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United States Department of Energy

Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Gunnison, Colorado

Attachment 4, Water Resources Protection Strategy

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Uranium Mill Tailings Remedial Action Project UMTRAP

ATTACHMENT 4

WATER RESOURCES PROTECTION STRATEGY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 WATER RESOURCES PROTECTION STRATEGY SUMMARY

To achieve compliance with the proposed U.S. Environmental Protection Agency (EPA) groundwater protection standards (Subpart A of 40 CFR 192), the U.S. Department of Energy (DOE) proposes to meet background concentrations or the EPA maximum concentration limits (MCLs) for hazardous constituents in groundwater in the uppermost aquifer (lower Tertiary gravel aquifer) at the point of compliance (POC) at the Gunnison Landfill Uranium Mill Tailings Remedial Action (UMTRA) Project disposal site near Gunnison, Colorado (DOE, 1989). The proposed remedial action will ensure protection of human health and the environment. A summary of the principal features of the water resources protection strategy for the Landfill disposal site follows.

- The disposal option proposed for the Gunnison uranium processing site involves consolidation of the uranium tailings and associated contaminated materials at the Landfill disposal site. These materials will be placed in a partially below-grade disposal cell designed to reduce radon emanation, resist degradation, minimize infiltration, and withstand differential settlement.

- Several design features were incorporated into the disposal cell as a result of the design considerations. A multiple-component cover has been included to reduce infiltration and provide evapotranspiration, and to meet the UMTRA project longevity requirements. The tailings will be placed below optimum moisture content to minimize transient drainage. Construction water for dust control will be carefully monitored. The disposal cell foundation and the location of the site have been optimized to utilize favorable geochemical conditions and unsaturated zone properties of the foundation materials and hydrogeologic conditions of the site.

- The design of the disposal cell considered the importance of climate on the rate of infiltration through the cover of the disposal cell, the effects of transient drainage on subsurface drainage into foundation materials, the relation of transient drainage to the thickness of foundation materials required to attenuate hazardous constituents in the tailings seepage geochemically, retardation of tailings seepage in the unsaturated zone as soil moisture storage, and dilution and dispersion in the uppermost aquifer.

- To achieve compliance with the proposed EPA groundwater protection standards at the disposal site, the DOE proposes to meet background concentrations or MCLs for the designated hazardous constituents in groundwater at the POC in the uppermost aquifer hydraulically downgradient from the disposal site. The lower Tertiary gravel aquifer is the uppermost aquifer at the Gunnison disposal site.

- Selection of hazardous constituents (40 CFR 192.02, Table 1, Appendix I, and Appendix IX, 40 CFR 264) is based upon hydrogeologic characterization at the processing and disposal sites. The hazardous constituents at the Gunnison site resulted from the uranium processing operations, will be present in materials stabilized at the Landfill disposal site, and were identified from descriptions of the uranium recovery process, characterization of the contaminated materials, and evaluation of groundwater quality data. Based upon pore fluid or batch leach test statistical mean or median values, the following 11 hazardous constituents exceeded the laboratory method detection limits: arsenic, cadmium, chromium, net gross alpha (gross alpha minus uranium), lead, molybdenum, nitrate, radium-226 and -228, selenium, silver, and uranium. Additional potentially hazardous elements that exceeded the laboratory method detection limit are antimony, beryllium, cobalt, copper, nickel, sulfide, thallium, vanadium, and zinc.

- Concentrations of seven hazardous constituents exceeded the MCLs in tailings pore water and batch leach tests. These hazardous constituents are arsenic, cadmium, chromium, net gross alpha, molybdenum, selenium, and uranium. Additionally, seven regulated elements exceeded the statistical maximum background groundwater concentration and are designated hazardous constituents with sufficiently high source concentrations that may affect groundwater quality. These constituents are antimony, beryllium, cobalt, copper, nickel, vanadium, and zinc.

- Elements of hazardous compounds (40 CFR 192.02, Appendix I) were also examined. The four elements and their respective hazardous compounds are the following: (1) aluminum as aluminum phosphide; (2) ammonium as a salt of vanadic acid; (3) fluoride as carbon oxyfluoride; and (4) strontium as strontium sulfide. None of these four compounds would exist under geochemical conditions expected of uranium mill tailings. Therefore, these hazardous compounds and their respective elements are not considered to be hazardous constituents that may occur at the disposal site.

- The proposed concentration limits for the designated hazardous constituents were selected based upon the MCLs and the statistical maximum background concentrations (for constituents without MCLs) in groundwater in the uppermost aquifer at the Landfill disposal site. The statistical maximum is represented as the 99 percent confidence maximum for constituents with normal and log-normal distributions. In some cases, based upon the distribution, statistics were not appropriate and the maximum observed concentration or the method detection limit was chosen (See Attachment 3, Section 3.1.5). The proposed concentration limits for cadmium, chromium, net gross alpha, lead, molybdenum, selenium, silver, and uranium will be the EPA primary MCLs. The proposed concentration limit for arsenic will be the statistical maximum background groundwater value, which is 0.053 mg/l. Proposed concentration limits for antimony, beryllium, cobalt, copper, nickel, vanadium, and zinc will be the statistical maximum background groundwater concentration of these constituents.

- The POC at the Landfill disposal site will be downgradient along the northwest and east/northeast edge of the disposal cell in the uppermost aquifer, which is the lower Tertiary gravel aquifer.

- To demonstrate compliance of the disposal cell design with the proposed EPA groundwater protection standards, design parameters were evaluated in conjunction with hydrogeologic characteristics of the Landfill disposal site to determine the distribution of hazardous constituents in groundwater under transient and steady state conditions.

2.0 CONCEPTUAL DESIGN FEATURES FOR WATER RESOURCES PROTECTION

The following are the cell design and hydrogeologic characteristics important to the performance of the proposed disposal cell: (1) the consolidation of contaminated materials in the disposal cell with a vegetated cover, an infiltration barrier, and the bentonite mat will reduce the infiltration rate and minimize long-term seepage from the disposal cell; (2) the embankment slopes will be contoured to provide efficient drainage of the embankment surface and further minimize infiltration of surface water; (3) the upper saturated zone beneath the disposal cell is not an aquifer because it is perched and because of its low yield; (4) the foundation geologic materials beneath the proposed disposal cell possess favorable properties for geochemical attenuation of hazardous constituents in the tailings pore water; (5) most of the seepage from the disposal cell will be held as storage in the unsaturated zone and it is therefore highly unlikely that tailings pore water from the disposal cell will reach the uppermost aquifer; and (6) hazardous constituent concentrations in any tailings seepage from the disposal cell that reaches the uppermost aquifer are geochemically attenuated, then diluted and dispersed by groundwater underflow to below the proposed background concentration or MCLs.

The DOE has assessed the performance of the disposal cell in conjunction with the hydrogeologic system and has shown that the disposal cell will minimize and control releases of hazardous constituents to groundwater and surface water and radon emanations to the atmosphere to the extent necessary to protect human health and the environment. Natural, stable materials have been proposed for use in construction of the Landfill disposal cell so that long-term performance is ensured. The final design consideration is to comply with the longevity requirement in 40 CFR 192.

A groundwater monitoring program will be carried out during and after the remedial action period to demonstrate that the performance of the disposal unit is in accordance with the design requirements, and to ensure compliance of the disposal site with the EPA groundwater protection standards. Groundwater in the uppermost aquifer will be monitored downgradient from the disposal cell at the POC, using existing DOE monitor wells where applicable and installing new monitor wells as necessary. Background groundwater quality will also continue to be monitored upgradient from the disposal cell. Compliance wells will be sampled quarterly during the first and second years following completion of remedial action activities, semi-annually for years three through six, and annually thereafter until the end of the performance monitoring period. The constituents to be monitored will include designated hazardous constituents, major anions and cations, and a standard suite of field parameters.

Demonstration of cleanup and control of existing processing-related groundwater contamination will be addressed under a separate DOE program and will be part of a separate process to comply with the National Environmental Policy Act. The proposed remedial action will not preclude or interfere with active groundwater restoration, should it be required, because the tailings will be relocated to a remote disposal site.

The DOE and the the Colorado Department of Health have jointly developed a program for testing water from Gunnison homes potentially affected by groundwater contamination from the Gunnison tailings. The program is designed to determine concentrations of uranium in groundwater tapped by residents near the tailings site. Testing program results will be evaluated to determine whether steps are needed to protect the health of affected residents. A health risk assessment being undertaken by the DOE is currently underway and will be completed by July 1990.

While the UMTRA Project has committed to supply an alternate water source to the affected water users, the action levels that define when this supply is provided and when it is to end have yet to be determined. Three action levels may apply in this situation: The first is the standard set by the EPA for groundwater compliance at UMTRA Project sites, 30 picocuries per liter (pCi/l) (0.044 milligrams per liter, or mg/l). The second is 20 pCi/l (0.030 mg/l) as determined by a standard EPA health risk assessment for toxicity to children. The third is to supply water if the well is near or within the contaminant plume.

2.1 DESIGN CONSIDERATIONS

2.1.1 Climate and infiltration

Climate is an important design consideration because of its influence on the quantity of water available to percolate through the cover of the disposal cell and through stabilized residual radioactive materials, and its potential effect on the migration of hazardous constituents to groundwater.

The climate in the vicinity of the Gunnison site is semiarid. The average annual precipitation is 11 inches, with half of the precipitation in the form of winter snow and half as thunder-showers. Most of the precipitation occurs during July and August, with an average of 1.7 inches per month. November and December are the driest months, with about 0.7 inch per month. The annual normal temperature is 37.7°F. Average daily winter temperatures are usually about 10°F, with a 31°F diurnal range, while summer temperatures average 60°F and have a 40° diurnal range. Prevailing winds are most frequently from the west. Adjusted evapotranspiration at the Landfill site is approximately 10.5 inches per year. The evapotranspiration at the Landfill site is over 90 percent of the average annual precipitation.

The high rate of evapotranspiration at the Landfill disposal site is advantageous for limiting deep percolation of precipitation through the proposed disposal cell. The vegetated top cover of the cell will transpire excess moisture from precipition and snowmelt as well or better than the existing soil surface at the Landfill disposal site. To minimize infiltration, it is necessary to optimize soil thickness, soil texture, and vegetation, and to minimize the permeability of the underlying infiltration barrier so that excess infiltration can be evapotranspirated. Cover performance is discussed in more detail in Section 2.2.

2.1.2 Surface drainage

The relation of surface topography to disposal cell location and final grading should consider the ability of the disposal cell to divert surface flow from around the disposal cell and limit the quantity of water available for infiltration by shedding surface flow from the disposal cell.

Topgraphically, the disposal site lies on a southward-sloping plain dissected by erosion features that include two narrow to moderately broad gullies. The gullies trend to the west and southeast of the site, respectively, as shown on Figure 2.1. The sloping plain on which the disposal cell will be placed is formed on extensive gravel soils.

Surface runoff from the drainage area north of the site will be diverted laterally away from the disposal cell by a permanent interceptor swale north of the disposal site (see Figure 2.1). The swale will be constructed to divert surface runoff partly through the east branch and partly through the west branch to both existing gullies on the southeast and west sides of the site (East Long Gulch and Chance Gulch, respectively). The natural surface slope and the final grade of the disposal site will facilitate drainage of surface waters around the disposal cell rather than into it.

2.1.3 Subsurface drainage

The ability of the disposal cell foundation to accept transient drainage of excess moisture from the tailings without adversely impacting groundwater or surface water resources is an important design consideration.

The saturated and unsaturated hydraulic conductivity characteristics of the subsoils beneath the proposed disposal cell are currently being evaluated. The foundation soils are a clayey to sandy gravel, and should be capable of accepting transient and steady state tailings drainage without creating a perched saturated surface in the foundation soils. The amount of transient drainage that can be allowed is dependent upon the geochemical attenuation capabilities of the subsoils, the ability of the unsaturated zone to accept transient drainage as storage, and the capability of the Tertiary gravel aquifer to dilute and disperse concentrations below the proposed concentration limits. Sections 2.2.2, 3.2.1, and 3.2.2 discuss subsurface drainage in detail as it relates to the overall performance of the disposal cell.

2.1.4 Disposal cell longevity

The EPA groundwater protection standards require that the disposal cell be designed to stabilize the contaminated material and protect the environment for 1000 years where reasonably achievable, and in any case for at least 200 years.

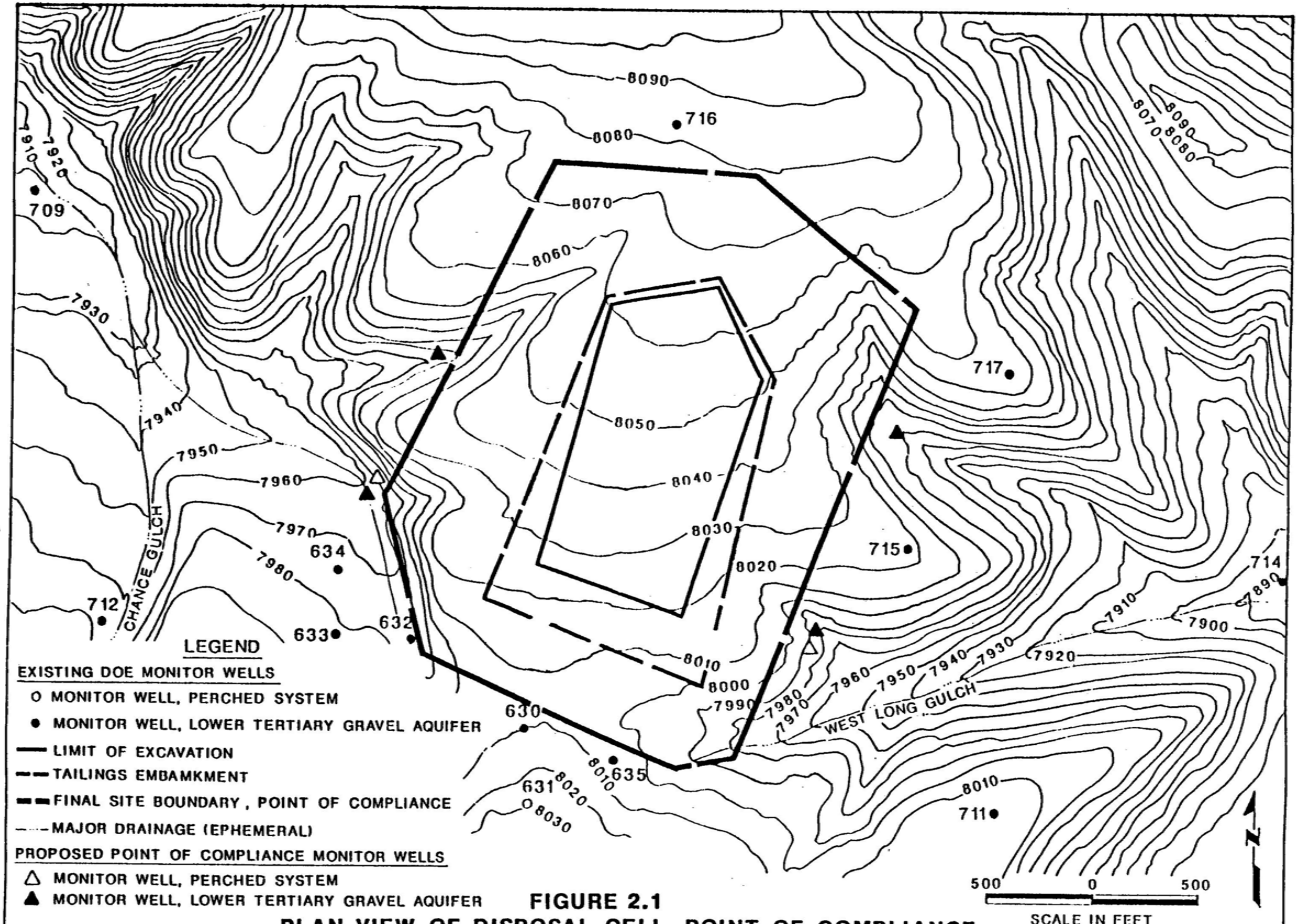

FIGURE 2.1
PLAN VIEW OF DISPOSAL CELL, POINT OF COMPLIANCE, AND GROUNDWATER MONITORING NETWORK GUNNISON LANDFILL DISPOSAL SITE, COLORADO

2.2 DESIGN FEATURES

This section describes the principal design features of the proposed disposal cell at the Landfill disposal site that will ensure compliance with the EPA groundwater protection standards, and will demonstrate that the design features do not rely on active maintenance to ensure adequate long-term performance. Additional details and specifications of the conceptual design are provided in Attachment 1.

The disposal cell will cover approximately 35 acres (see Figure 2.1). The cell will rise to a maximum height of 70 feet above the surrounding ground surface. The top of the disposal cell will slope at 1.55 percent, and the sides of the cell will slope at 33 percent.

2.2.1 Disposal cell cover components

The disposal cell will have a vegetated, multiple-component cover. Figure 2.2 is a diagramatic cross section through the disposal cell. Figure 2.3 is a detailed cross section of the disposal cell cover components. Figures 3.15 and 3.16 of Attachment 3 are hydrostratigraphic cross sections of the disposal cell at the Landfill disposal site.

From top to bottom, the disposal cell cover consists of the following components:

- o Rocky soil (gravel mulch) with vegetation (one foot).
- o Select fill, rooting medium and frost-protection fill (six feet).
- o Biobarrier fill (one foot).
- o Bedding (0.5 feet).
- o Bentonite mat.
- o Radon barrier (two feet).

The characteristics and purpose for including each of these cover components is discussed in more detail as follows.

<u>Rocky soil (gravel mulch) with vegetation</u>

The topsoil from the footprint area will be carefully removed and stockpiled for placement on the uppermost 12 inches of the cover. The primary purpose of the topsoil will be to establish and maintain vegetation on the cover. In addition, rock will be blended with the topsoil to form a gravel mulch. The gravel mulch will resist surface erosion when vegetation is not present on the cover. The topsoils at the disposal site are generally a silty, fine, gravelly sand to a gravelly sandy silt and are estimated to

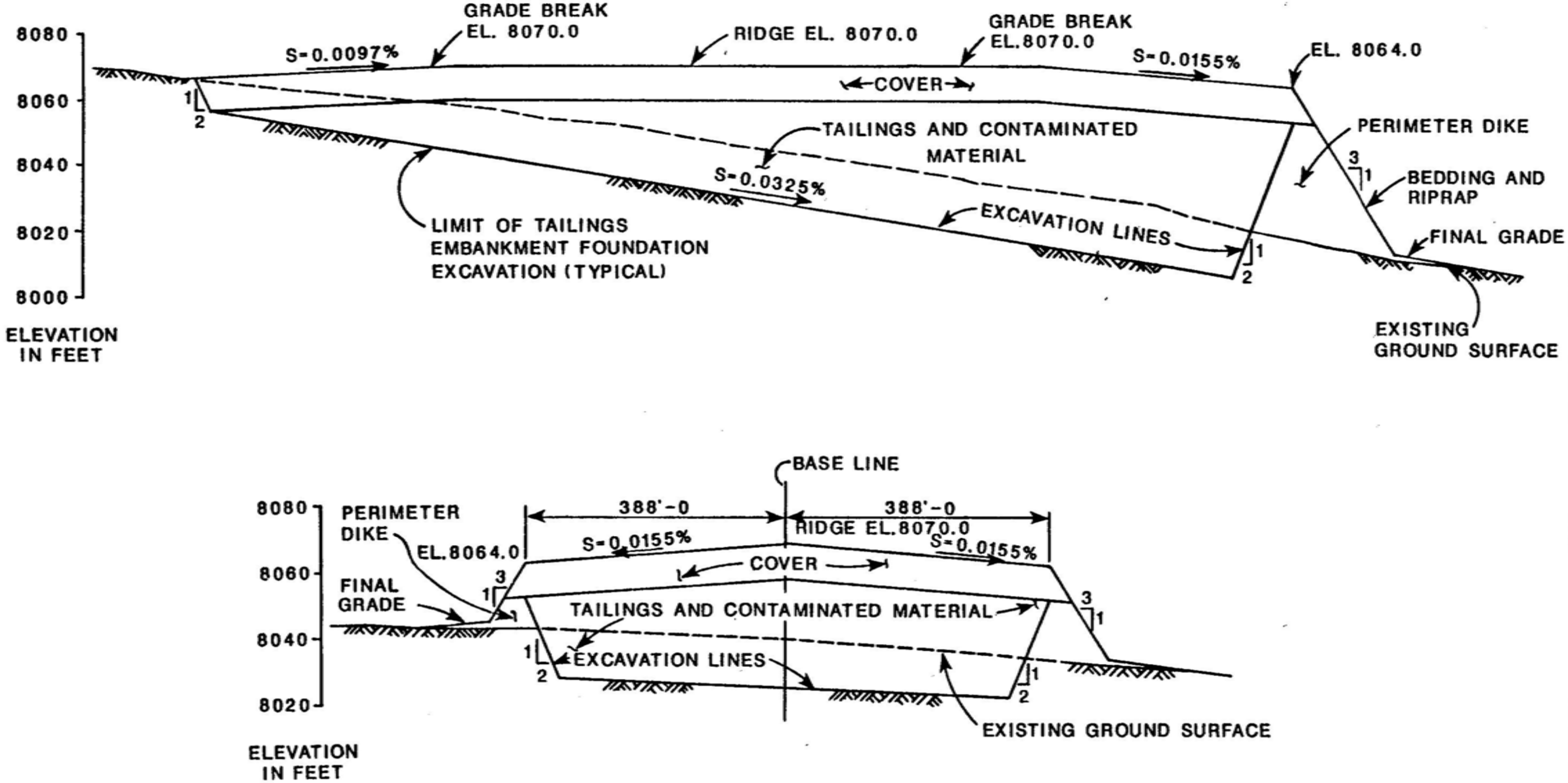

FIGURE 2.2
DIAGRAMMATIC CROSS SECTIONS OF THE PROPOSED DISPOSAL CELL AT THE GUNNISON LANDFILL DISPOSAL SITE, COLORADO

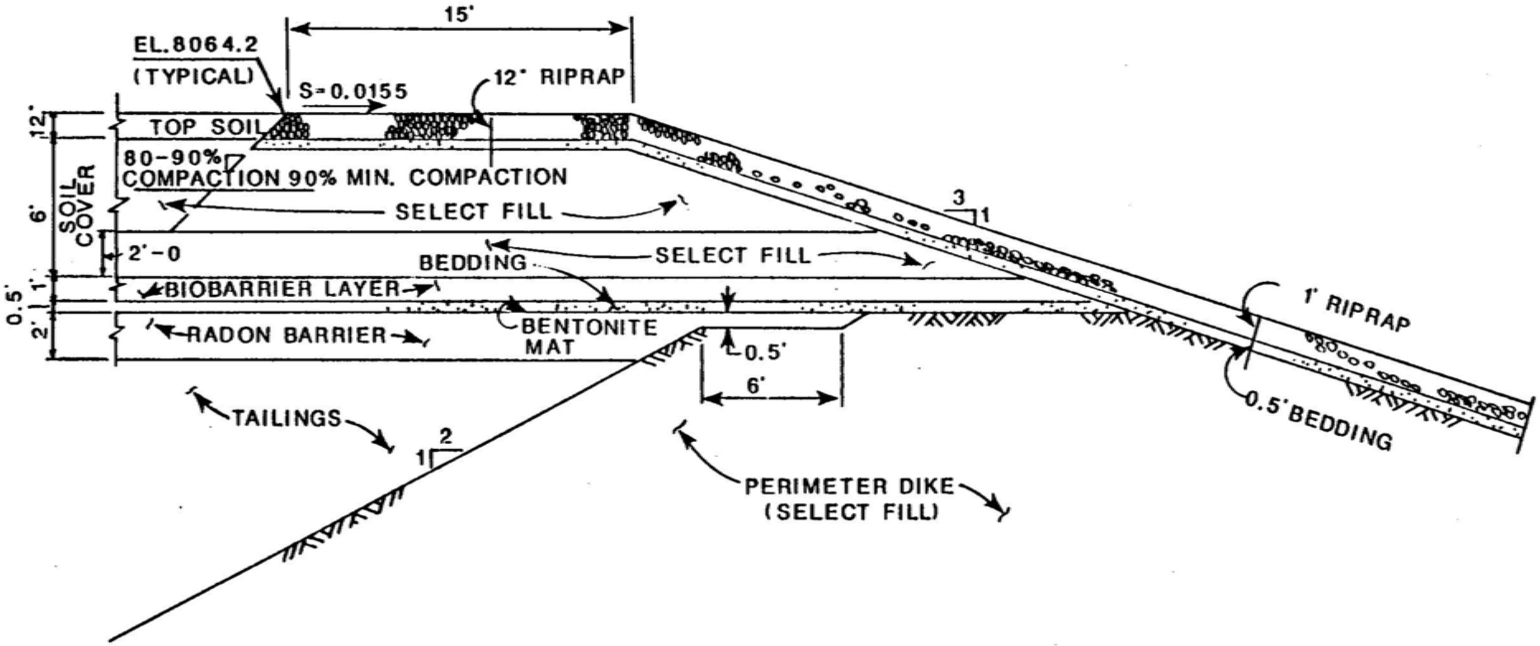

FIGURE 2.3
DISPOSAL CELL COVER SYSTEM
AT THE GUNNISON LANDFILL DISPOSAL SITE, COLORADO

have a saturated hydraulic conductivity of 1 x 10^{-3} centimeters per second (cm/s) (Attachment 1, Calculation GUN-643-03-00).

Select fill rooting medium and frost protection fill

Beneath the rocky soil with vegetation will be six feet of selected fill material for rooting and frost protection. This material will be relatively fine-grained to enhance moisture retention in the root zone and consumptive use of excess moisture by evapotranspiration (Attachment 1, Calculation GUN-643-03-00). This fill material will also help protect the underlying bentonite mat and radon barrier from freezing. The estimated maximum frost depth for the Landfill site is approximately seven feet (Attachment 1, Calculation GUN-643-02-00). This fill layer has an estimated saturated hydraulic conductivity of 2 x 10^{-5} cm/s (Attachment 1, Calculation GUN 643-03-00).

Biobarrier fill

The one-foot-thick biointrusion layer will serve to resist intrusion of roots and burrowing animals into the underlying bentonite mat and radon barrier. This will be a very coarse-textured fill (D_{50} = 3.0 inches) with an estimated saturated hydraulic conductivity of one cm/s (Attachment 1, Calculation GUN-643-03-00).

Bedding fill

The six-inch-thick bedding/drain component is included primarily to rapidly drain any excess moisture off the underlying bentonite mat. It will also serve as a bedding layer to prevent intrusion of the coarse biointrusion barrier into the underlying bentonite mat. The estimated saturated hydraulic conductivity of this fill is 3.2 x 10^{-2} cm/s (Attachment 1, Calculation GUN-643-03-00).

Bentonite mat

The bentonite mat is a 0.25-inch-thick, pure sodium bentonite clay bound between a polypropylene and a polyester scrim. The bentonite mat has a saturated hydraulic conductivity of 2 x 10^{-9} cm/s (Attachment 1, Calculation GUN-643-03-00) and is included as an infiltration barrier. The bentonite mat has the lowest hydraulic conductivity of any of the disposal cell cover components. Water-balance modeling of the cover using the HELP model (see Attachment 1, Calculation GUN-643-03-00) has shown that the bentonite mat will aid in restricting infiltration of surface water.

Radon barrier

The radon barrier will be two feet thick and will be comprised primarily of low-plasticity clay (Attachment 1, Calculation GUN-643-03-00). The purpose of the radon barrier will be to limit the flux of radon from the contaminated materials within the cell to acceptable concentrations. The radon barrier will have a low saturated hydraulic conductivity (1.8 x 10^{-6} cm/s) and will also help to limit infiltration of excess moisture into the tailings.

2.2.2 Transient drainage and control of construction water

The tailings will be placed below optimum moisture content. An unsaturated flow analysis of drainage of moisture from the tailings after placement and compaction was performed (Calculation GUN-04-89-02-03-00). Results of the analysis show that the maximum flux of moisture from the tailings is slightly less than 3 x 10^{-8} cm/s, and decreases to the upper-boundary (cover) flux of 2 x 10^{-9} cm/s after approximately 450 years because the cover design, specifically the bentonite mat, limits water inflow to this rate. The disposal cell foundation soils should be capable of accepting a maximum transient moisture flux of 3 x 10^{-8} cm/s, and should therefore remain unsaturated. The effects of transient drainage of tailings pore water on compliance with the groundwater protection standards is presented in the performance assessment (Section 3.2).

Construction water for compaction and dust control will be carefully monitored so that moisture contents in the disposal cell materials will not cause an increase in the predicted flux of transient drainage.

2.2.3 Disposal cell longevity

Natural, stable materials have been proposed for use in construction of the Gunnison disposal cell to ensure long-term performance. Materials for the rock erosion protection layer have been selected, based on durability, suitability, and size, that will perform adequately over the design life of the disposal cell. The bedding material has been selected using the same durability criteria as for the rock. The compacted radon barrier material will be protected from erosion by the overlying cover components.

3.0 DISPOSAL AND CONTROL OF RADIOACTIVE MATERIALS AND NONRADIOACTIVE CONTAMINANTS

3.1 GROUNDWATER PROTECTION STANDARD

The proposed disposal cell at the Landfill disposal site is designed to control radioactive materials and nonradioactive contaminants in conformance with groundwater protection standards as required by the proposed EPA standards in 40 CFR 192.02(a)(3). The DOE proposes to meet background concentrations or EPA MCLs for designated hazardous constituents in groundwater in the uppermost aquifer at the POC at the Landfill disposal site. The lower Tertiary gravel is considered to be the uppermost aquifer beneath and hydraulically downgradient from the disposal site.

Perched groundwater occurs in the lower portion of the Tertiary volcaniclastic stratum at a depth of 34 to 69 feet beneath the present land surface of the Landfill disposal site. This perched groundwater, which is the first zone of saturation beneath the disposal cell, is not considered to be the uppermost aquifer (see Section 3.2.3 of Attachment 3).

The EPA groundwater protection standard consists of three components: (1) a list of designated hazardous constituents; (2) a corresponding list of proposed concentration limits for the constituents; and (3) a POC. These three main components are discussed below.

3.1.1 Hazardous constituents

Hazardous constituents at the Landfill disposal site were identified from characterization of the tailings materials. A description of the uranium recovery process, and evaluation of groundwater quality data is discussed in Attachment 3.

Hazardous constituents must satisfy two criteria: (1) they must be present, or reasonably expected to be present in or derived from, the residual radioactive material to be stabilized at the disposal site; and (2) they must be constituents listed in Table 1 in 40 CFR 192.02(a)(3)(i) or Table 1 in 40 CFR 192.02 (a)(3)(iii). Appendix IX of 40 CFR 264 may be referenced to satisfy the analytical requirements of Appendix I of 40 CFR 192. Appendix IX organics were screened for in samples from on-site monitor wells at the Gunnison processing site. None were detected.

Potentially hazardous inorganic constituents possibly related to uranium processing activities that exceed laboratory method detection limits in the uranium tailings pore fluid and batch leach tests include arsenic, cadmium, chromium, net gross alpha (gross alpha minus uranium), lead, molybdenum, nitrate, radium-226 and -228, selenium, silver, and uranium. Additional elements included in Appendix I, 40 CFR 192, and Appendix IX, 40 CFR 264, that are also monitored and which exceeded the laboratory method detection limit are antimony, beryllium, cobalt, copper, nickel, vanadium, and zinc. Elements of hazardous compounds that exceeded the laboratory method detection limit were aluminium, ammonium, fluoride, and strontium. Groundwater samples were chemically analyzed for all the these constituents at the disposal site (Calculation GUN-04-90-12-07). Of these constituents analyzed, the hazardous inorganic constituents have MCLs specified by the draft final EPA groundwater protection standards (40 CFR 192). The list of elements and elements of hazardous compounds have no MCLs.

The four elements of hazardous compounds and their respective hazardous compounds are the following: (1) aluminum as aluminum phosphide; (2) ammonium as a salt of vanadic acid; (3) fluoride as carbon oxyfluoride; and (4) strontium as strontium sulfide. None of these four compounds would exist under geochemical conditions expected of uranium mill tailings. Therefore, these hazardous compounds and their respective elements are not considered as hazardous constituents at the Landfill disposal site and are not discussed further.

Concentrations of seven hazardous constituents exceeded the MCLs in tailings pore water and batch leach tests. These hazardous constituents are arsenic, cadmium, chromium, net gross alpha, molybdenum, selenium, and uranium. Additionally, seven selected elements exceeded the statistical maximum background groundwater concentration and are designated hazardous constituents with sufficiently high source concentrations that may affect groundwater quality. These constituents are antimony, beryllium, cobalt, copper, nickel, vanadium, and zinc.

Concentrations of seven hazardous constituents and seven of the listed elements discussed above exceed the MCLs or the statistical maximum in background groundwater. These hazardous constituents and elements of hazardous compounds have the potential to impact groundwater quality at the Landfill disposal site.

3.1.2 Proposed concentration limits

To achieve compliance with the proposed EPA groundwater protection standards at the Landfill disposal site, the DOE proposes to meet MCLs or background concentrations in groundwater in the uppermost aquifer (lower Tertiary gravel) at the POC for the hazardous constituents designated in Section 3.1.1 and listed in Table 3.1. The proposed concentration limits based on EPA groundwater protection standards and the statistical maximum background concentrations in groundwater in the lower Tertiary gravel aquifer beneath the site are also listed in Table 3.1.

3.1.3 Point of compliance

The POC at the Landfill disposal site will be the downgradient edge of the disposal cell in the uppermost aquifer, which is the lower Tertiary gravel. Predicted concentrations of

Table 3.1 Proposed concentration limits for the Landfill disposal site, near Gunnison, Colorado[a]

Hazardous constituent[b]	MCL	Background[c] statistical maximum	Proposed concentration[d] limit
Arsenic	0.05	0.053	0.053
Cadmium	0.01	0.0007	0.01
Chromium	0.05	0.02	0.05
Gross alpha (net)[e]	15.0	11.9	15.0
Lead	0.05	0.01	0.05
Molybdenum	0.1	0.017	0.1
Nitrate	44.0	11.9	44.0
Radium-226 & -228[e]	5.0	1.7	5.0
Selenium	0.01	0.0027	0.01
Silver	0.05	0.005	0.05
Uranium	0.044	0.006	0.044
Antimony	None	0.0015	0.002
Beryllium	None	0.0025	0.003
Cobalt	None	0.025	0.03
Copper	None	0.01	0.01
Nickel	None	0.02	0.02
Tin	None	0.0025	0.003
Vanadium	None	0.01	0.01
Zinc	None	0.013	0.013

[a]Concentrations in mg/l unless noted otherwise.
[b]Hazardous constituents from Table 1 and Appendix I, 40 CFR 192, and Appendix IX, 40 CFR 264.
[c]Statistical maximum value in Landfill disposal site background groundwater quality; Calculation GUN-05-90-14-10.
[d]Proposed concentration limit is the higher value of MCL or statistical maximum background.
[e]Units are pCi/l.

hazardous constituents at the POC are listed in Table 3.2. Future groundwater monitoring at the Landfill disposal site, including the number of monitor wells at the POC and the frequency of sampling, are discussed briefly in Section 3.4, and will be presented in detail in the forthcoming surveillance and maintenance plan for the Landfill disposal site.

3.2 PERFORMANCE ASSESSMENT

The DOE is required to demonstrate that the performance of the disposal cell will comply with the EPA groundwater protection standard (40 CFR 192.02(a)(3)). To achieve compliance, the DOE proposes to meet MCLs or the statistical maximum in background groundwater for the designated hazardous constituents (listed in Section 3.3.1) in groundwater in the uppermost aquifer (lower Tertiary gravel) at the POC.

The DOE will meet MCLs or the statistical maximum for background groundwater by demonstrating the following:

- o Geochemical characteristics of the foundation soils and rock are favorable for attenuating hazardous constituents that may exit the base of the disposal cell.
- o The transient drainage of tailings seepage into the unsaturated zone should remain in the unsaturated zone above the uppermost aquifer and may never reach the uppermost aquifer.
- o Proposed background concentrations and MCLs can be met at the POC in the uppermost aquifer by considering geochemical attenuation in the unsaturated zone beneath the disposal cell, and mixing and dilution in the uppermost aquifer. This analysis considers a range of possible cover flux values (1×10^{-8} cm/s to 1×10^{-9} cm/s) and transient drainage of tailings pore fluids.

Should tailings leachate from the disposal cell ever reach the uppermost aquifer, the concentrations of the identified hazardous constituents at the POC will be below the proposed background concentrations and MCLs, as shown in Table 3.2, because of geochemical attenuation processes in the foundation soils and mixing and dilution of the tailings leachate with groundwater underflow in the uppermost aquifer (Calculations GUN-06-90-15-03 and GUN-05-90-13-06 (1 and 2)). The following assesses in detail the performance of the Landfill disposal cell.

3.2.1 Geochemical attenuation

Section 3.2.6 of Attachment 3 discusses in detail the geochemical conditions of the foundation soils at the Landfill disposal site.

Laboratory testing of the foundation soils shows that hazardous constituents in the tailings pore fluids are reduced by 100 percent in many instances, and by 84 percent for uranium, in one pore volume. Table 3.32 of Attachment 3 shows the results of

Table 3.2 Proposed concentration limits and predicted concentrations of hazardous constituents at the point of compliance, Landfill disposal site near Gunnison, Colorado[a]

Hazardous constituent[b]	Source concentration[c]	Laboratory method detection limit	Maximum concentration limit	Background[d] Statistical maximum	Background[d] Mean or median	Proposed[e] concentration limit	Predicted[f] concentration at the POC
Table I							
Arsenic	2.87	0.01	0.05	0.053	0.022	0.053	0.049
Barium	0.05	0.1	1.0	0.1	0.05	1.0	0.12
Cadmium	0.64 m	0.001	0.01	0.0007	0.0005	0.01	0.001
Chromium	0.16	0.01	0.05	0.02	0.012	0.05	0.02
Gross alpha[g]	882.8 m[h]	1.0	15.0	24.0	18.7	24.0	47.7[k]
Lead	0.03	0.01	0.05	0.01	0.005	0.05	0.005
Mercury	0.0001	0.0002	0.002	0.0001	0.0001	0.002	<0.0001
Molybdenum	0.36 m	0.01	0.1	0.017	0.008	0.1	0.01
Nitrate	5.9 m	1.0	44.0	11.9	1.1	44.0	1.5
Radium-226 and -228[g]	3.0[h]	1.0	5.0	1.8	0.8	5.0	0.1
Selenium	0.2 m	0.005	0.01	0.003	0.003	0.01	0.003
Silver	0.025	0.01	0.05	0.005	0.005	0.05	0.003
Uranium	4.72 m	0.003	0.044	0.006	0.004	0.044	0.37
Appendix I and IX							
Antimony	0.034 m	0.003	None	0.002	0.002	0.002	0.006
Beryllium	0.13	0.005	None	0.003	0.003	0.003	0.494
Cobalt	8.2 m	0.05	None	0.03	0.03	0.03	0.025
Copper	3.87 m	0.02	None	0.01	0.01	0.01	0.01
Cyanide	0.005[i]	0.01	None	0.005	0.005	0.005	0.005
Nickel	10.1 m	0.04	None	0.02	0.02	0.02	0.035
Sulphide	0.05[i]	0.1	None	0.05	0.05	0.05	0.002
Thallium	0.03	0.1	None	0.05	0.05	0.05	0.005
Tin	j	0.005	None	0.003	0.003	0.003	j
Vanadium	0.51 m	0.01	None	0.01	0.007	0.01	0.01
Zinc	17.9 m	0.005	None	0.013	0.004	0.013	0.02

[a]All units are mg/l unless noted otherwise.
[b]Hazardous constituents from Table I and Appendix I, 40 CFR 192 and Appendix IX, 40 CFR 264.
[c]Source concentration is median or mean value when noted by "m" next to value of 1990 pore water quality data.
[d]Monitor wells 609, 610, 611, 626, 629, 630, 631, 632, 634, 635, 638, 640, and 802.
[e]Proposed concentration limit is higher of MCL or statistical maximum background.
[f]Resultant concentration after mixing background water with the seepage from the tailings pile. Geochemical attenuation of vadose zone geologic material taken into account. Assumes tailings placed at optimum moisture content and a flux of 2×10^{-9} cm/s. POC is the point of compliance.
[g]Units are pCi/l. Gross alpha is net gross alpha (gross alpha minus dissolved uranium).
[h]Source concentration is mean value from 1990 tailings batch leach test results.
[i]Source concentration is statistical mean value from 1990 tailings batch leach test results.
[j]Not analyzed for.
[k]Unattenuated value. Uranium and radium are major contributors to gross alpha. Neither of these two elements are a problem, therefore, gross alpha will not be a problem.

the laboratory column leach experiments to determine attenuation of hazardous constituents by the samples of the foundation soils. In summary, the results of the tests show:

- o The pH of the feed solution was quickly neutralized (and became slightly alkaline).

- o The hazardous constituents and elements in compounds listed in Appendix I of 40 CFR 192 present in the feed solution (representative of the tailings pore fluid) are attenuated by at least 84 percent, and in many cases completely (100 percent).

The cumulative outflow of tailings fluids from the base of the disposal cell is estimated to be 190 cm after 1000 years (see Section 3.2.2). Approximately 90 cm has been estimated to drain after 200 years. This cumulative drainage represents only a fraction of one pore volume of disposal cell tailings fluids. Results of the laboratory column tests show that hazardous constituents in the representative feed solution were attenuated (as discussed above) in one pore volume. Therefore, the foundation soils have the capacity to attenuate geochemically all of the tailings pore fluids that would drain under transient and steady state conditions from the Landfill disposal site.

3.2.2 Storage of tailings seepage in the unsaturated zone

Conceptually, following completion of the remedial action, moisture within the disposal cell will re-distribute to reach equilibrium and some moisture will drain out of the bottom of the cell. Unsaturated and saturated hydraulic properties of the disposal cell foundation materials are currently being characterized to assess the potential of the foundation to accept tailings pore water drainage from the cell without creating a perched or saturated condition. Transient drainage modeling, as discussed in Section 2.2.2, shows that the maximum expected flux of tailings pore water from the cell will be 3×10^{-8} cm/s. The saturated hydraulic conductivity of the disposal cell foundation is very likely much greater than the maximum expected transient flux rate, and therefore the foundation soils should not become saturated immediately beneath the cell.

The heterogeneity of the ~~hydrogeologic system beneath~~ the disposal site precludes sophisticated modeling of saturated/unsaturated flow of tailings pore water for any distance below the base of the cell. However, because of the low rate of tailings pore water drainage, the thickness of saturated and unsaturated geologic material between the base of the cell and the uppermost aquifer, and favorable geochemical properties beneath the cell as discussed in Section 3.2.1, there is a high probability that pore water (and contaminants) from the tailings will never reach the uppermost aquifer.

3.2.3 Mixing and dilution

In the unlikely event that tailings seepage reaches the uppermost aquifer in less than 1000 years or for the design life of the disposal cell, the resultant concentrations of the hazardous constituents identified in the Gunnison tailings will be below the proposed background concentrations and MCLs at the POC in the uppermost aquifer as shown in Table 3.2.

Solute transport modeling was conducted to predict resultant concentrations of the hazardous constituents (Calculation GUN-06-90-15-03-00). The following conservative assumptions were made in the modeling:

- Dilutive effects of the perched groundwater system beneath the disposal cell (see Section 3.2.3 of Attachment 3) were not considered.

- Input concentrations to groundwater underflow in the uppermost aquifer were derived from laboratory column leach testing. The results of the laboratory testing reflect concentrations after attenuation in only one pore volume passing through a 1.3-foot-long column of representative foundation geologic material, whereas approximately 80 feet of material are available to attenuate contaminants between the base of the disposal cell and the uppermost aquifer.

The model was run for a range of possible steady state cover flux rates. Assuming even the most conservative cover flux rate of 1×10^{-8} cm/s, proposed background concentrations and MCLs for the designated hazardous constituents will be met at the POC. The laboratory saturated hydraulic conductivity of the bentonite mat is 2×10^{-9} cm/s, which represents the design flux (assuming a unit hydraulic gradient) of the Gunnison vegetated cover system (DOE, 1989a). In addition, the model input included the transient drainage rates calculated by the UNSAT-2 modeling (see Calcualtion GUN-04-89-02-03-00). See calculation GUN-06-90-15-03-00 for a complete description of the solute transport modeling.

3.2.4 Performance assessment summary

Section 3.2 described and referenced how the DOE proposes to meet background concentrations and MCLs for the designated hazardous constituents at the Landfill site.

In summary, the DOE has demonstrated that there is a high probability that any tailings pore water that may drain from the base of the disposal cell will be geochemically attenuated in the vadose zone. Additionally, tailings pore water will be stored in the foundation soils as unsaturated flow, and may never reach the uppermost aquifer. Admittedly, because of the complex stratigraphy beneath the disposal site, no analysis can demonstrate conclusively that tailings pore water will not reach the uppermost aquifer before the 200-year mandated minimum design life of the disposal cell. Therefore, the DOE has also demonstrated that background concentrations and MCLs can be met at the POC by a conservative mixing and dilution analysis using a solute transport model.

3.3 CLOSURE PERFORMANCE ASSESSMENT

The DOE has demonstrated that the proposed remedial action plan at the disposal site will comply with Subpart A (40 CFR 192) of the proposed EPA groundwater protection standards by meeting MCLs or background concentrations at the POC. The DOE has assessed the performance of the designed disposal cell at the Landfill disposal site in conjunction with the hydrogeologic system, and has shown that the disposal cell will minimize and control the release of hazardous constituents to groundwater and surface water and radon emanations to the atmosphere to the extent necessary to protect human health and the environment (40 CFR 192.02(a)(4)).

Natural, stable materials have been proposed for use in the construction of the disposal cell so that long-term performance is ensured (see Section 2.2.2). The DOE has also demonstrated that the design features necessary for compliance with the groundwater protection standards minimize the need for further maintenance of the disposal site.

3.4 GROUNDWATER MONITORING PROGRAM

Pursuant to 40 CFR 192.02(a)(4)(b), this section addresses a groundwater monitoring plan to be carried out during and after the remedial action period, which will be adequate to demonstrate that initial performance of the disposal cell is in accordance with the design requirements. A detailed groundwater monitoring program will be provided in the surveillance and maintenance plan for the disposal site.

A program to monitor groundwater in the uppermost aquifer (lower Tertiary gravels) downgradient from the disposal cell will consist of analyzing groundwater samples from a series of monitor wells downgradient from the disposal cell at the POC. Existing DOE monitor wells will be retained for future groundwater monitoring. Background groundwater quality will also continue to be monitored upgradient from the disposal cell. Existing monitor wells will be used where applicable, and new monitor wells will be installed as necessary. The proposed monitor well network is shown in Figure 2.1.

Performance monitoring frequency is outlined in the surveillance and maintenance guidance document (DOE, 1986). Compliance monitor wells will be sampled twice during the construction period, quarterly during the first two years following completion of remedial action activities, semiannually during years three through six, and annually thereafter until the end of the performance monitoring period. The constituents to be monitored include designated hazardous constituents (see Table 3.2), major anions and cations, and the standard suite of field parameters.

The definition of an excursion for the designated hazardous constituents at the disposal site will be based on the exceedance of the MCLs or statistical maximums in background groundwater in the lower Tertiary gravels. Potential excursions will be discussed in detail in the surveillance and maintenance plan. A natural variability is associated with proposed concentration limits for the designated hazardous constituents at the disposal site. This natural variability must be considered when defining excursions, and the proposed concentration limits should be reviewed and updated (if required) annually to incorporate additional background water quality data. This approach is consistent with the surveillance and maintenance guidance document (DOE, 1986).

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 cell monitoring program indicates that the 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 detecting an excursion.

The Landfill 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. It is not anticipated that the designed disposal cell at the Landfill site will fail, because all natural materials will be utilized, and because the radon barrier will be adequately protected from disruption.

4.0 CLEANUP AND CONTROL OF EXISTING CONTAMINATION

The DOE is responsible for demonstrating that cleanup or control of existing processing-related groundwater contamination at the Gunnison site will comply with the proposed EPA groundwater protection standards in Subpart B of 40 CFR 192.

The present level of site characterization is sufficient to address only whether the remedial action will comply with the draft final EPA groundwater protection standards. The DOE has decided that aquifer restoration (groundwater cleanup) will be addressed under a separate DOE program and will be part of a separate National Environmental Policy Act process because of the extent of the characterization of residual wastes and a more intensive investigation of unsaturated flow and aquifer properties. A conceptual groundwater restoration strategy must be developed, modeled, and/or tested on benchmark and pilot scales. Realistic concentration limits and a groundwater cleanup standard can be proposed after this has been performed.

Based on the current level of characterization at the Gunnison processing site, cleanup of groundwater in the uppermost aquifer, the alluvial and terrace gravels, will be necessary because concentrations of uranium, a hazardous constituent in groundwater, exceeds the EPA MCL for uranium. Historically, concentrations of uranium in exceedance of the MCL have been found to occur in groundwater samples from domestic and DOE monitor wells more than 2000 feet downgradient of the processing site. Domestic wells and DOE monitor wells off-site but adjacent to the processing site show uranium to exceed the MCL for uranium consistently. This represents a risk to human health and the environment.

The DOE and the the Colorado Department of Health have jointly developed a program for testing water from Gunnison homes potentially affected by groundwater contamination from the Gunnison tailings. The program is designed to determine concentrations of uranium in groundwater tapped by residents near the tailings site. Testing program results will be evaluated to determine whether steps are needed to protect the health of affected residents. A health risk assessment being undertaken by DOE is currently underway and will be completed by July 1990.

While the UMTRA Project has committed to supply an alternate water source to the affected water users, the action levels that define when this supply is provided and when it is to end have yet to be determined. Three action levels may apply in this situation. The first is the standard set by EPA for groundwater compliance at UMTRA Project sites, 30 picocuries per liter (pCi/l) (0.044 mg/l). The second is 20 pCi/l (0.030 mg/l), as determined by a standard EPA health risk assessment for toxicity to children. The third is to supply water if the well is near or within the contaminant plume.

REFERENCES

DOE (U.S. Department of Energy), 1989. Technical Approach Document, Revision II, UMTRA DOE/AL-050425.0002, DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

DOE (U.S. Department of Energy), 1986. Guidance for UMTRA Project Surveillance and Maintenance, UMTRA DOE/AL-350124.0000, DOE UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.