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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
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DISCLAIMER

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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.5.1 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:

- Definition of hydrogeologic characteristics of the environment, including the hydrostratigraphy, aquifer hydraulic parameters, areas of aquifer recharge and discharge, potentiometric surface, and groundwater velocity.
- 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.
- 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.
- Description of water resource use, including availability, current and future use, value, and alternative supplies.
- 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.

- 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.

- 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.

- 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:

- Brown's Wash alluvium beneath the present tailings pile, and alluvial terrace deposits beneath the proposed disposal site (Quaternary age).

- Tununk Shale Member of the Mancos Shale (Cretaceous age).

- Dakota Sandstone (Cretaceous age).

- 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 1.5×10^{-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).

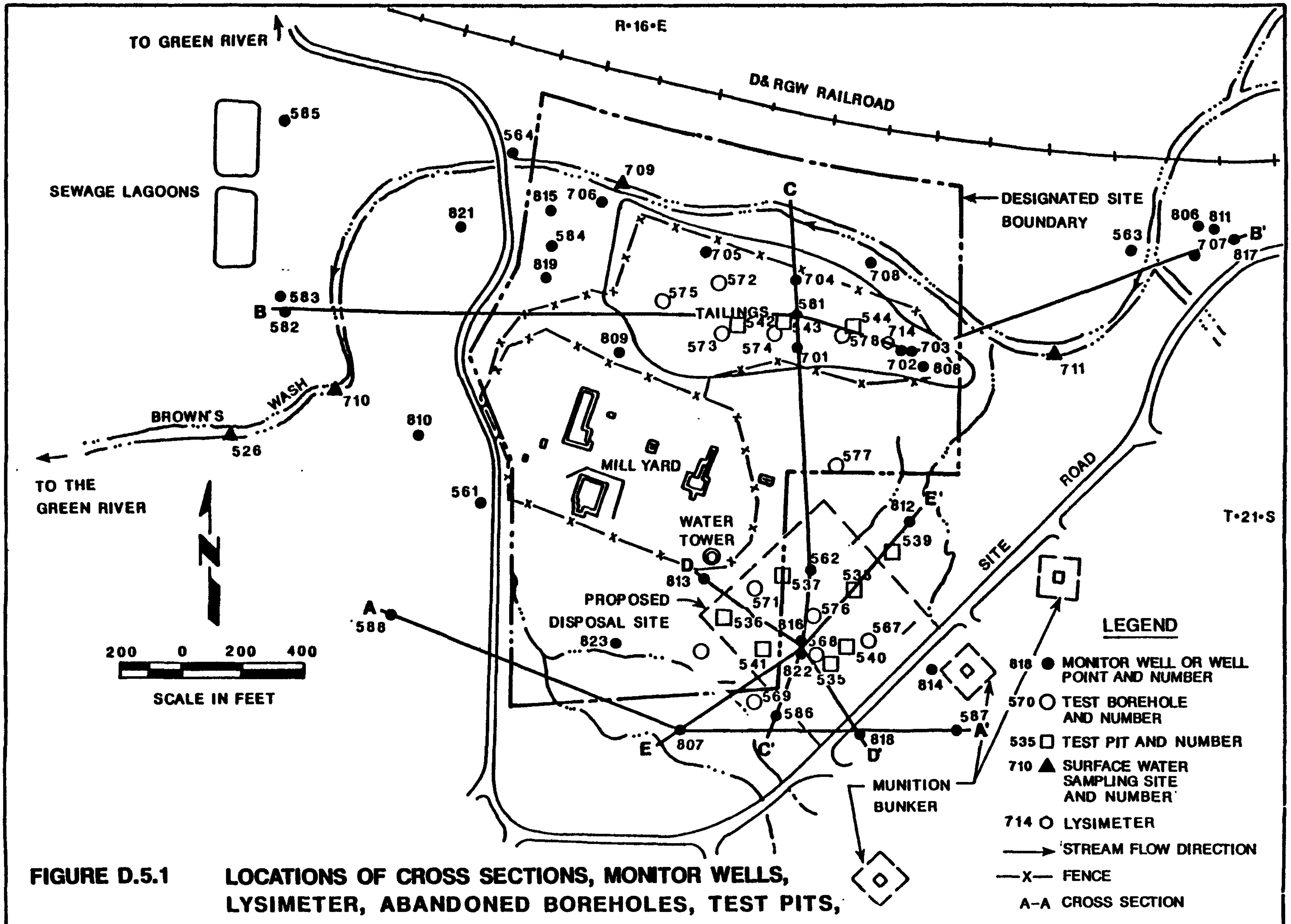


FIGURE D.5.1 LOCATIONS OF CROSS SECTIONS, MONITOR WELLS, LYSIMETER, ABANDONED BOREHOLES, TEST PITS, AND SURFACE WATER SAMPLING SITES, GREEN RIVER, UTAH, TAILINGS SITE

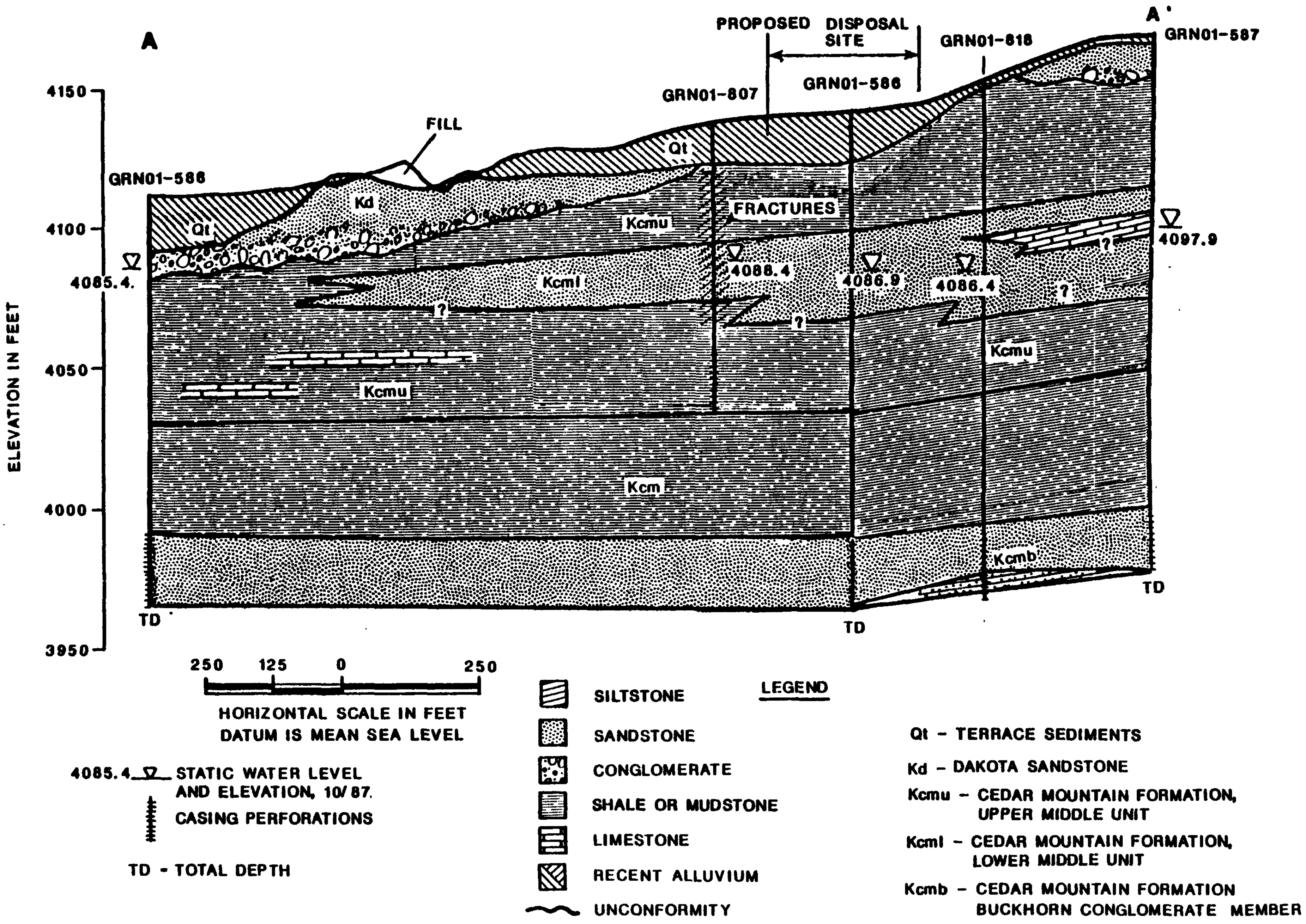


FIGURE D.5.2 HYDROGEOLOGICAL CROSS SECTION A-A', GREEN RIVER, UTAH, TAILINGS SITE

NOTE: VERTICAL EXAGGERATION X 5

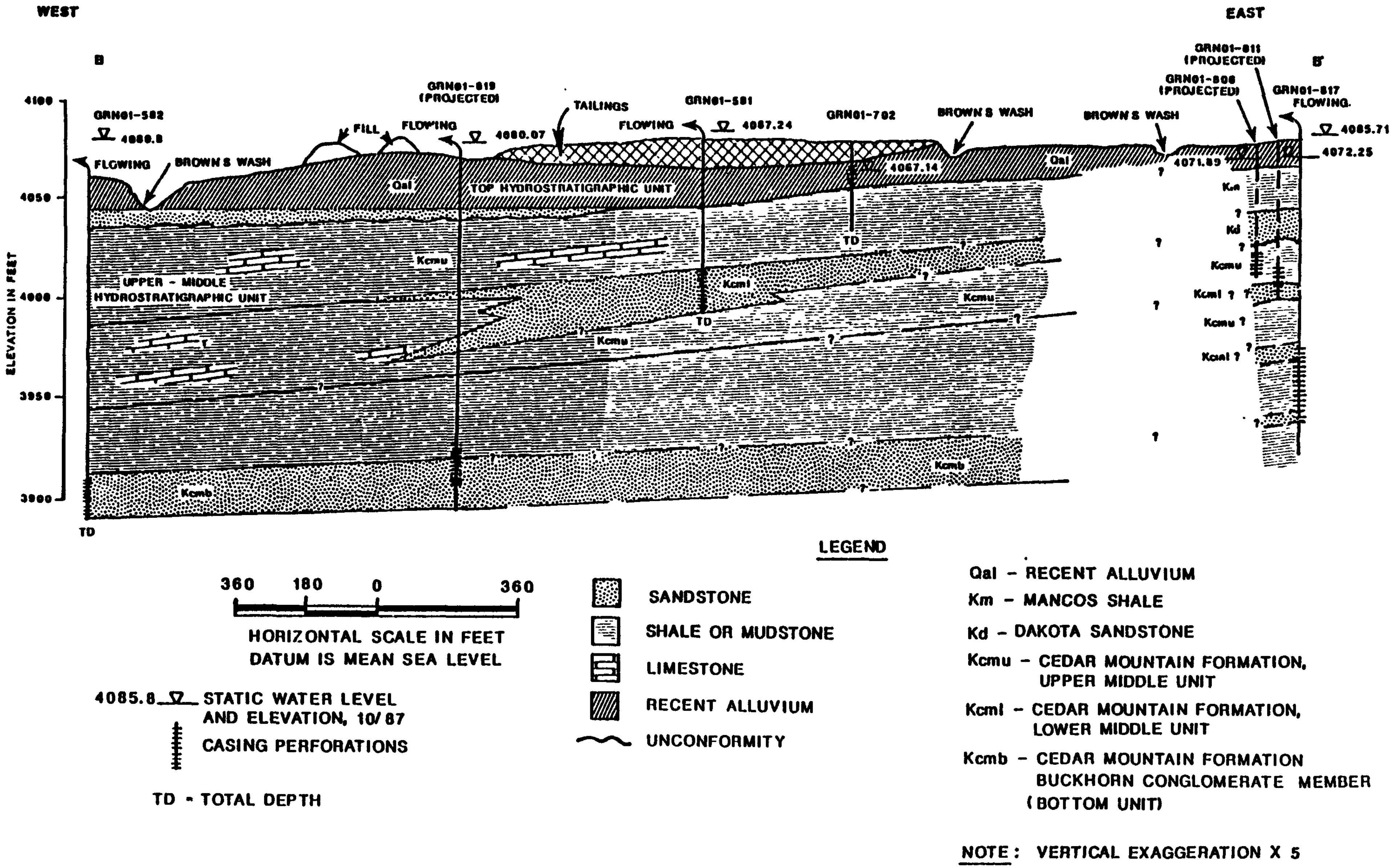


FIGURE D.5.3
HYDROGEOLOGICAL CROSS SECTION B-B'
GREEN RIVER, UTAH, TAILINGS SITE

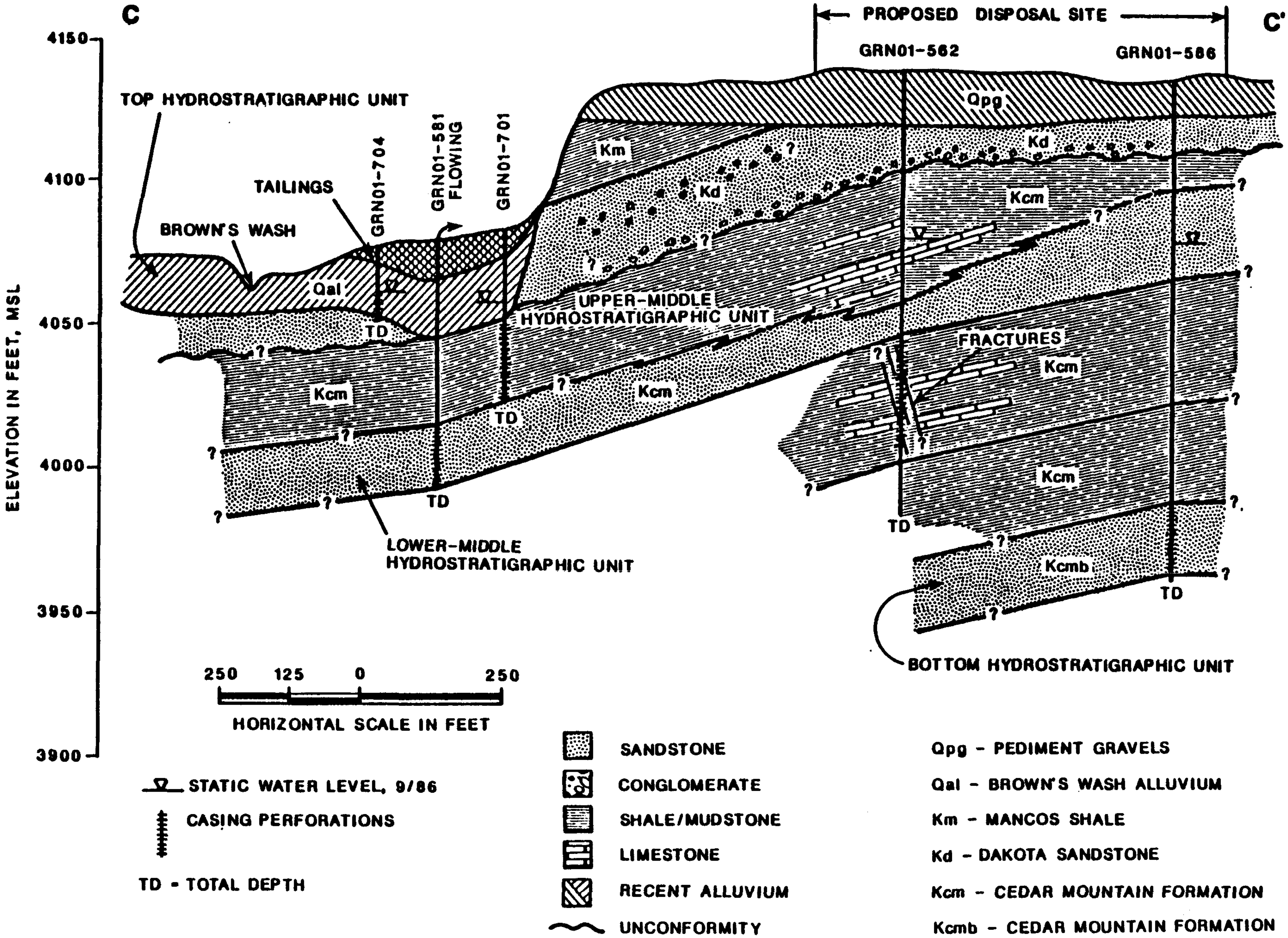
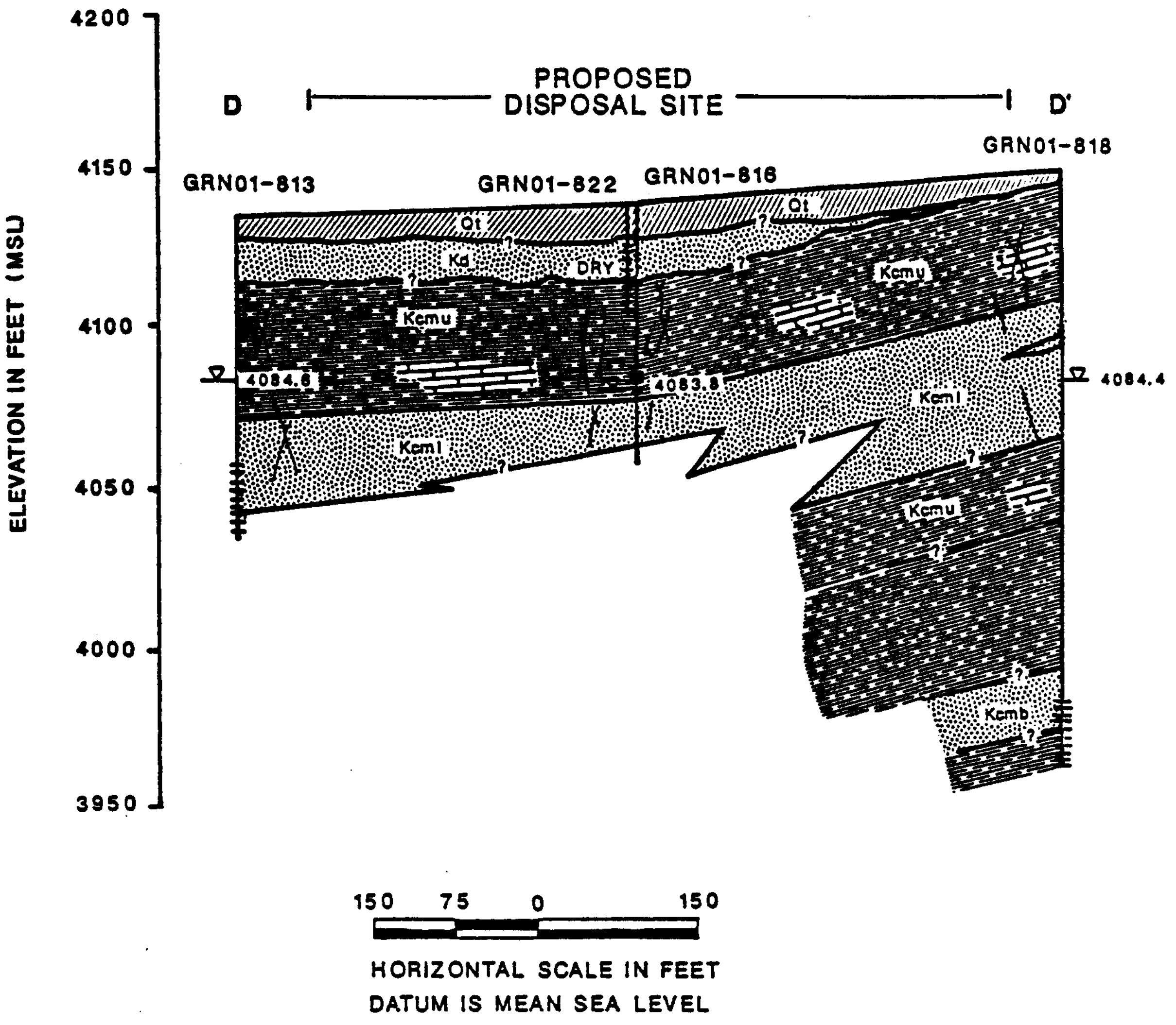


FIGURE D.5.4 HYDROGEOLOGIC CROSS SECTION C-C', GREEN RIVER TAILINGS SITE



LEGEND

▒ SANDSTONE OR SILTSTONE
▓ SHALE OR MUDSTONE
☰ LIMESTONE
▨ RECENT ALLUVIUM
〰 UNCONFORMITY
✗ FRACTURES

Qt - TERRACE SEDIMENTS
Kd - DAKOTA SANDSTONE
Kcmu - CEDAR MOUNTAIN FORMATION, UPPER MIDDLE UNIT
Kcml - CEDAR MOUNTAIN FORMATION, LOWER MIDDLE UNIT
Kcmb - CEDAR MOUNTAIN FORMATION BUCKHORN CONGLOMERATE MEMBER (BOTTOM UNIT)

4084.4 ▽ STATIC WATER LEVEL AND ELEVATION, 10/87
╪ CASING PERFORATIONS
TD - TOTAL DEPTH

NOTE: VERTICAL EXAGGERATION X 3

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

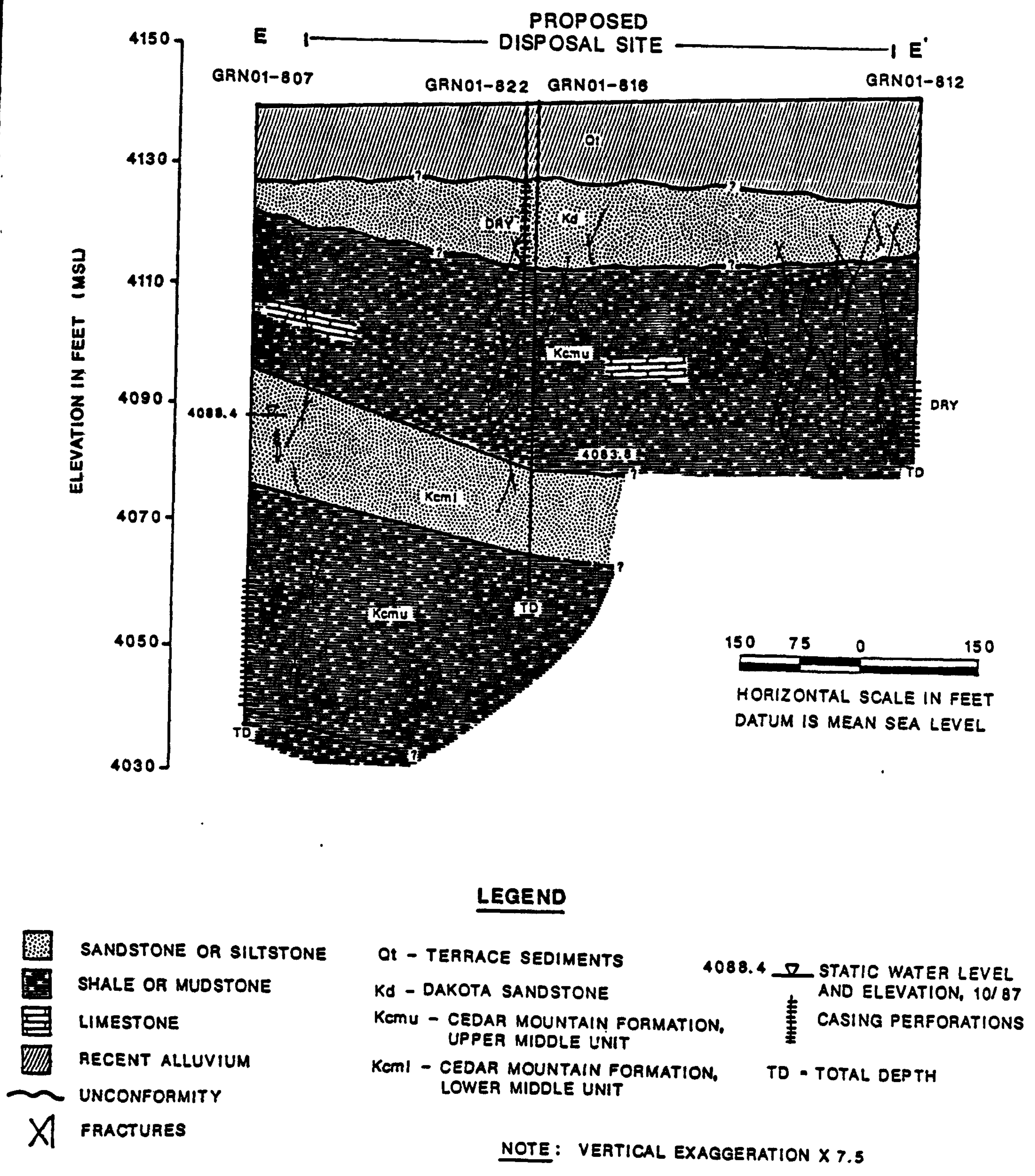


FIGURE D.5.6
HYDROGEOLOGICAL CROSS SECTION E-E'
GREEN RIVER, UTAH, TAILINGS SITE

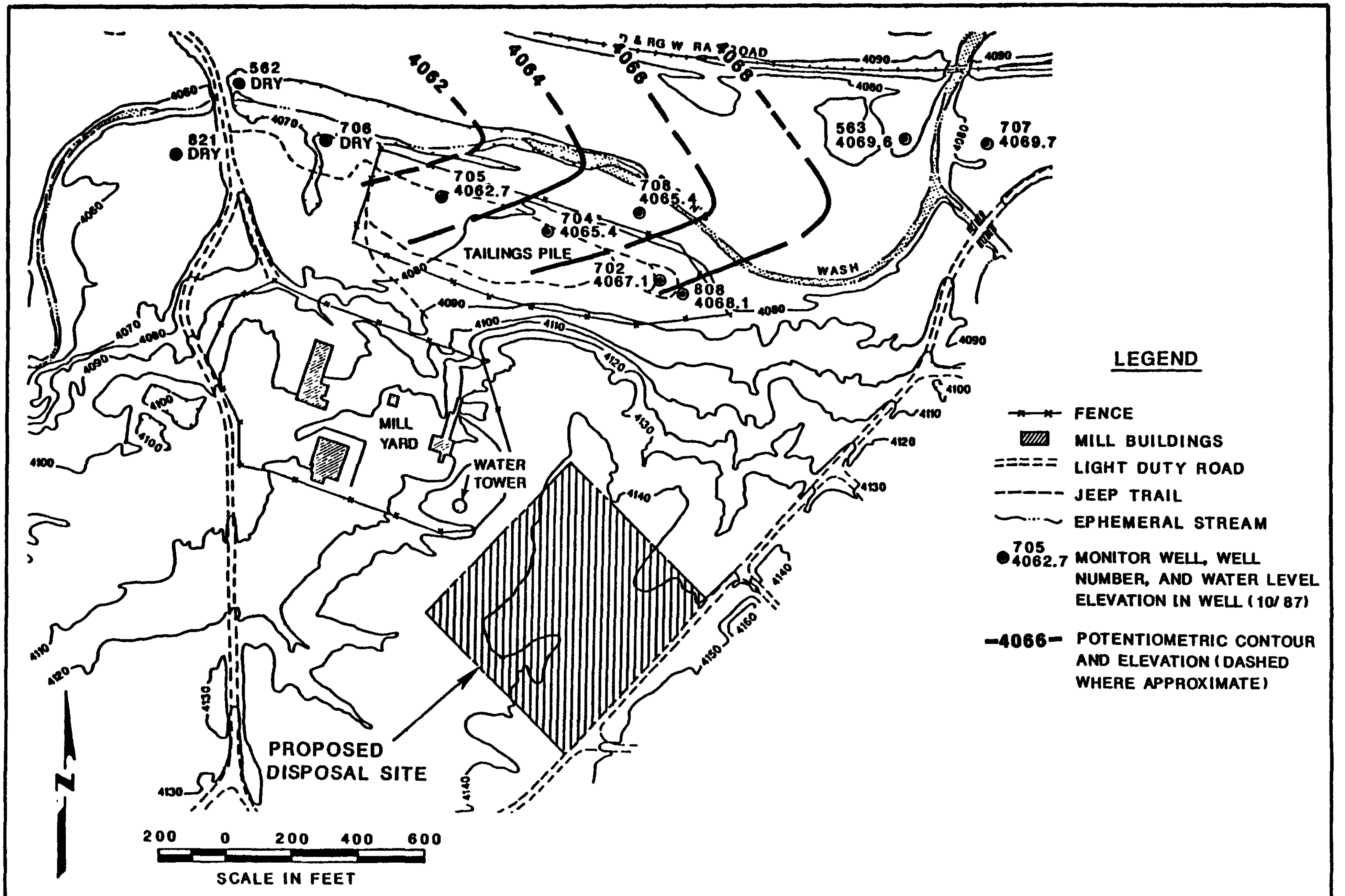


FIGURE D.5.7

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

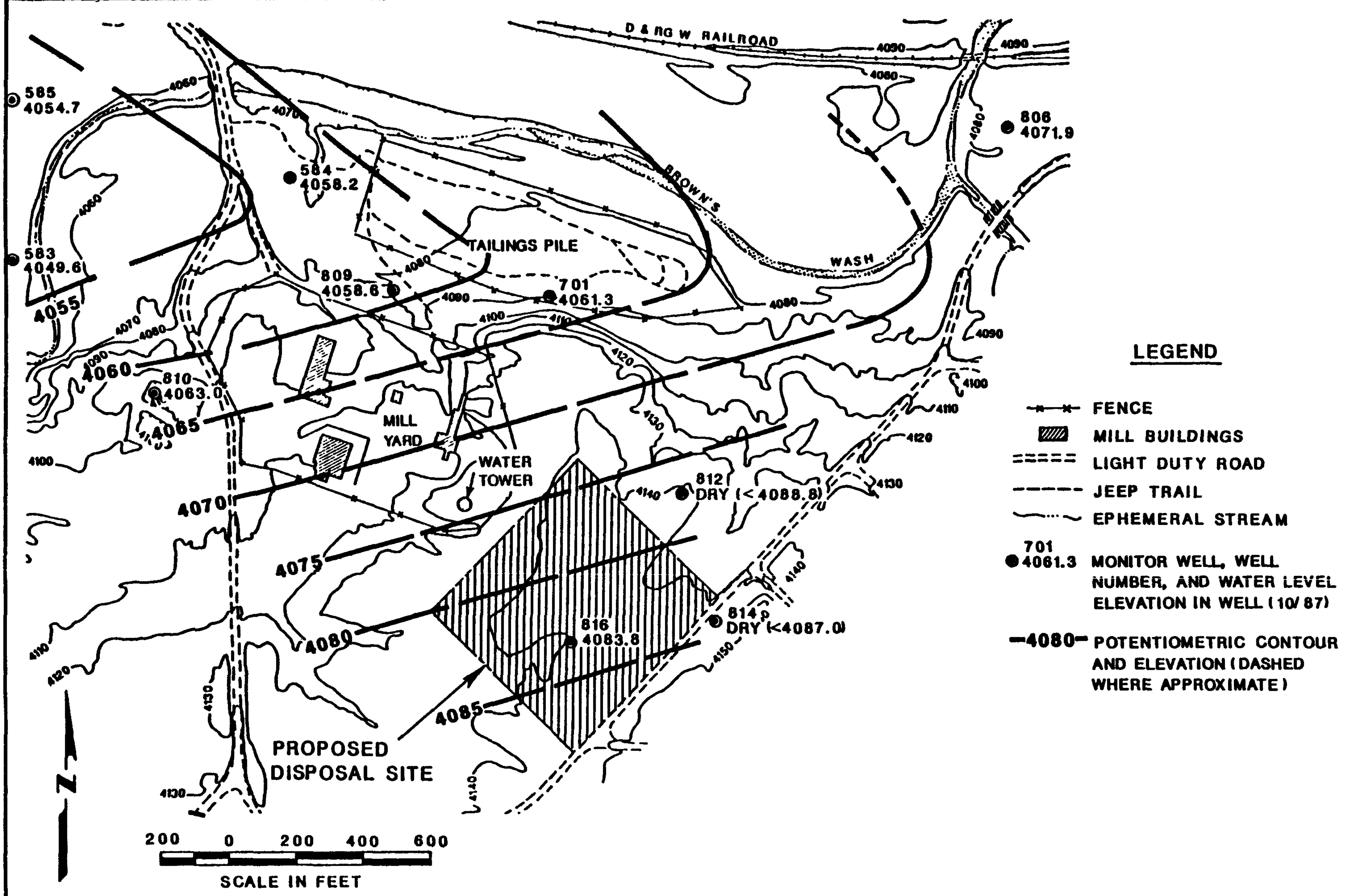


FIGURE D.5.8

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

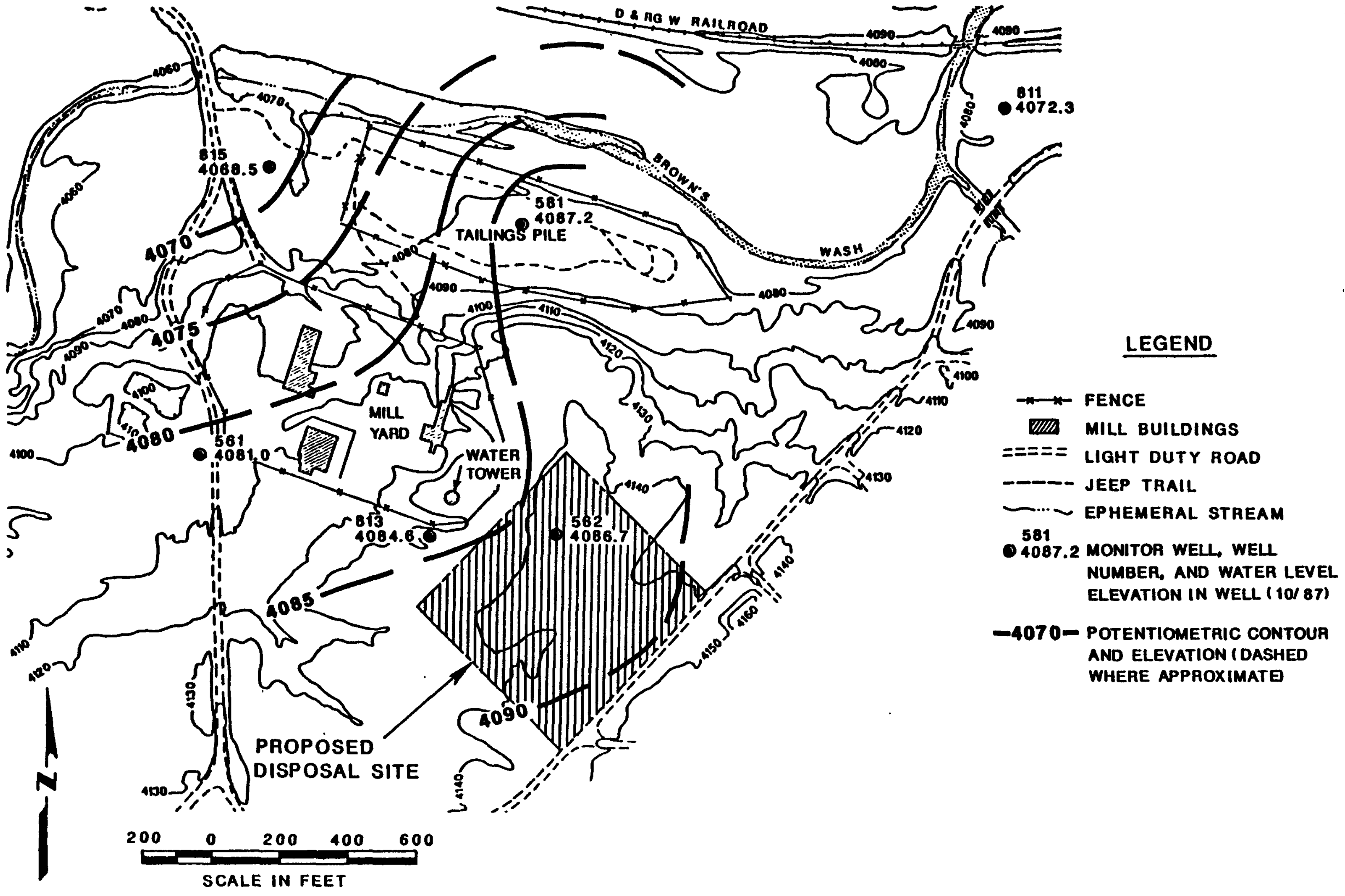


FIGURE D.5.9

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

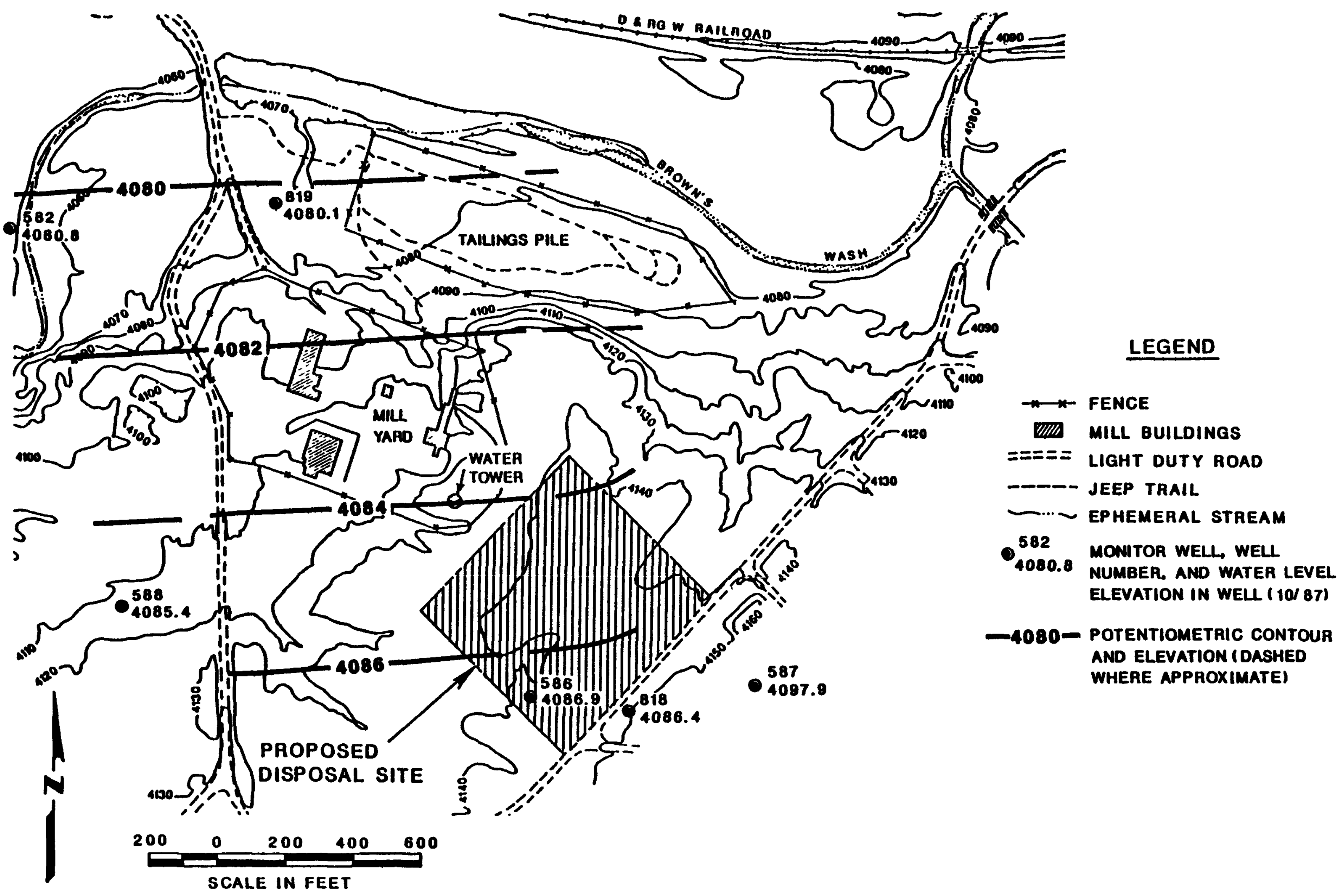
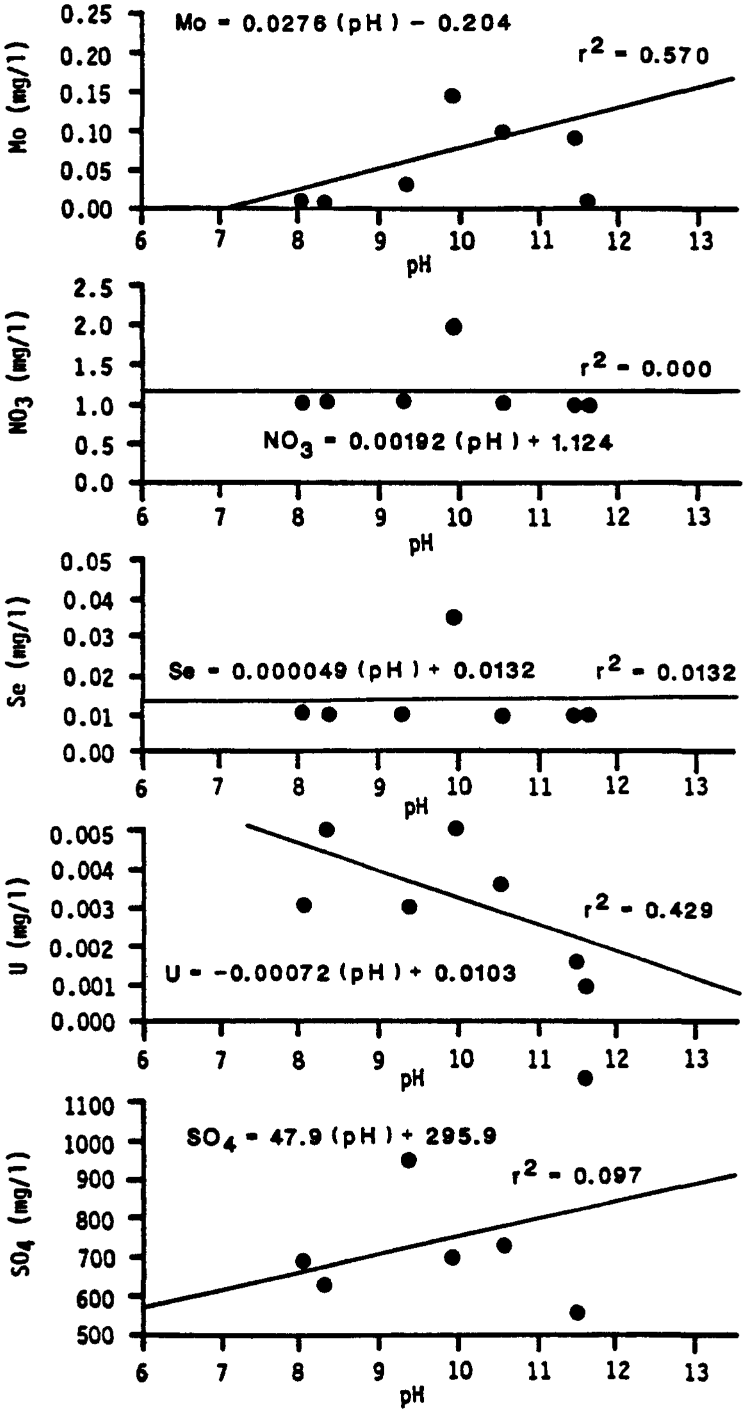


FIGURE D.5.10

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

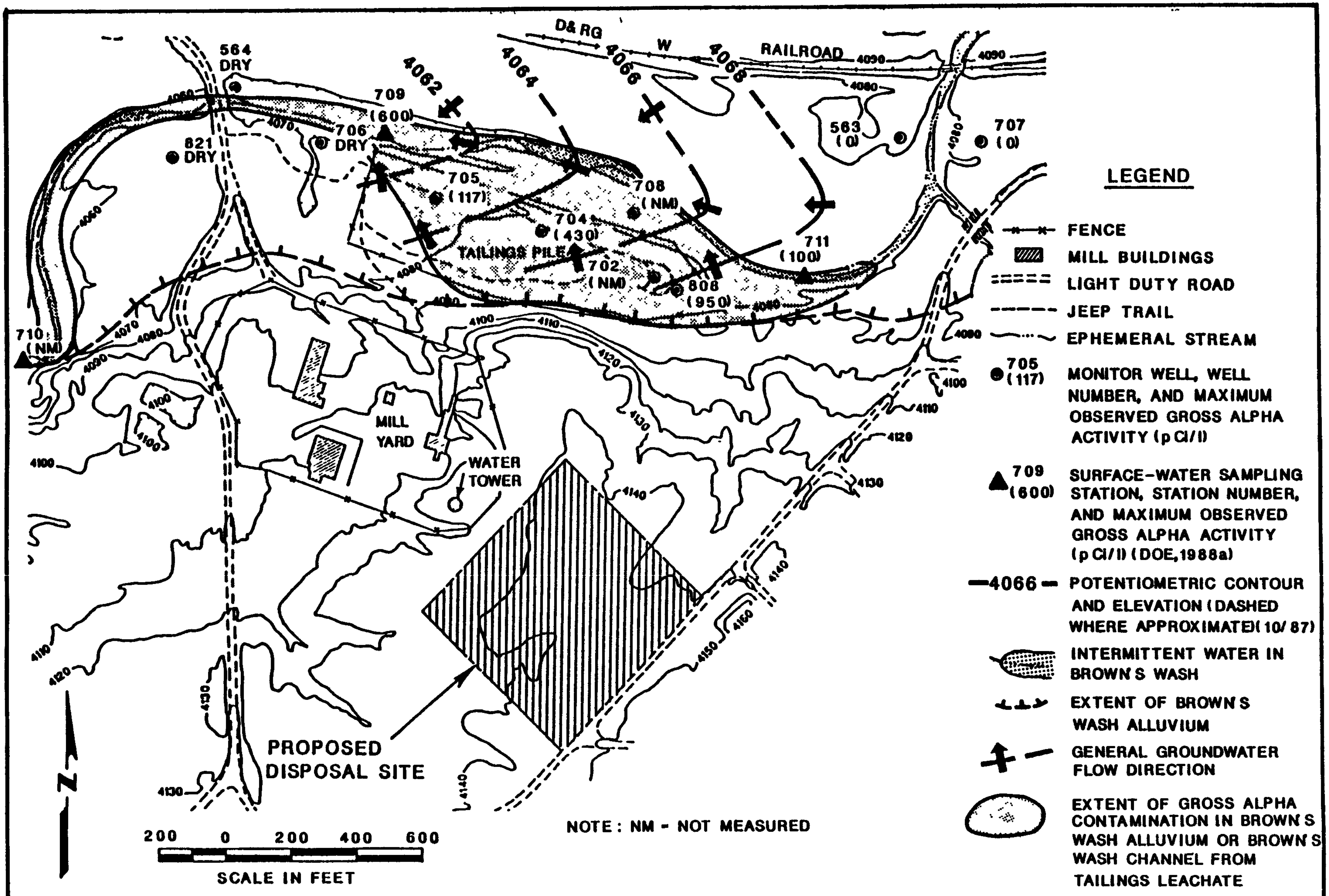


FIGURE D.5.12
MAXIMUM OBSERVED ACTIVITIES AND EXTENT OF GROSS ALPHA CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

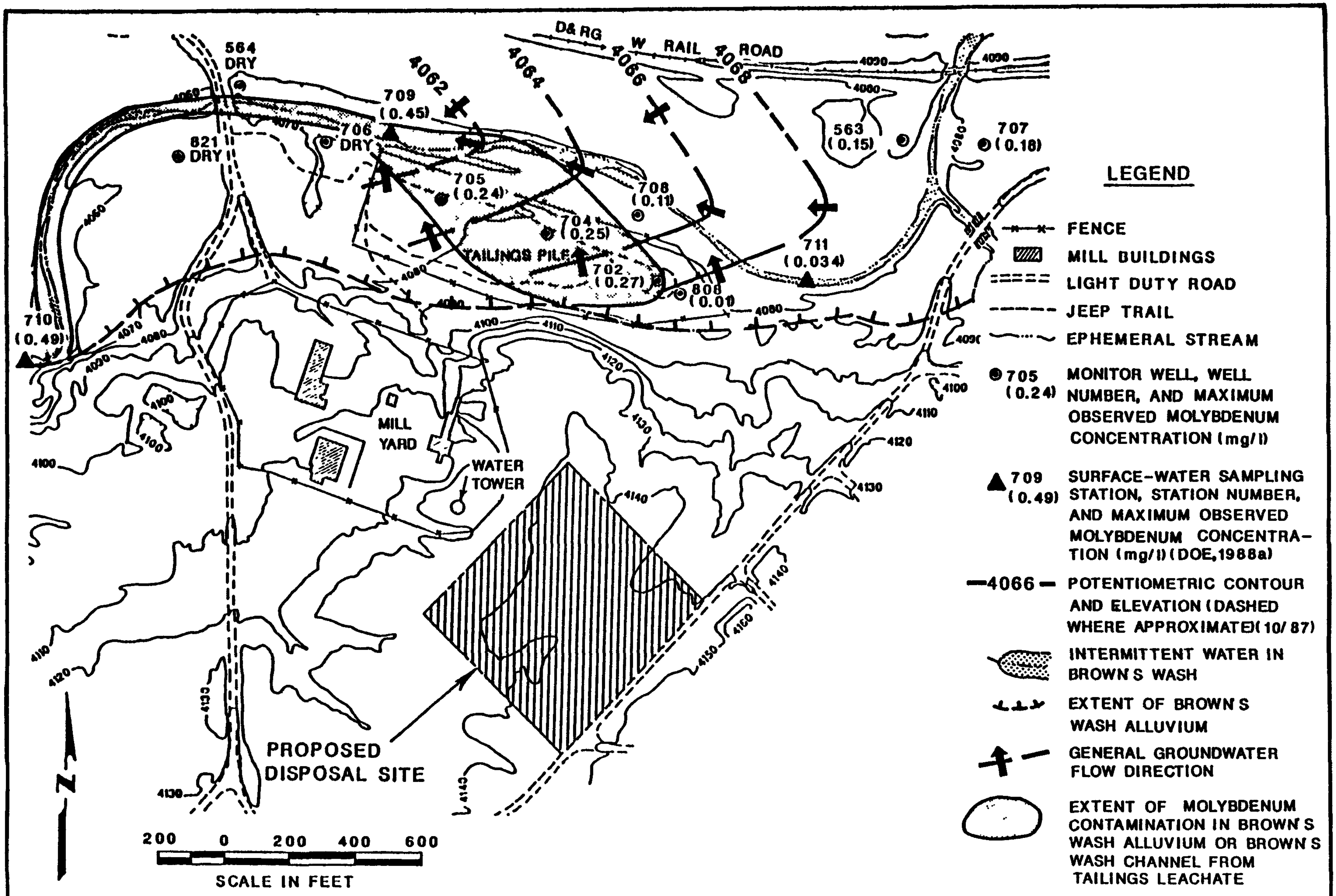


FIGURE D.5.13

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

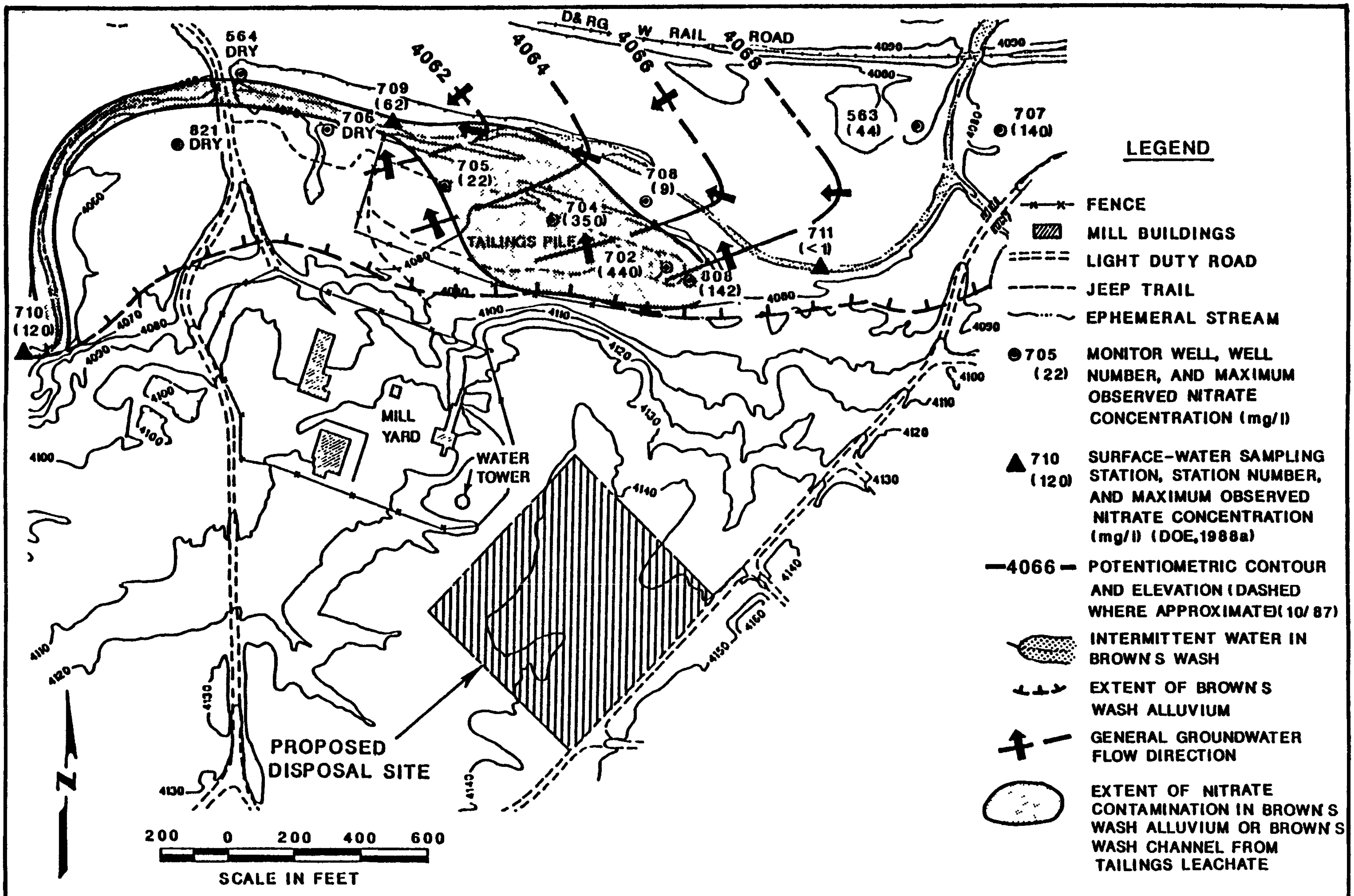


FIGURE D.5.14
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF NITRATE CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

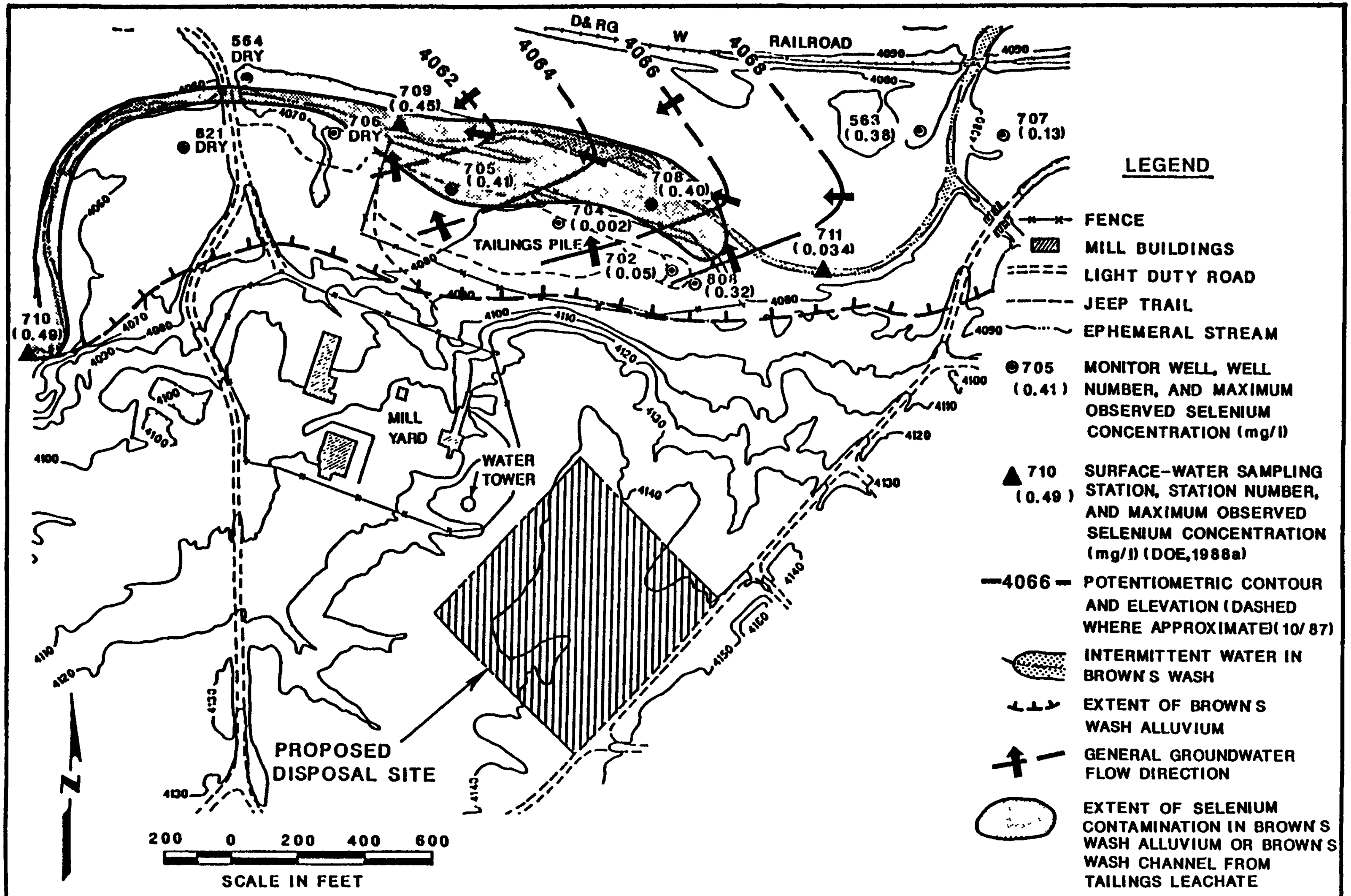


FIGURE D.5.15
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF SELENIUM CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

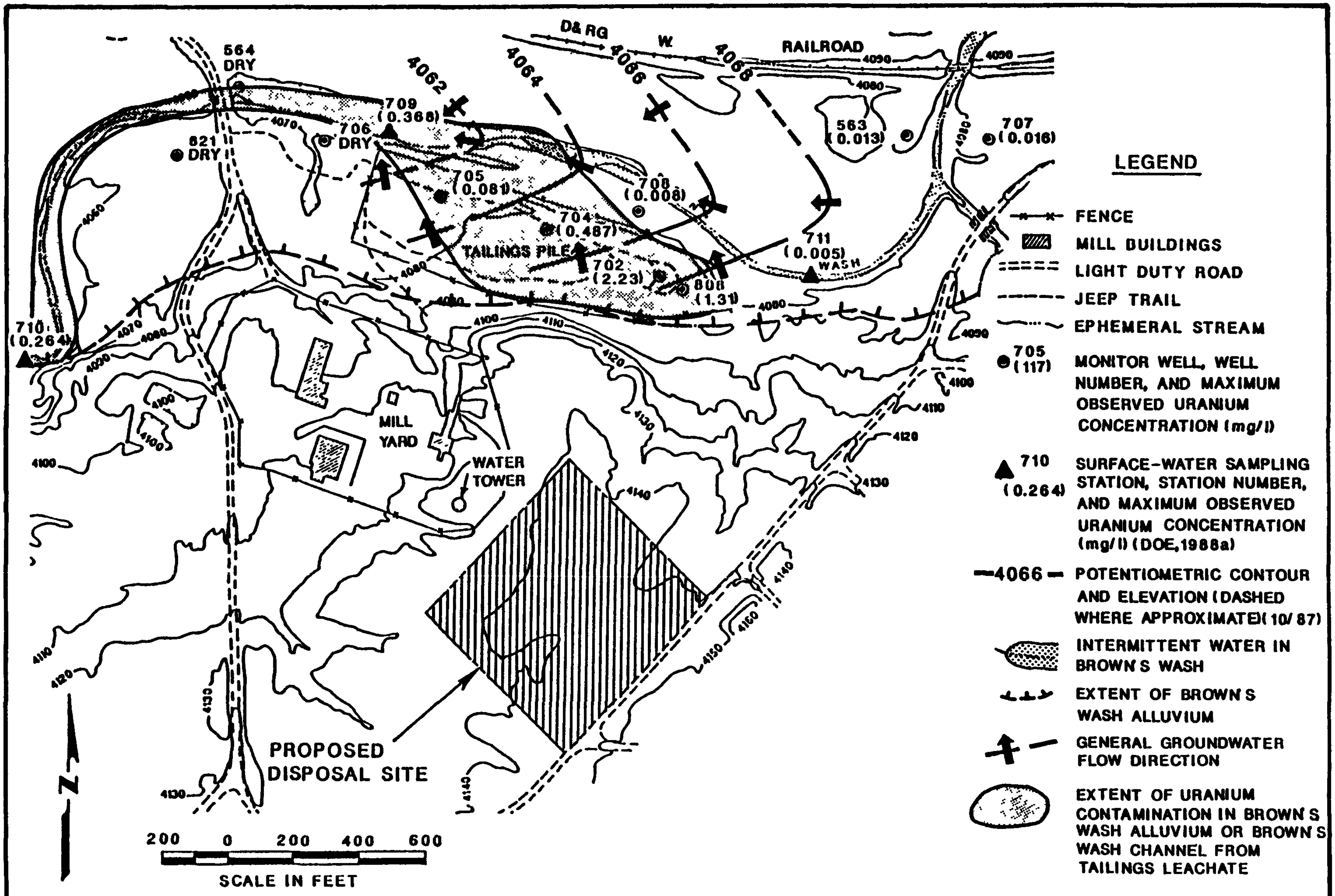


FIGURE D.5.16
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF URANIUM CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

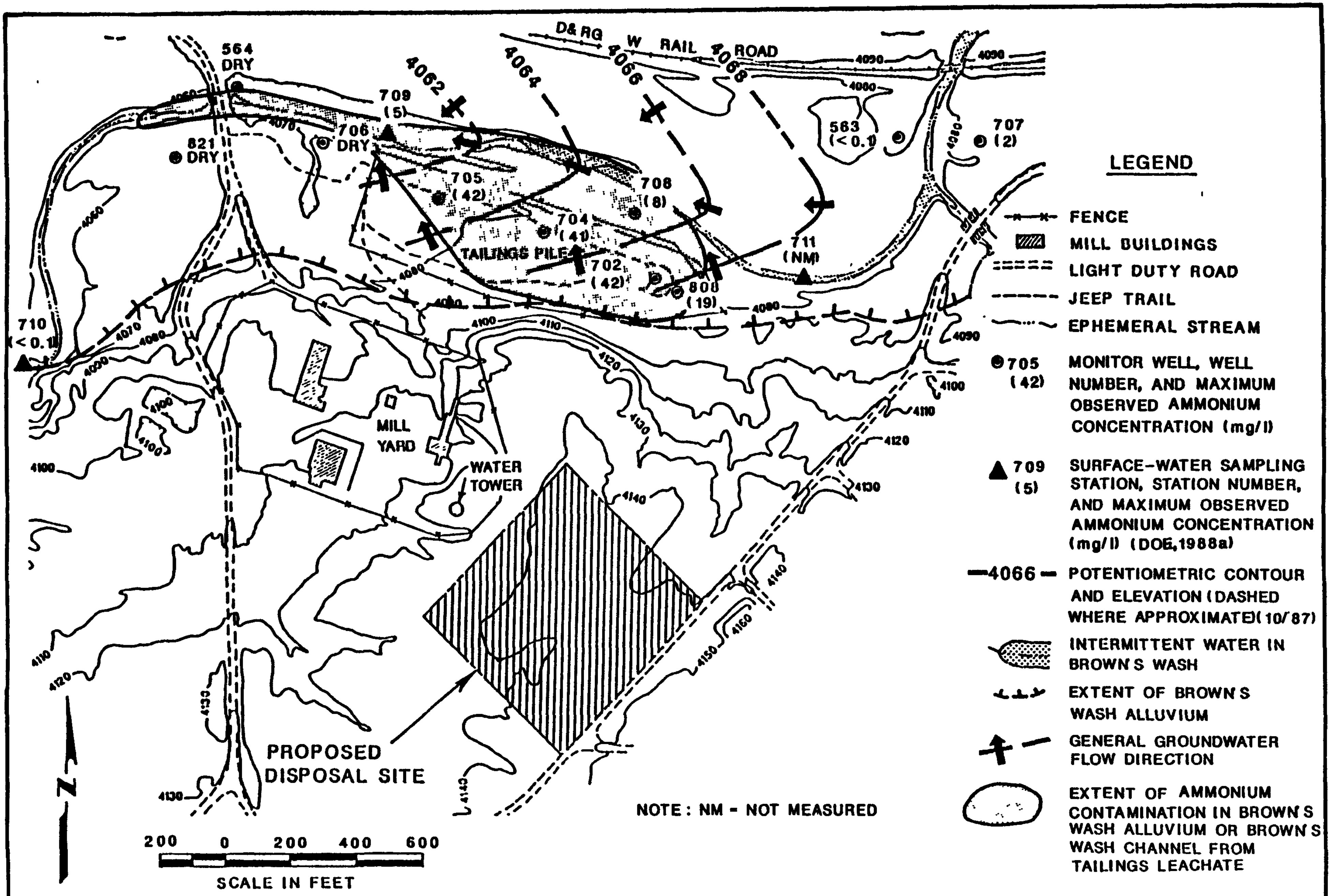


FIGURE D.5.17
MAXIMUM OBSERVED CONCENTRATIONS AND EXTENT OF AMMONIUM CONTAMINATION IN THE TOP HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

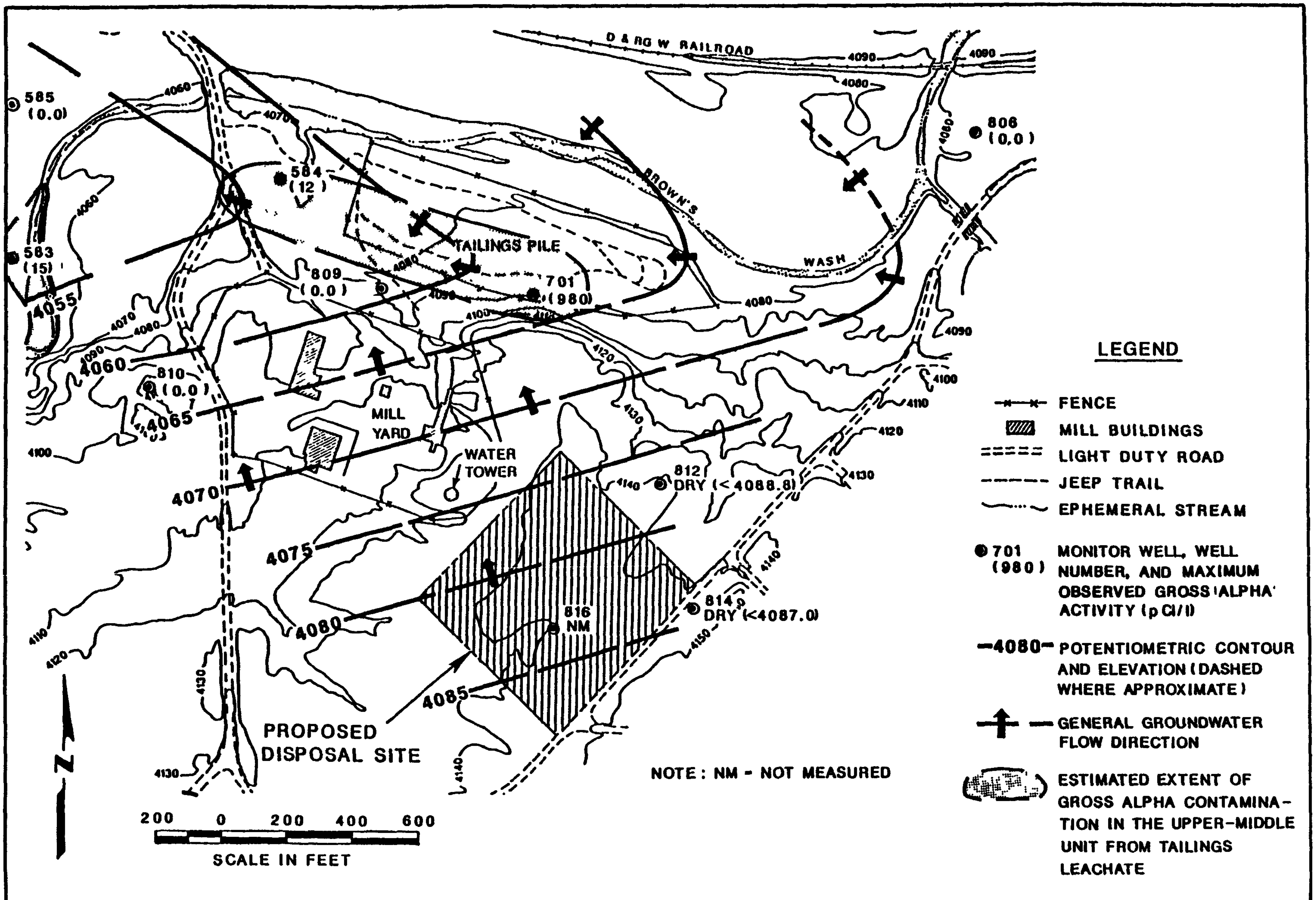


FIGURE D.5.18
MAXIMUM OBSERVED ACTIVITIES AND ESTIMATED EXTENT OF GROSS ALPHA CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

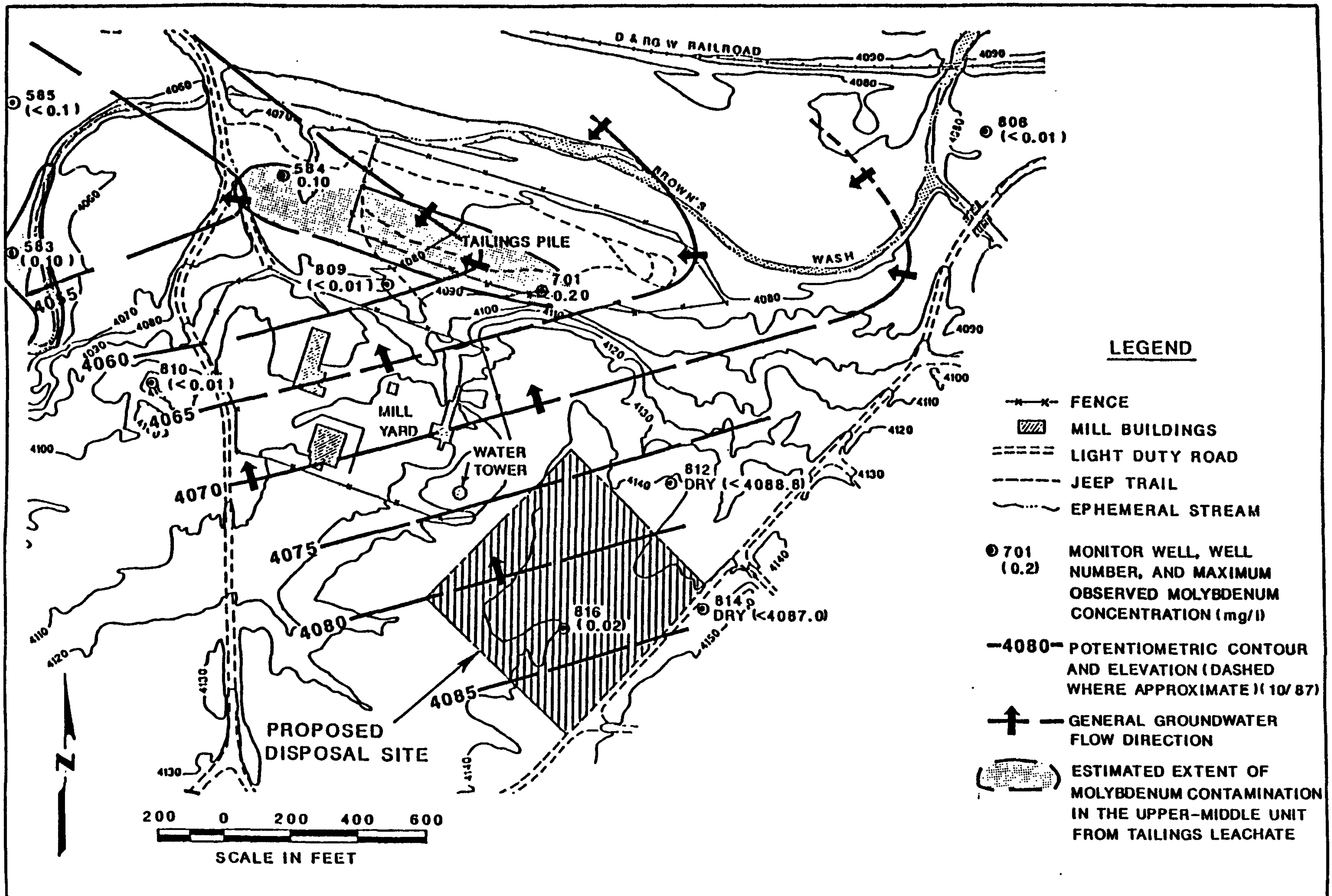


FIGURE D.5.19
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF MOLYBDENUM CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

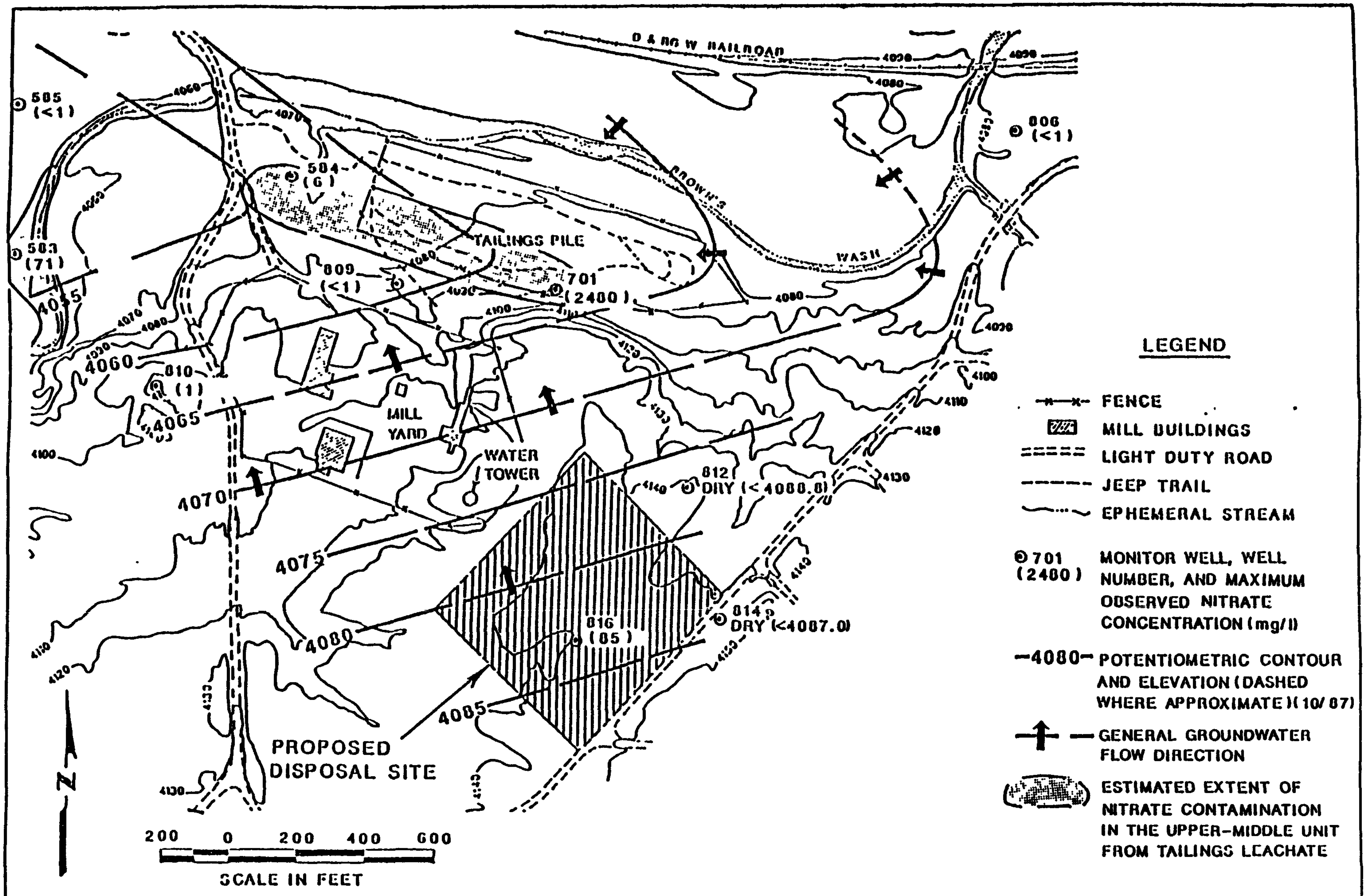


FIGURE D.5.20
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF NITRATE CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

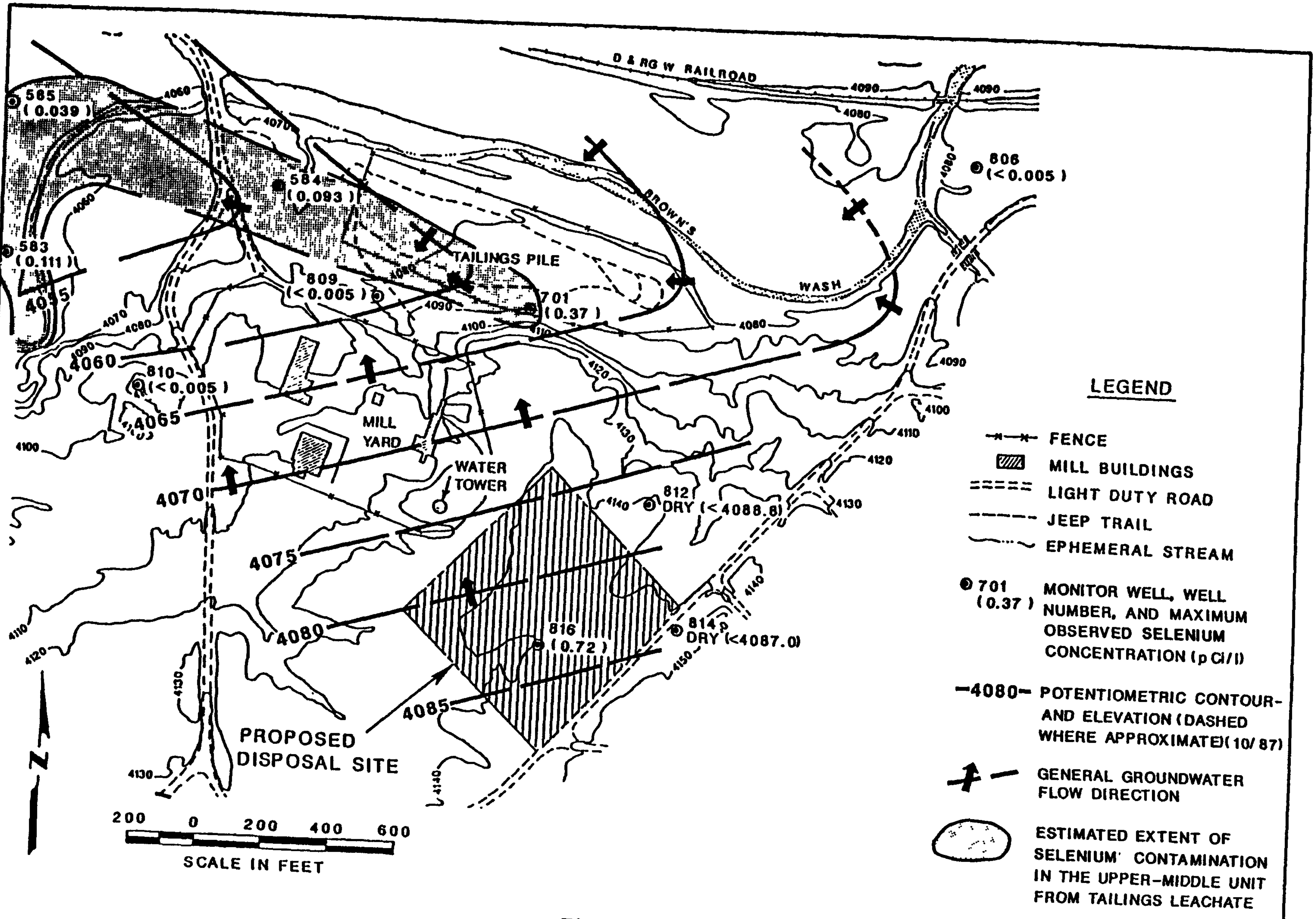


FIGURE D.5.21
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF SELENIUM CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE

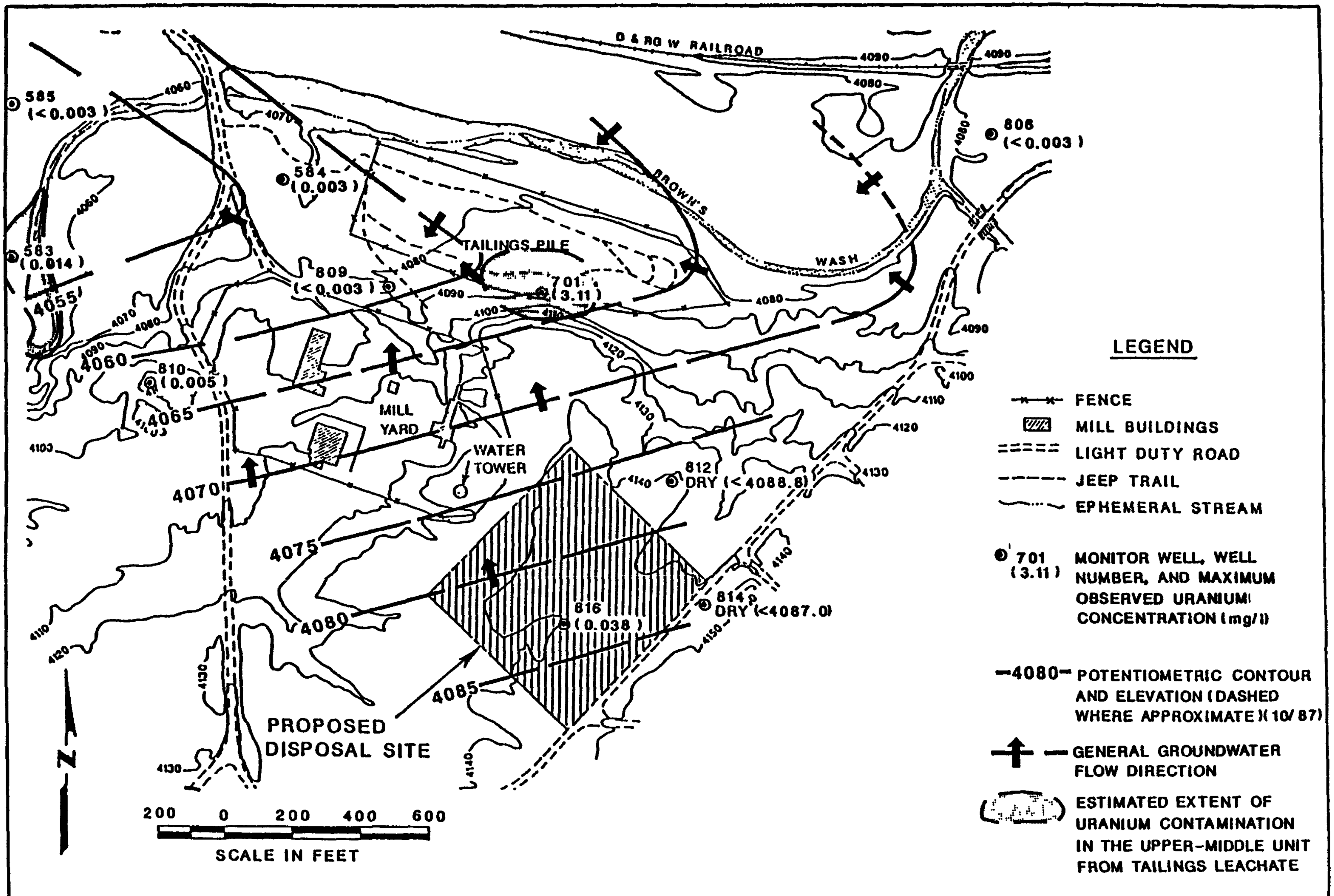
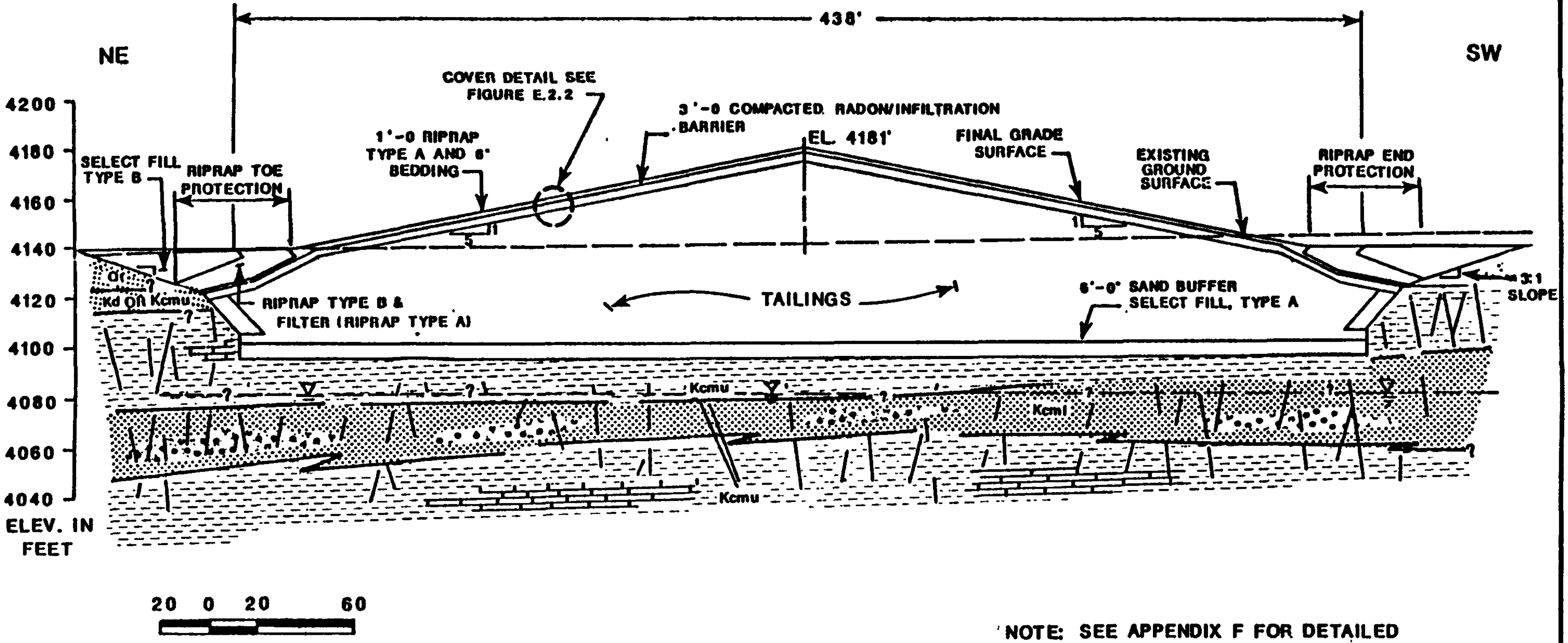


FIGURE D.5.22
MAXIMUM OBSERVED CONCENTRATION AND ESTIMATED EXTENT OF URANIUM CONTAMINATION IN THE UPPER-MIDDLE HYDROSTRATIGRAPHIC UNIT, GREEN RIVER, UTAH, TAILINGS SITE



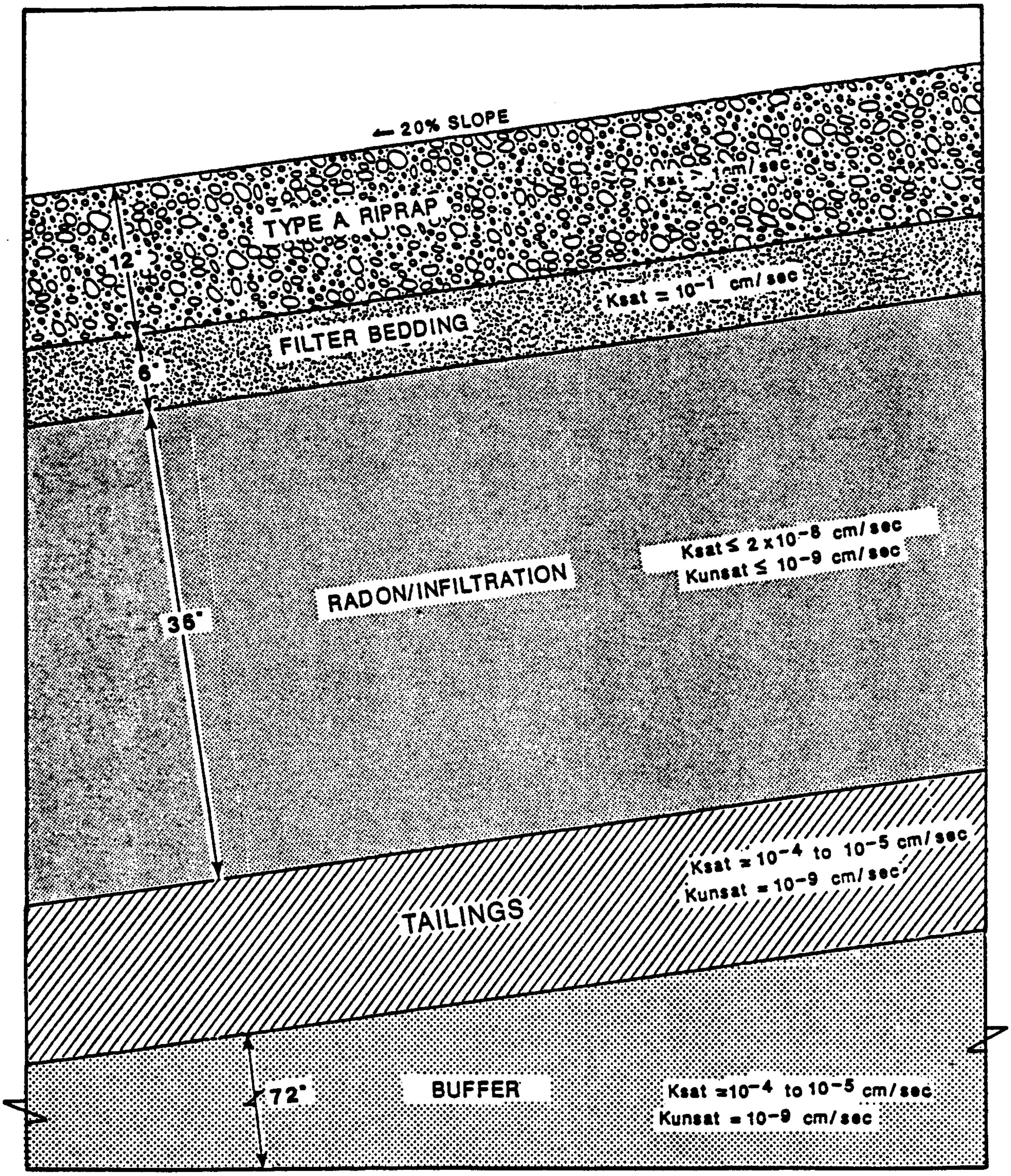
NOTE: SEE APPENDIX F FOR DETAILED PLANS AND SPECIFICATIONS

LEGEND

	FORMATION	MATERIAL	SYMBOL	
Ql	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

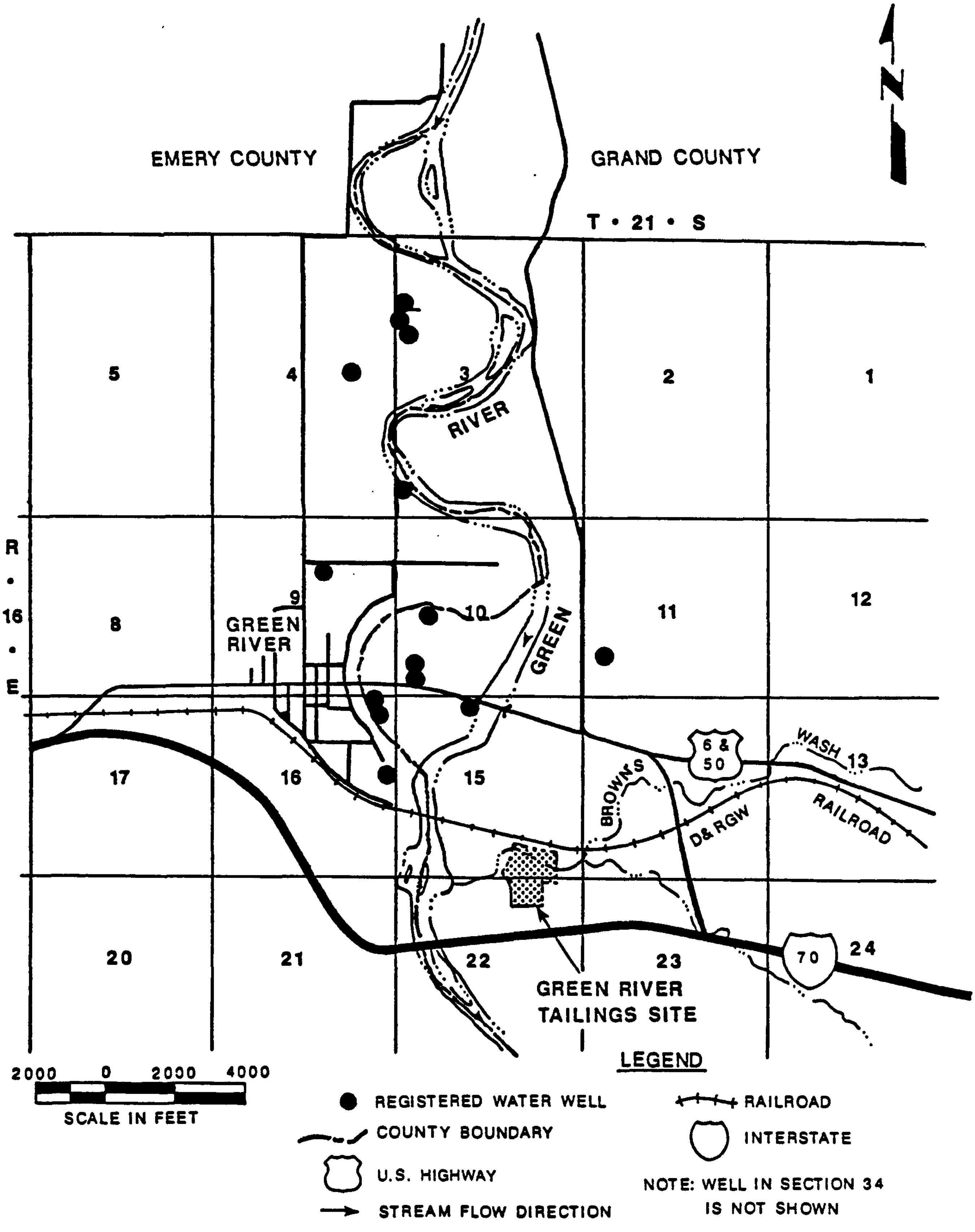


FIGURE D.5.25 LOCATIONS OF REGISTERED WATER WELLS IN TOWNSHIP 21 SOUTH, RANGE 16 EAST, NEAR GREEN RIVER, UTAH

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			Well casing			Screened depth[a] (ft)	Interval length (ft)	Flow relationship
			Elevation (ft)	Depth[a] (ft)	Diameter (in)	Elevation (ft)	Depth[a] (ft)	Diameter (in)			
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	4.0	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	8.0	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

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[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 x 10^{-10}
807	B	80 (Kcmu)	TX	2.4	5.0	153.4	153.4	47.7	100	95.6	2.4 x 10^{-11}
813	A	40 (Kcmu)	TX	7.6	14.9	137.8	120.7	89.7	100	95.7	1.3 x 10^{-9}
813	B	65 (Kcml)	TX	0.8	4.8	149.2	149.2	17.0	100	4.3	7.0 X 10^{-9}
816	A	40 (Kcmu)	TX	8.5	12.6	133.9	125.0	92.6	100	96.4	3.5 x 10^{-9}
816	B	65 (Kcml)	TX	1.6	7.0	141.8	141.8	22.8	100	4.4	2.4 x 10^{-8}
818	A	125 (Kcm)	TX	8.0	14.6	139.2	123.4	90.5	100	95.0	5.0 x 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

		Water elevation[a]			
Well number	Elevation (top of casing)	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[b]	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

[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	113.	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.	271.			
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

PARAMETER	UNIT OF MEASURE	563-01 06/04/86 PARAMETER VALUE+/-UNCERTAINTY		563-01 09/07/86 PARAMETER VALUE+/-UNCERTAINTY		563-01 02/27/87 PARAMETER VALUE+/-UNCERTAINTY		563-01 10/02/87 PARAMETER VALUE+/-UNCERTAINTY			563-01 01/10/88 PARAMETER VALUE+/-UNCERTAINTY		
ALKALINITY	MG/L CACO3		457.		487.		430.		465.			462.	
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.		410.			417.	
CHLORIDE	MG/L		342.		240.		342.		290.			340.	
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		-		-		-		45.	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		0.07	<	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		41.		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		7.50		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	
SILICON	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	0.0121	0.0104	0.0105	0.013	0.0105
VANADIUM	MG/L	0.32	0.22	-	< 0.01	0.07
ZINC	MG/L	0.026	0.131	-	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		< 0.001		< 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	7.10		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.		2000.	
STRONTIUM	MG/L			-		-		7.2		6.3	
SULFATE	MG/L	5030.00		5512.00		6210.00		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	0.046	0.025	0.03	0.0125	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.		440.		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		0.234			
SILICON	MG/L	-		-		-		-			
SILICA	MG/L	-		-		-		-			
SILVER	MG/L	-		-				< 0.01			
SODIUM	MG/L	1920.		1790.		1600.		1830.			
STRONTIUM	MG/L	-		-		-		-			
SULFATE	MG/L	5030.		5700.		5620.		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		93.		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 210	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		0.083		< 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		904.00		798.		800.		800.	
STRONTIUM	MG/L	-						5.5		5.5	
SULFATE	MG/L	3260.00		3005.00		3070.		2980.		2980.	
SULFIDE	MG/L	-		-		-				-	
TEMPERATURE	C - DEGREE	26.00		16.00		15.		20.		20.	
TH 230	PCI/L	< 0.10		< 0.10		-		1.1	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				
		702-01 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
TIN	MG/L	-	-	-	< 0.005	< 0.005
TOTAL SOLIDS	MG/L	4990.00	4870.00	5050.	5090.	5100.
URANIUM	MG/L	0.90	0.70	0.749	1.19	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

		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
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		0.02			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		6.81			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.			2960.			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	1.40	1.46	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	271.		271.		271.		265.		247.	
ALUMINUM	MG/L	0.2		0.2		0.2		< 0.1		0.39	
AMMONIUM	MG/L	19.		18.		19.		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	150.		151.		150.		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.		3100.		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	702-04 10/06/87	702-04 04/12/88
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

PARAMETER	UNIT OF MEASURE	LOCATION ID - SAMPLE ID AND LOG DATE 704-01 07/14/82 PARAMETER VALUE+/-UNCERTAINTY		704-01 06/05/86 PARAMETER VALUE+/-UNCERTAINTY		704-01 09/07/86 PARAMETER VALUE+/-UNCERTAINTY		704-01 03/13/87 PARAMETER VALUE+/-UNCERTAINTY		704-01 01/12/88 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.		534.		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.	60.	-		-		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		0.17	
NICKEL	MG/L	-		-		0.05		-		-	
NITRATE	MG/L	4.00		20.		350.		467.		57.	
NITRITE	MG/L	-		-		< 0.1		-		-	
ORG. CARBON	MG/L	-		404.		70.		-		112.	
PB-210	PCI/L	-		1.	0.9	1.5	1.7	-		-	
PH	SU	7.90		7.46		7.11		7.45		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		13.8	
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	0.042		< 0.005		0.092		< 0.007		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	4500.00		4200.		5290.		5450.		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 07/14/82	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
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	0.444
VANADIUM	MG/L	< 0.05	-	0.24	-	0.07
ZINC	MG/L	-	-	0.025	-	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				
		705-01 07/15/82	705-01 09/16/82	705-01 06/06/86	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
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	-	< 0.001	-
CALCIUM	MG/L	450.00	490.00	456.	483.	413.
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.	316.	315.
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	7.31	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	2100.	2090.	2450.
STRONTIUM	MG/L	-	-	-	6.6	-
SULFATE	MG/L	5410.00	5021.00	5930.	6420.	6590.
SULFIDE	MG/L	-	-	-	-	-
TEMPERATURE	C - DEGREE	18.00	19.00	15.	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 06/06/86	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		0.49		< 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	0.4		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.		401.		400.	
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.	170.	950.	130.
GROSS BETA	PCI/L	76.	57.	93.	33.	26.	40.	310.	56.	450.	88.
IRON	MG/L	< 0.03		0.72		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		0.24		0.09		< 0.01		< 0.01	
NICKEL	MG/L	-		-		-		-		-	
NITRATE	MG/L	11.5		3.5		1.9		137.		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	1.7	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	
SILICON	MG/L	-				-		-		-	
SILICA	MG/L	-				-		-		-	
SILVER	MG/L	-				0.02		-		-	
SODIUM	MG/L	2300.		2540.		1920.		720.		700.	
STRONTIUM	MG/L			-				-		-	
SULFATE	MG/L	5600.		6890.		5950.		3000.		3000.	
SULFIDE	MG/L			-		< 0.1		-		-	
TEMPERATURE	C - DEGREE	16.5		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	10400.	10800.	9230.	4980.	4960.
URANIUM	MG/L	0.081	0.0617	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	540.		460.		490.		460.		452.	
CHLORIDE	MG/L	99.		98.		107.		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.	440.	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		10.2		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	702.		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	4610.	4620.	4610.
URANIUM	MG/L	1.72	1.80	1.69
VANADIUM	MG/L	0.07	0.06	0.06
ZINC	MG/L	0.011	0.012	0.011

MAPPER DATA FILE NAME: GRN01*UDPGW0102183

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 04/11/88	
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	343.00	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	0.40	0.284	
SILCON	MG/L	6.70	-	-	-	-	
SILICA	MG/L	-	-	7.	-	-	
SILVER	MG/L	< 0.01	-	< 0.01	-	-	
SODIUM	MG/L	2275.00	2100.00	1980.	2370.	1760.	
STRONTIUM	MG/L	-	-	0.8	-	-	
SULFATE	MG/L	5409.00	5684.00	6180.	6280.	4800.	
TEMPERATURE	C - DEGREE	21.00	13.00	20.	10.0	8.2	
TH-230	PCI/L	< 0.40	-	-	-	-	
TIN	MG/L	-	-	< 0.005	-	-	
TOTAL SOLIDS	MG/L	8940.00	9190.00	9340.	10400.	7800.	
URANIUM	MG/L	0.027	0.034	0.0080	0.0077	0.0175	

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 11/21/82	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	908.		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	180.		160.		200.		100.		100.	
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.	37.
GROSS BETA	PCI/L	4.5	18.	2.3	9.6	5.	11.	0.0	38.	49.	35.
IRON	MG/L	< 0.03		0.12		< 0.01		< 0.03		0.11	
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.		770.		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.		2500.		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		0.012		< 0.005		< 0.005		0.013	

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	0.013		< 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.		-		81.7			
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	0.122		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		0.046		0.068			

MAPPER DATA FILE NAME : GRN01X00PGW0102191

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	< 0.40	-		-	-	-
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	403.00	-		-	-	-
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	7410.00	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	-	2.2		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	11.5		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	1190.		1170.	1170.	1170.
STRONTIUM	MG/L	-			-	-	-
SULFATE	MG/L	1640.00	3040.		3020.	3020.	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 07/14/82	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
TOTAL SOLIDS	MG/L	6040.00	7110.	7160.	7400.	7420.
URANIUM	MG/L	1.40	3.11	2.94	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 06/06/86			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		
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		510.			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		190.			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			0.01			0.11	
NICKEL	MG/L		-			0.06			-			-			-	
NITRATE	MG/L		1190.			570.			2400.			1120.			1020.	
NITRITE	MG/L		-		<	0.1			-			-			-	
ORG. CARBON	MG/L		-			96.			-			41.			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		-			1.4	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			0.124			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		-			2.0			-			-			-	
SULFATE	MG/L		3030.			3420.			3170.			3100.			3000.	
SULFIDE	MG/L								-			-			-	
TEMPERATURE	C DEGREE		17.			17.0			16.			16.0			14.6	
TH-230	PCI/L					1.2	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 06/06/86	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	7120.	6550.	7070.	6460.	6130.
URANIUM	MG/L	3.05	1.06	1.59	1.71	2.23
VANADIUM	MG/L	-	0.18	-	< 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	0.015				
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	91.				
CHROMIUM	MG/L	0.15				
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	1150.				
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

		LOCATION ID - SAMPLE ID AND LOG DATE
		701-01 05/11/88
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE +/-UNCERTAINTY
TOTAL SOLIDS	MG/L	6680.
URANIUM	MG/L	2.99
VANADIUM	MG/L	0.08
ZINC	MG/L	0.018

MAPPER DATA FILE NAME: GRN01*UDPGWQ102190

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 01/14/88		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	193.		670.		1030.		1270.		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.		218.		186.	
CHLORIDE	MG/L	740.		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	-		-		0.0	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.		112.		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	0.10		< 0.1		< 0.01		0.09		0.05	
NICKEL	MG/L	0.05		-		-		-		-	
NITRATE	MG/L	11.		71.		10.		18.3		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	8.10		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		0.009		0.019		0.104		0.062	
SILICA	MG/L	3.		-		-		-		-	
SILVER	MG/L	< 0.01		-		-		-		< 0.01	
SODIUM	MG/L	1220.		1520.		1690.		1870.		1060.	
STRONTIUM	MG/L	6.5		-		-		-		-	
SULFATE	MG/L	2630.		2580.		2340.		2290.		1440.	
SULFIDE	MG/L			-		-		-		< 0.1	
TEMPERATURE	C - DEGREE	17.5		11.		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.		5810.		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	0.03	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.	15.	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		13.4	
MANGANESE	MG/L	0.02		0.05		0.02		0.03		0.07	
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		2.60		2.7		2.91		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	1080.		1610.		1190.		1580.		1630.	
STRONTIUM	MG/L	3.1						-		3.50	
SULFATE	MG/L	3160.		3150.		3100.		2560.		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	4820.		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 03/11/87	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 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	759.		1007.		930.		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	0.040		< 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		8.57		7.10		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	0.089		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	3140.		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.		5420.		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

		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
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		0.004		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.	11.	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	1980.		1940.		1950.		1930.		1920.	
STRONTIUM	MG/L	-		-		-		-		-	
SULFATE	MG/L	2370.		2300.		2450.		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.		5670.	

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	809-01 10/21/87 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 07/16/88 PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	530.		405.		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		0.012	
BALANCE	%	-		-		-		-		-	
BARIUM	MG/L	-		-		-		-		0.04	
BORON	MG/L	0.5		0.64		0.6		0.59		0.71	
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		3.77		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		0.13		< 0.03		0.32		0.04	
LEAD	MG/L	-		-		-		-		0.01	
MAGNESIUM	MG/L	16.		11.9		1.70		6.94		13.7	
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		8.1		8.3		8.05		8.72	
PHOSPHATE	MG/L	-		-		-		-		-	
PO-210	PCI/L	-		-		-		-		-	
POTASSIUM	MG/L	4.1		3.46		1.25		2.5		3.8	
RA-226	PCI/L	0.6	0.7	0.2	0.2	0.1	0.7	0.2	0.7	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.		5100.		2710.		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

		LOCATION ID - SAMPLE ID AND LOG DATE									
		809-01 10/23/87		809-01 01/07/88		810-01 10/26/87		810-01 01/07/88		810-01 07/16/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
URANIUM	MG/L	<	0.003		0.0014		0.005		0.004		0.0012
VANADIUM	MG/L	<	0.01		0.01	<	0.01	<	0.01	<	0.01
ZINC	MG/L	<	0.005		0.009	<	0.005		0.127		0.013

MAPPER DATA FILE NAME: GRN01*UDPGW102109

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	8.41	8.83	8.83	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	4740.	4830.	4830.	4830.	4830.
STRONTIUM	MG/L	10.8	11.2	11.2	11.2	11.2
SULFATE	MG/L	4330.	4460.	4460.	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	0.0211	0.0254	0.0134	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 05/12/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY	PARAMETER VALUE	+/-UNCERTAINTY
ALKALINITY	MG/L CACO3	701.		745.		508.		635.		660.	
ALUMINUM	MG/L	0.2		< 0.1		< 0.1		0.2		0.21	
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	321.		298.		300.		270.		328.	
CHLORIDE	MG/L	60.		110.		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	5200.		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		5.40		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.		1070.	
STRONTIUM	MG/L	0.8				-		-		8.83	
SULFATE	MG/L	4180.		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.		7610.		7340.		7070.		7190.	
URANIUM	MG/L	0.0354		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 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	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.		2160.		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.	49.	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		1.24		1.33		122.		111.	
MANGANESE	MG/L	0.01		0.02		0.02		0.17		0.15	
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	0.1	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		0.072		0.007		0.178	
SILICA	MG/L	-		-		-		-		-	
SILVER	MG/L	-		-		< 0.01		-		-	
SODIUM	MG/L	740.		756.		809.		1660.		1870.	
STRONTIUM	MG/L	-				-		-		-	
SULFATE	MG/L	450.		532.		637.		3900.		4140.	
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	4200.				
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.		1012.		973.		961.		979.	
ALUMINUM	MG/L	0.3		0.2		< 0.1		0.09		0.01	
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		-		-		-		< 0.01	
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	1600.		1540.		1570.		1610.		1680.	
STRONTIUM	MG/L	2.5				-		-		2.60	
SULFATE	MG/L	2520.		2380.		[illegible]		2570.		2460.	
SULFIDE	MG/L	-				-		-		45.1	
TEMPERATURE	C - DEGREE	12.		16.5		16.0		15.0		15.7	
TH-230	PCI/L	0.1	1.7			-		-		-	
TIN	MG/L	< 0.005				-		-		-	
TOTAL SOLIDS	MG/L	4770.		17900.		4520.		4630.		4630.	

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 03/11/87	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	0.017

MAPPER DATA FILE NAME: GRN01*UOPGW0102187

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 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	745.	707.	790.	606.		606.	
ALUMINUM	MG/L	13.1	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		0.01	
BALANCE	%	-1.92	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.	19.6	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.	2700.	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.	11.
GROSS BETA	PCI/L	-	-	-	2.9	12.	0.	11.
IRON	MG/L	9.53	2.43	0.16	< 0.03		0.32	
LEAD	MG/L	< 0.01	< 0.01	-	-		-	
MAGNESIUM	MG/L	12.2	3.01	1.32	0.90		1.03	
MANGANESE	MG/L	0.07	0.12	0.02	< 0.01		< 0.01	
MERCURY	MG/L	< 0.0002	< 0.0002	-	-		-	
MOLYBDENUM	MG/L	0.11	0.15	< 0.1	< 0.01		< 0.01	
NICKEL	MG/L	0.08	< 0.04	-	-		-	
NITRATE	MG/L	0.1	< 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	8.15		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.	600.		666.	
STRONTIUM	MG/L	0.5	0.7	-	-		-	
SULFATE	MG/L	700.	481.	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	1940.	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	0.042	0.020	-	0.005		0.013	

MAPPER DATA FILE NAME: GRN043UDPGWQ102105

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.		544.		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.		1070.	
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		3.21		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.	16.	19.	2.	19.	14.	9.	7.	11.
IRON	MG/L	< 0.03		0.14		< 0.01		< 0.01		< 0.01	
LEAD	MG/L	-		-		0.02		< 0.01		0.01	
MAGNESIUM	MG/L	2.71		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		< 0.0002		< 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	8.15		8.20		8.27		8.27		8.27	
POTASSIUM	MG/L	1.43		1.55		1.5		1.5		1.7	
RA-226	PCI/L	0.3	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2
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.		579.		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

		LOCATION ID - SAMPLE ID AND LOG DATE								
		845-04 07/16/88			845-05 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		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.			3650.				
COPPER	MG/L	<	0.01		<	0.01				
FLUORIDE	MG/L		3.3			3.3				
GROSS ALPHA	PCI/L		0.	19.		0.	24.			
GROSS BETA	PCI/L		0.	10.		0.	12.			
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	0.1			
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		2870.			2830.				
URANIUM	MG/L	<	0.0003		<	0.0003				
VANADIUM	MG/L		0.01			0.02				
ZINC	MG/L	<	0.005			0.005				

MAPPER DATA FILE NAME: GRN01*UDPGW0192188

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		-		-		-		-2.08	
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	14.	9.	10.	-	
IRON	MG/L	0.07		< 0.01		< 0.03		0.34		0.04	
LEAD	MG/L	0.01		-		-		-		0.01	
MAGNESIUM	MG/L	3.48		2.20		4.5		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	9.92		10.51		8.1		8.05		11.49	
PHOSPHATE	MG/L	< 0.1		-		-		-		< 0.1	
POTASSIUM	MG/L	8.20		2.46		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.		702.		546.	
SULFIDE	MG/L	-		-		-		-		-	
TEMPERATURE	C - DEGREE	16.		16.5		12.0		16.0		17.	
TH-230	PCI/L	-		0.0	0.4			-		-	
TIN	MG/L	< 0.005		-		-		-		< 0.005	
TOTAL SOLIDS	MG/L	1920.		1920.		1830.		1870.		1990.	
URANIUM	MG/L	0.0049		0.0036		< 0.003		0.0012		< 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	0.015	-	0.007	0.012	< 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 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	
ALKALINITY	MG/L CACO3	546.		419.		593.		565.		614.	
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	-		-		-		< 0.001		-	
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.	12.	-		1.	13.
GROSS BETA	PCI/L	13.	8.	0.0	16.	0.	10.	-		0.0	9.4
IRON	MG/L	< 0.03		< 0.03		0.19		0.14		0.04	
LEAD	MG/L	-		-		-		< 0.01		-	
MAGNESIUM	MG/L	0.02		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		1.54		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.		731.	
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	2480.		2200.		2130.		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 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
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

PARAMETER	UNIT OF MEASURE	508-01 10/02/87 PARAMETER VALUE	+/-UNCERTAINTY	508-01 01/10/88 PARAMETER VALUE	+/- UNCERTAINTY	508-01 07/21/88 PARAMETER VALUE	+/-UNCERTAINTY	817-01 10/22/87 PARAMETER VALUE	+/-UNCERTAINTY	817-02 10/22/87 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	4.2		1.43		6.90		2.7		2.7	
CHLORIDE	MG/L	220.		240.		640.		320.		310.	
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.	12.	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		0.89		1.48		0.71		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	1880.		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 04/10/88	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									
		817-03 10/22/87		817-01 10/22/87		817-05 10/22/87		817-01 04/10/88		817-02 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	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	0.0	0.1	0.0	0.1	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.		139.		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.		1470.		1480.		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 --				
		817-01 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		817-01 01/10/88		817-05 01/10/88		817-01 07/18/88		818-01 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		0.85		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					-		-		-	
TIN	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

		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 04/05/88	
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY		PARAMETER VALUE+/-UNCERTAINTY	
ALKALINITY	MG/L CACO3	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		2.1		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	0.1	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		0.0044	
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				
		818-02 10/20/87	818-03 10/20/87	818-04 10/20/87	818-05 10/20/87	818-01 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		848-01 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.		610.		610.		610.		880.	
CHROMIUM	MG/L	0.01		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.	19.	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	1.60		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.		144.		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		16.2		16.2		18.0	
TH-230	PCI/L	-		-		-		-		-	
TIN	MG/L	-		-		-		-		-	
TOTAL SOLIDS	MG/L	2420.		2420.		2410.		2410.		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				
		848-02 01/05/88	848-03 01/05/88	848-04 01/05/88	848-05 01/05/88	848-04 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*UDPGW0102493

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 01/11/87		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	%	-0.08		-		-		-		-	
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		1.03		4.4		4.54		5.96	
CHLORIDE	MG/L	640.		307.		300.		300.		540.	
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		4.2		3.65		4.3	
GROSS ALPHA	PCI/L	-		-		0.0	10.	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	1.70		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		1.02		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.		690.		834.	
STRONTIUM	MG/L	9.6		-		-		-		-	
SULFATE	MG/L	649.		615.		630.		674.		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.		2110.		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 03/11/87	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

PARAMETER	UNIT OF MEASURE	849-04 10/26/87 PARAMETER VALUE+/-UNCERTAINTY		849-04 01/05/88 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.	0.	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	0.2	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	2420.		578.				
SULFIDE	MG/L	-		-				
TEMPERATURE	C - DEGREE	16.0		14.3				
TH-230	PCI/L	-		-				
TIN	MG/L	-		-				
TOTAL SOLIDS	MG/L	3820.		2400.				

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	
		849-01 10/26/87	849-01 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*UDPGW0102192

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

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Constituent[a]	Number of analyses[b]	Arithmetic mean[c] ($\bar{X}$)	Standard deviation x2[c] (2s)	Statistical concentration range[c] ($\bar{X}\pm2s$)	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

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[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 ($\bar{X}\pm2s$)	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 ($\bar{X}\pm2s$)	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

[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-	$UO_2CO_3^o$	$UO_2(CO_3)_2^{2-}$	$UO_2(CO_3)_3^{4-}$
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. S.I. = 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	< 0.005
CADMIUM	MG/L	0.0030	< 0.0001	< 0.0001	< 0.0001
CALCIUM	MG/L	71.	57.	59.	60.
CHLORIDE	MG/L	8.	7.	7.	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	0.04	0.02	0.04	0.06
FLUORIDE	MG/L	0.4	0.3	0.3	0.4
IRON	MG/L	0.02	0.03	< 0.02	< 0.02
LEAD	MG/L	0.003	< 0.001	< 0.001	< 0.001
MAGNESIUM	MG/L	9.	8.	8.	8.
MANGANESE	MG/L	< 0.01	< 0.01	< 0.01	< 0.01
MERCURY	MG/L	< 0.0001	< 0.0001	< 0.0001	< 0.0001
MOLYBDENUM	MG/L	0.007	0.004	0.003	0.002
NICKEL	MG/L	< 0.02	< 0.02	< 0.02	< 0.02
NITRATE	MG/L	1.8	0.2	0.3	2.0
POTASSIUM	MG/L	8.	7.	8.	7.
SELENIUM	MG/L	0.011	0.010	0.009	0.011
SILICA	MG/L	13.3	11.4	11.7	11.1
SODIUM	MG/L	29.	24.	23.	22.
STRONTIUM	MG/L	0.71	0.60	0.62	0.63
SULFATE	MG/L	187.	152.	156.	169.
THALLIUM	MG/L	< 0.001	< 0.001	< 0.001	< 0.001
TIN	MG/L	< 0.001	< 0.001	< 0.001	0.001
TOTAL SOLIDS	MG/L	388.	302.	295.	315.
URANIUM	MG/L	0.182	0.177	0.168	0.172
VANADIUM	MG/L	0.24	0.25	0.24	0.22
ZINC	MG/L	0.02	0.02	< 0.01	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			
		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	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	0.42	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

PARAMETER	UNIT OF MEASURE	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 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

		LOCATION ID - SAMPLE ID AND LOG DATE			
		837-01 05/08/89 (b)	838-01 05/08/89 (b)		
PARAMETER	UNIT OF MEASURE	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY	PARAMETER VALUE +/- UNCERTAINTY
ALUMINUM	MG/L	0.26	< 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	0.010		
VANADIUM	MG/L	0.01	0.01		
ZINC	MG/L	0.02	< 0.01		

MAPPER DATA FILE NAME: GRN01*UDPSWQ100236

[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:

- o Mostly below-grade disposal of the tailings to limit the exposed area of the pile, and thereby minimize percolation of precipitation through the tailings.

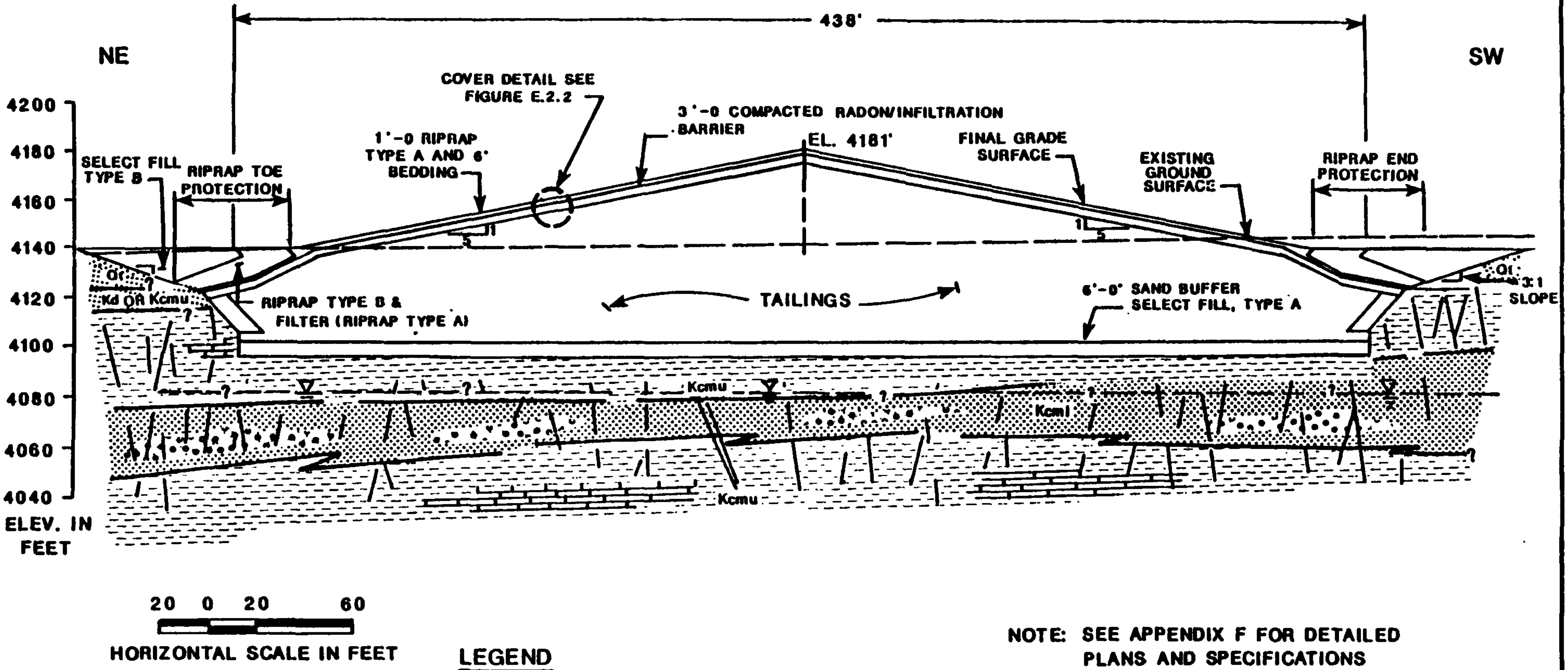
- o Consistent, uniform, vertical fracturing of the foundation bedrock to prevent ponding ("bathtubbing") in the tailings, and promote drainage of runoff water from the toe of the cell.

- o Abundant, desirable, secondary minerals on the foundation fracture surfaces to attenuate tailings seepage in the unlikely event that seepage leaves the cell.

- o Strong, upward, vertical hydraulic gradients in the saturated bedrock downgradient of the disposal site to inhibit downward migration of contamination.

- o Flow direction in the shallow groundwater beneath the disposal site that is toward the present tailings pile and existing contamination.

- o 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

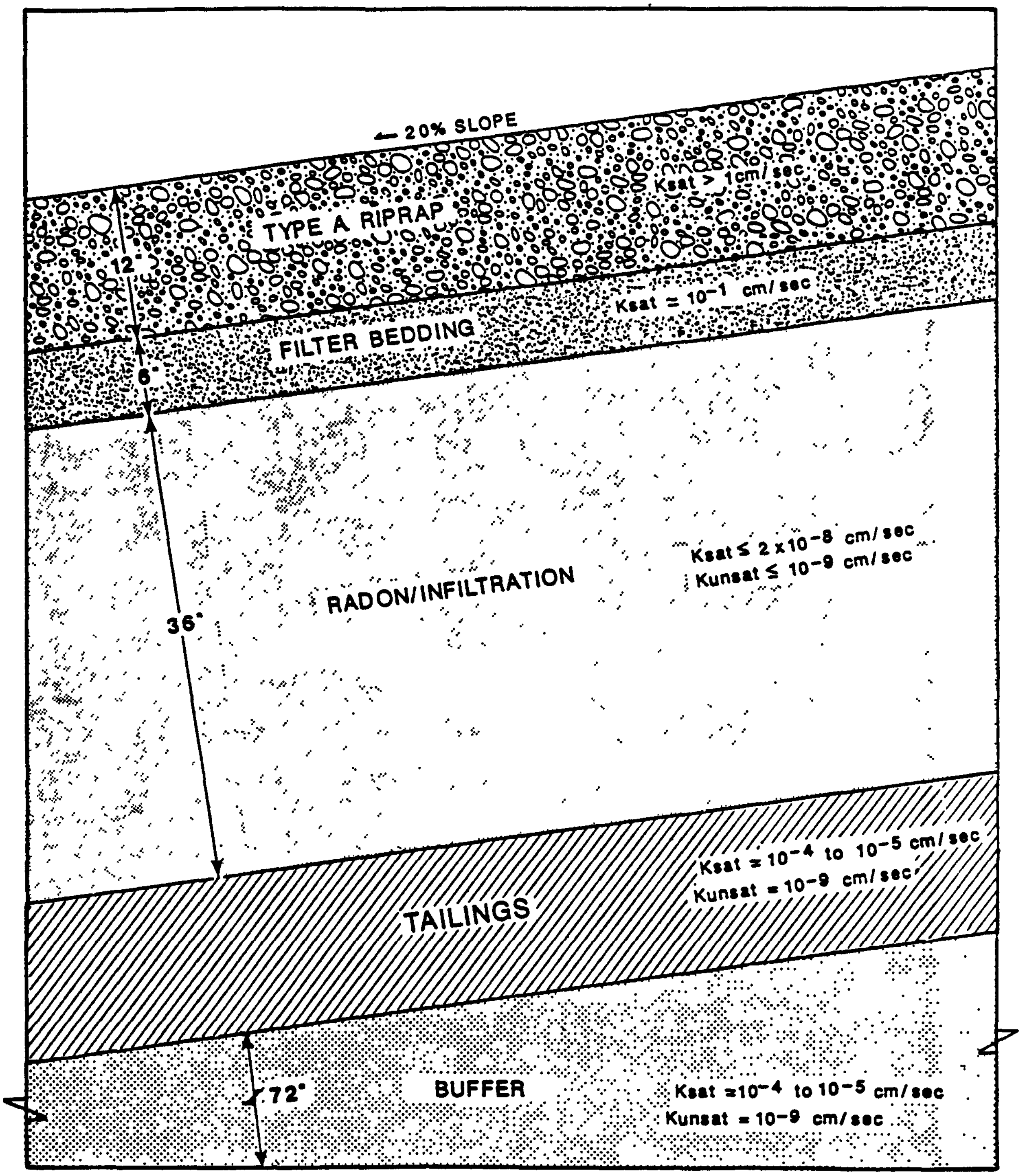
	FORMATION	MATERIAL	SYMBOL
Qt	TERRACE SEDIMENTS	SOILS	▨
Kd	DAKOTA SANDSTONE	BEDROCK	▨ SANDSTONE OR SILTSTONE
Kcmu	CEDAR MOUNTAIN FORMATION UPPER-MIDDLE UNIT		▤ SHALE OR MUDSTONE
Kcml	CEDAR MOUNTAIN FORMATION LOWER-MIDDLE UNIT		▦ LIMESTONE
			⁂ CONGLOMERATE

⫽ 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 X 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	0.001	0.010	Title I
Chromium	1.88	0.03	0.01	0.05	Title I
Molybdenum	0.15	0.27	0.01	0.1	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):

- Cadmium.
- Chromium.
- Molybdenum.
- Nitrate.
- Selenium.
- Uranium.

Concentrations for the following inorganic hazardous constituents without MCLs are higher than laboratory method detection limits (see Table E.3.1):

- Nickel.
- 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	0.438
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.

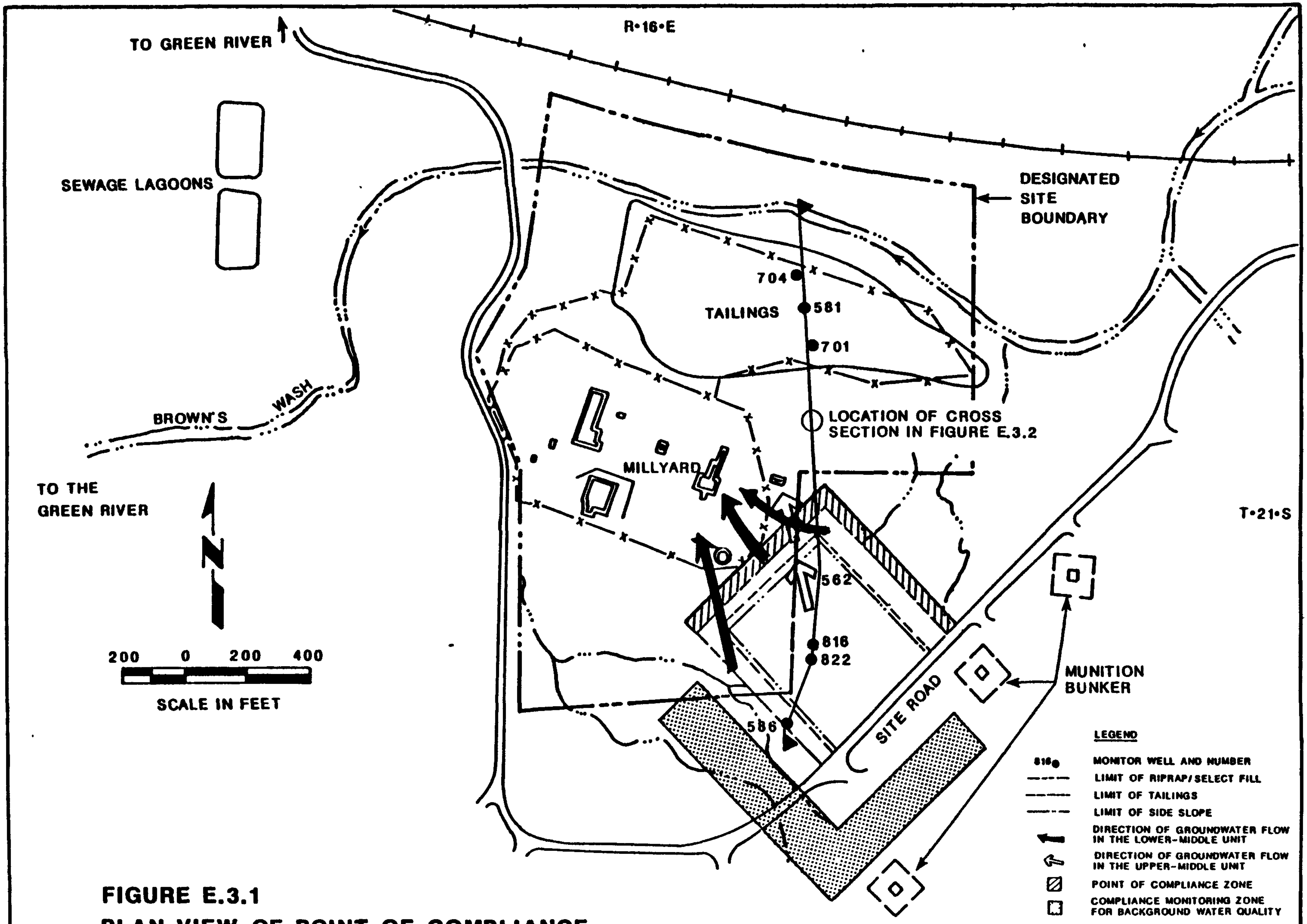
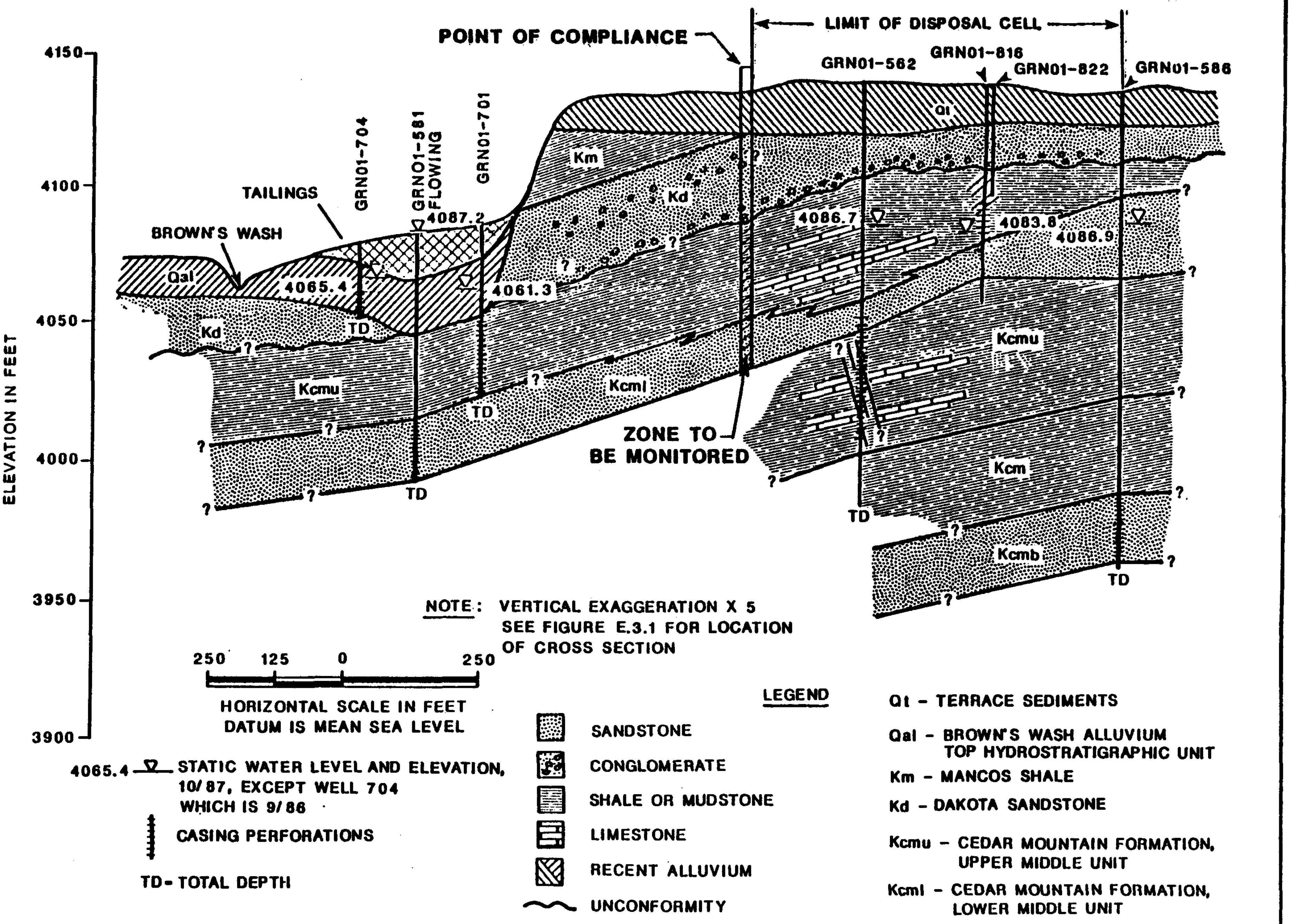


FIGURE E.3.1

PLAN VIEW OF POINT OF COMPLIANCE
AND RELATED DISPOSAL CELL AND COMPLIANCE MONITORING FEATURES
GREEN RIVER, UTAH, UMTRA PROJECT DISPOSAL SITE



NOTE: VERTICAL EXAGGERATION X 5
SEE FIGURE E.3.1 FOR LOCATION OF CROSS SECTION

4065.4 ▽ STATIC WATER LEVEL AND ELEVATION, 10/87, EXCEPT WELL 704 WHICH IS 9/86

CASING PERFORATIONS

TD - TOTAL DEPTH

LEGEND

▒	SANDSTONE
▓	CONGLOMERATE
▤	SHALE OR MUDSTONE
▦	LIMESTONE
▨	RECENT ALLUVIUM
〰	UNCONFORMITY

Qt - TERRACE SEDIMENTS

Qal - BROWN'S WASH ALLUVIUM TOP HYDROSTRATIGRAPHIC UNIT

Km - MANCOS SHALE

Kd - DAKOTA SANDSTONE

Kcmu - CEDAR MOUNTAIN FORMATION, UPPER MIDDLE UNIT

Kcml - CEDAR MOUNTAIN FORMATION, LOWER MIDDLE UNIT

Kcmb - CEDAR MOUNTAIN FORMATION BUCKHORN CONGLOMERATE MEMBER (BOTTOM UNIT)

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.

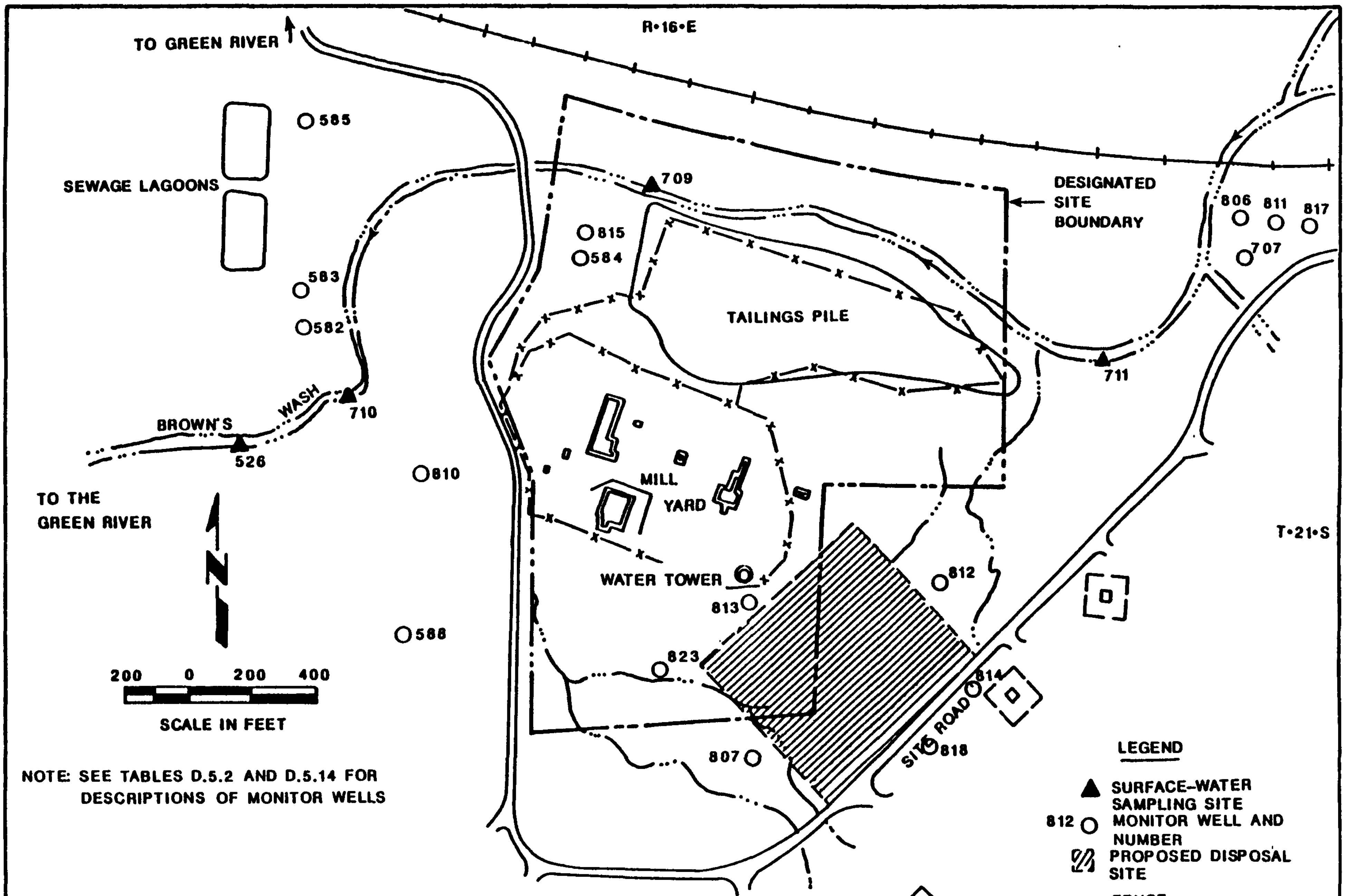
Monitoring during remedial action activities shall take place semi-annually. Samples shall be taken from the wells shown in Figure E.3.3. The wells shown in Figure E.3.3 will be retained for post-closure monitoring, but they will not be sampled as frequently as the proposed performance monitoring wells 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

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

NOTE: SAMPLING LOCATIONS 801 AND 802 ARE NOT SHOWN

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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