective action plan would be the same as that for the unsaturated zone monitoring system.

The corrective action plan for the Green River disposal site will also be presented in the S&M plan.

E.3.6 CLEANUP AND CONTROL OF EXISTING CONTAMINATION

Subpart B of 40 CFR 192 requires that the DOE perform a groundwater cleanup evaluation of existing contamination at the Green River processing site. The DOE and NRC consider that evaluation of groundwater cleanup should be deferred until after the EPA promulgates final groundwater protection standards, provided that disposal may proceed independently of cleanup. This section addresses two issues: (1) demonstration that the DOE may proceed with disposal independently of cleanup ("decoupling"); and (2) potential restoration methods that could be employed at the Green River site should restoration be deemed necessary.

E.3.6.1 Decoupling

Section D.5.2.7 of Appendix D addresses the extent of existing groundwater contamination from uranium milling activities at the Green River processing site. Sections E.3.1.3 and E.3.4 address the programs to monitor groundwater quality peripheral to the disposal cell during and after remedial actions. Given that the water quality has been established at both the old tailings site and at the disposal site, the DOE has demonstrated that existing contamination and any future contamination resulting from disposal activities can be distinguished and appropriate corrective actions can be taken to control any contamination resulting from disposal activities (see Section E.3.5).

Finally, because the period of construction activities is relatively short at the Green River site, and the extent of existing contamination is mostly within the site boundaries, there is little chance that human health or the environment could be affected by leaving the contamination as is during the interim period between remedial action activities and the evaluation of groundwater cleanup.

E.3.6.2 Potential restoration methods

Active restoration methods fall into two general categories: (1) above-ground removal methods, wherein the contaminated water is removed from the aquifer, treated, and either disposed of, used, or reinjected into the aquifer; and (2) in situ methods, such as the addition of chemical lixiviants to mobilize the contamination in the subsurface aquifer system. An aquifer restoration program at the Green River site may involve one or more of the restoration methods discussed below.

Extraction

Contaminated groundwater can be extracted with wells or trenches. The use of trenches is limited to relatively shallow contamination (generally less than 50 feet deep) and is most useful in materials with low permeability. For most cases where the contamination is in permeable materials and in cases of low permeability but deep contamination, wells are the preferred extraction method.

Treatment

The need for treatment prior to discharge or reinjection into an aquifer depends upon the concentrations of contaminants in the extracted groundwater and the regulations regarding discharge of effluent to surface and groundwater. Various methods for treating the contaminated water are available. Most of the treatment methods are chemical. These include chemical precipitation, coagulation, ion exchange, flocculation, neutralization, sorption, and reverse osmosis. Contamination can be separated physically from water using evaporation ponds. Biological treatment can be used to transform nitrate to nitrogen gas and oxygen gas. The preferred treatment methods depend on the specific mix of contaminants, the concentration of the contaminants, the general water quality, the volumetric flow of the treatment stream, and the available area for treatment facilities.

In situ treatment

In addition to above-ground treatment, two in situ treatment methods may be applied. These are lixiviant injection and permeable treatment beds or walls. Both methods can be used to cause reducing geochemical conditions, which would cause the trace metal contaminants to precipitate or absorb out of solution into the solid phase. Although chemical reduction could reduce solute concentrations to less than the appropriate concentration limits, dissolution or desorption could occur as the geochemical environment reequilibrates. Therefore, chemical reduction does not provide long-term assurances that adequate water quality could be maintained. The preferred in situ treatment would result in mobilizing contaminants by causing oxidizing conditions so that contaminants can be removed expeditiously from the subsurface. Permeable treatment beds or walls cannot be used effectively for this purpose.

A lixiviant is a solution of complexing species (either ions or molecules) that enhance the solubility of species (metals) to be removed from the aquifer during restoration. Injection of oxidizing lixiviants containing hydrogen peroxide or oxygen to oxidize the system and sodium bicarbonate to increase the pH may be useful for removing contaminants that may leach from the solid phase. Although this technology is unproven, it may be the only practicable method to remove trace metal contamination, primarily in the solid phase, that leaches to the groundwater at concentrations above the acceptable concentration limits.

Lixiviants would be introduced by injection or infiltration upgradient of the contamination. The lixiviant would move through the contaminated zone, interact with the liquid and solid phases, become impregnated with contaminants, and be extracted at the leading edge of the contaminant plume.

Discharge

Following the extraction, or extraction and treatment, of contaminated water, the water would be discharged. Options for discharge include:

- Discharge to surface water.
- Infiltration.
- Injection in shallow wells.
- Injection in deep wells.

Natural flushing

Natural flushing is a passive restoration method whereby dissolved or precipitated contaminants in groundwater are dispersed or removed over time by the natural flow of groundwater. Under Subpart B of the proposed EPA standards, passive restoration may be permitted if it can be demonstrated that natural flushing can occur within a period of 100 years or less and that the groundwater is not now and is not projected to be used for a community water supply (or other substantial use) within this period. Natural flushing may be employed as the sole method for aquifer restoration, or it may be used in conjunction with any of the active restoration methods described above. Natural flushing may be the most logical way to approach groundwater restoration at the Green River site.

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