UMTRA - DOE/AL -050505
.0000

United States Department of Energy

Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site At Grand Junction, Colorado

1. Attachment 4: Water Resources Protection Strategy
2. Attachment 5 Volume I 9/91
3. Attachment 5 Volume II 9/91

Final

September 1991

Appendix B of the
Cooperative Agreement
No. DE-FC04-81AL16257

Uranium Mill Tailings Remedial Action Project

UMT 65047.

SURF018511

UMTRA - DOE/AL -050505
.0000

United States Department of Energy

NON-[illegible]ORD

Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site At Grand Junction, Colorado

Attachment 4: Water Resources Protection Strategy

NON-[illegible]ORD

Final

September 1991

Appendix B of the Cooperative Agreement No. DE-FC04-81AL16257

Uranium Mill Tailings Remedial Action Project

ATTACHMENT 4

WATER RESOURCES PROTECTION STRATEGY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 WATER RESOURCES PROTECTION STRATEGY SUMMARY

The U.S. Department of Energy (DOE) must demonstrate compliance with the proposed U.S. Environmental Protection Agency (EPA) standards for groundwater protection at inactive uranium processing sites pursuant to Subparts A and C of 40 CFR 192. This section outlines the proposed strategy the DOE will pursue to demonstrate compliance with the standards at the Cheney disposal site, to be used for the contaminated materials from the inactive processing site at Grand Junction, Colorado. The main components of this demonstration are: 1) the groundwater protection standard, 2) a performance assessment, 3) a closure performance assessment, 4) a groundwater monitoring program, and 5) a corrective action plan.

To achieve compliance with the proposed EPA groundwater protection standards, the DOE proposes a narrative supplemental standard to ensure sufficient protection of human health and the environment. The supplemental standard applies to the uppermost aquifer (the Dakota Sandstone) and will not include numerical concentration limits for the hazardous constituents identified in the contaminated materials at the Grand Junction site and vicinity properties. A summary of the principal features of the water resources protection strategy for the Cheney disposal site follows:

- The disposal option proposed for the Grand Junction processing site involves relocation of contaminated materials to the Cheney disposal site. The materials will be placed in a partially below-grade disposal cell excavated into unsaturated Mancos Shale. The foundation of the cell will be constructed to take advantage of favorable geochemical conditions that will attenuate hazardous constituents in seepage from the cell. The disposal cell will have a [] riprap covered radon/infiltration barrier designed to meet the radiation protection standard and minimize the amount of infiltration from precipitation. The riprap will protect the radon barrier from frost and biointrusion.

- To achieve compliance with the proposed EPA groundwater protection standards at the Cheney disposal site, the DOE proposes a narrative supplemental standard that will demonstrate protection of human health and the environment. The basis for the supplemental standard is the limited use (Class III) designation of the groundwater in the Dakota Sandstone, which is the uppermost aquifer beneath the proposed disposal site. The groundwater meets the EPA criteria for a Class III designation because the total dissolved solids (TDS) content is greater than 10,000 milligrams per liter (mg/l) (40 CFR 192.11(e)) and the groundwater is not considered to be a resource. Furthermore, the uppermost aquifer lies approximately 750 feet below the existing ground surface and is hydrogeologically isolated from surface recharge by confining sandstones and shales overlying the aquifer. Concentration limits proposed for the uppermost aquifer are hypothetical because no groundwater monitoring is proposed for the uppermost aquifer.

- Hazardous constituents were identified that are likely to be in, or derived from, residual radioactive material at the processing site and vicinity properties. The hazardous constituents were identified by characterization of residual radioactive material, evaluation of groundwater quality data, and description of the uranium recovery process. Pore water from the tailings and vicinity property soils was analyzed for hazardous constituents and elements of potentially hazardous compounds listed in Table 1 and Appendix I of 40 CFR 192 and in Appendix IX of 40 CFR 264. All hazardous constituents that exceeded laboratory method detection limits were identified. The hazardous constituents (40 CFR 192 Table 1) identified at the Grand Junction site include: arsenic, barium, cadmium, chromium, net gross alpha activity, lead, mercury, molybdenum, nitrate, radium-226 and -228 activities, selenium, silver, and uranium. Hazardous constituents that are elements, and elements contained in hazardous compounds (40 CFR 192 Appendix I) include: aluminum, antimony, beryllium, cobalt, copper, cyanide, fluorine (as fluoride), nickel, strontium, sulfide, tin, vanadium, and zinc. No hazardous organic compounds were identified in the Grand Junction tailings or vicinity property materials.

- An assessment of the performance of the disposal cell in conjunction with subpile hydrogeologic conditions has shown that the underlying Mancos Shale foundation is capable of accepting tailings pore water that will drain from the cell following the remedial action. A conservative two-dimensional unsaturated-saturated flow analysis of transient drainage of tailings pore water shows that the maximum possible depth of saturation in the tailings will not approach the elevation that would allow establishment of the hydraulic gradient required to cause flow out of the disposal cell.

- The unsaturated Mancos Shale beneath the disposal cell also has the capacity to attenuate hazardous constituents geochemically. Geochemical processes that would reduce contaminant concentrations include adsorption by the shales and precipitation when reducing conditions are encountered. Hydrogen sulfide gas was encountered in some of the boreholes drilled through the Mancos Shale at the disposal site during characterization. The hydrogen sulfide gas creates a reducing environment in the Mancos Shale.

- The DOE has assessed the performance of the proposed disposal cell in conjunction with the hydrogeologic system, and has shown that the disposal cell will minimize and control releases of hazardous constituents to groundwater and surface water, and radon emanations to the atmosphere, to the extent necessary to protect human health and the environment. Natural, stable materials have been proposed for use in construction of the Cheney disposal cell so that long-term performance is ensured. The DOE has also demonstrated that design features necessary for compliance with the EPA groundwater protection standards minimize the need for further maintenance of the disposal site.

- No groundwater monitoring is proposed for the uppermost aquifer (Dakota Sandstone) at the Cheney disposal site as the tailings are hydrogeologically isolated from the uppermost aquifer, and groundwater in the Dakota Sandstone is limited use (Class III). [] <u>An indirect monitoring program will be implemented to provide an indication that the disposal cell is operating as designed and will not impact groundwater in the alluvial paleochannels.</u>

- o Demonstration of cleanup and control of existing processing-related groundwater contamination at the Grand Junction site will be addressed under a separate DOE project and will be part of a separate process under the National Environmental Policy Act. [] By deferring groundwater cleanup in the uppermost aquifer (alluvium) until the processing site can be adequately evaluated, human health and the environment will not be affected because: 1) no wells currently exist within the affected environment in the vicinity of the processing site that withdraw groundwater from the alluvium (based on a recent well inventory in the processing site vicinity); 2) no wells are anticipated to be drilled to exploit groundwater within this area in the near future; and 3) even if a well were drilled into the alluvium that pumped groundwater from within the affected area, concentrations of contaminants dissolved in the groundwater would not likely be elevated enough to pose an imminent danger to human health or the environment during the interim period between surface remedial action and groundwater cleanup (during which time groundwater use in the vicinity of the processing site will be prevented by institutional controls, and residents will be notified of potentially contaminated groundwater). Recent analyses of groundwater indicate that concentrations are remaining relatively stable with time, and Colorado River surface water samples (at low water stage) indicate that no concentrations of hazardous constituents exceed the proposed concentration limits. Deferral of groundwater cleanup until the tailings and all contaminated material are removed and the site can be fully evaluated does not preclude the possibility of the DOE performing active restoration at the site if warranted.

2.0 CONCEPTUAL DESIGN CONSIDERATIONS AND FEATURES FOR WATER RESOURCES PROTECTION

The disposal option proposed for the Grand Junction processing site involves relocation of the contaminated materials to the Cheney disposal site. The materials will be placed into a partially below-grade cell that will be excavated up to 50 feet [] deep into unweathered Mancos Shale. Figures 2.1 and 2.2 show a plan of the disposal cell and a diagrammatic cross section through the cell and foundation, respectively. The disposal cell will be approximately 60 acres in area and will have a [] rock cover with a frost protection layer. Clean-fill dikes will be placed beneath the sideslopes to preclude any lateral migration of tailings fluids away from the disposal cell.

The top of the cell will slope at two percent and will be covered with [] riprap erosion protection. The sides of the disposal cell will slope at two and 20 percent and will also be covered with [] riprap for erosion protection. The disposal cell cover has been designed to perform as a unit and in conjunction with the embankment foundation to protect human health and the environment by limiting radon flux through the cover and tailings seepage from the base of the cell. The design features of the [] rock cover are discussed in detail in the Technical Approach Document (DOE, 1989).

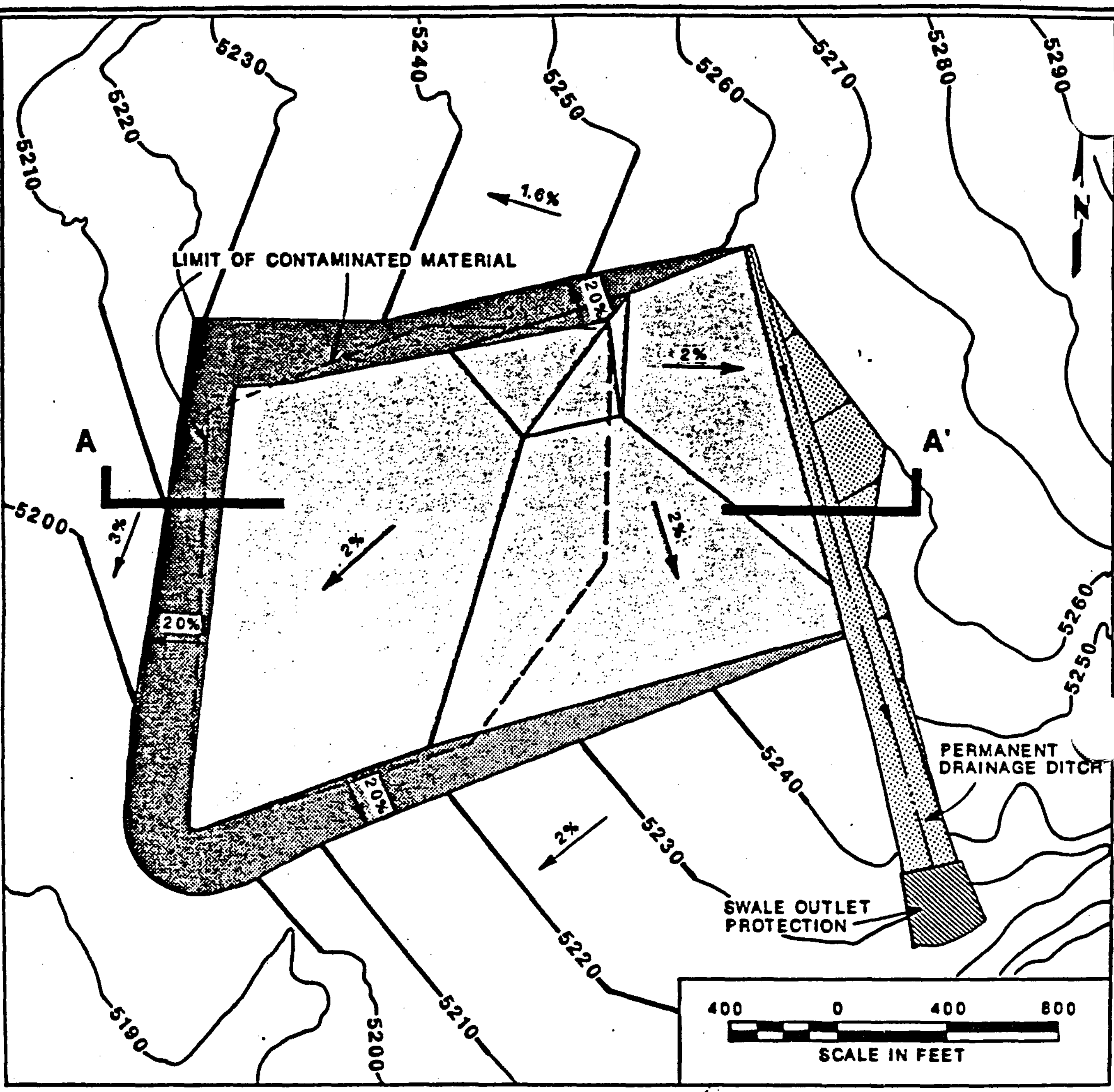
This section describes the disposal cell design considerations and features that are important for demonstrating compliance with the EPA groundwater protection standards at the Cheney disposal site.

2.1 DESIGN CONSIDERATIONS

The disposal cell location was selected after an extensive hydrologic characterization, discussed in Attachment 3. The Cheney disposal cell area does not overlie any saturated zones within the alluvium.

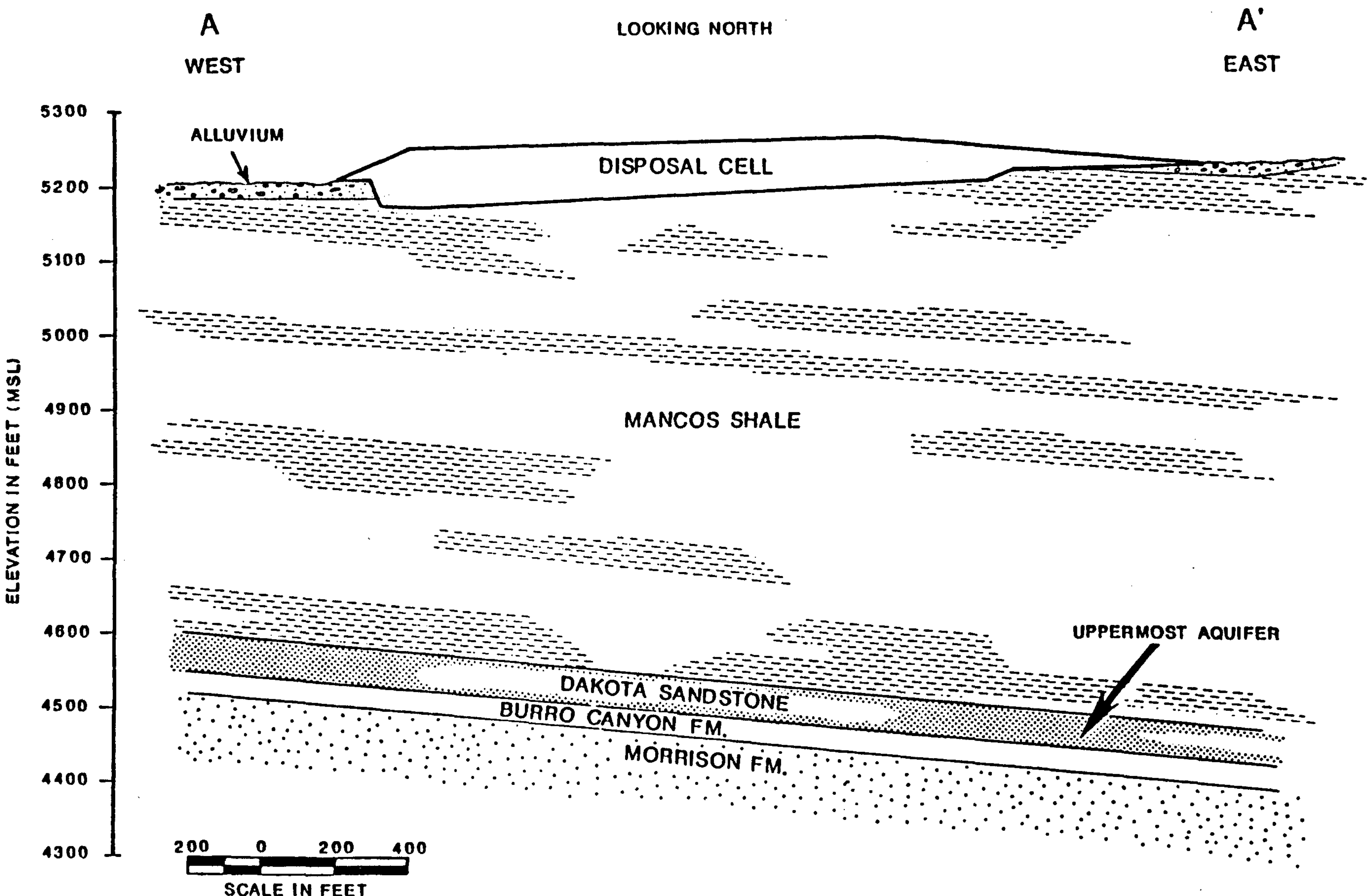
It is necessary to establish the foundation of the base of the disposal cell in Mancos Shale bedrock to eliminate the possibility of seepage of any ponded fluids within the cell into surrounding alluvial paleochannels. The depth of the cell excavation was thus determined by optimizing construction costs and material balances against depth into the Mancos Shale. The final design allows for encapsulation of all contaminated materials, and [] sufficient excavation to provide excess Mancos Shale material for use as clean-fill dike material above and below grade to buttress the entire cell, as cover frost protection material, and as buttress material to reduce the upland sideslopes of the cell for lengths of approximately 400 to 500 feet.

The design considerations of most importance for groundwater protection are climate and infiltration of precipitation, drainage of tailings pore water, geochemical attenuation of hazardous constituents, and placement of the contaminated materials in the cell. These are discussed in the following sections.



NOTE: SEE FIGURE 2.2 FOR CROSS SECTION.

FIGURE 2.1
CHENEY DISPOSAL SITE PLAN



NOTE: SEE FIGURE 2.1 FOR LOCATION OF CROSS SECTION.

FIGURE 2.2
DIAGRAMMATIC CROSS SECTION OF THE CHENEY DISPOSAL CELL AND FOUNDATION HYDROGEOLOGY

2.1.1 Climate and infiltration of precipitation

Climate has been considered in the design of the Cheney disposal cell. The disposal cell cover system must be capable of evaporating or shedding (by lateral drainage) excess moisture from snowmelt and rainfall.

Because there are no climate data specific to the Cheney disposal site, data from the weather station in Grand Junction are used to provide an estimate of the quantity and distribution of precipitation at the Cheney site. Grand Junction receives 8.4 inches of precipitation annually. Conservatively, it is estimated that the Cheney disposal site receives approximately 10 inches of precipitation annually, which is slightly more than Grand Junction because Cheney is slightly higher in elevation.

Evidence from site characterization of the shallow soils at the disposal site (see Section 3.2.3 of Attachment 3) indicates that very little or no precipitation deep-percolates to recharge groundwater. Extensive caliche horizons in the upper few feet of soils, and deposits of gypsum in the upper 10 to 15 feet of the alluvium, indicate that infiltration of precipitation over the site is not deep and does not extend beyond the depth of evaporation and transpiration. Age dating of the alluvial groundwater upgradient from the Cheney site (see Section 3.2.3 of Attachment 3) also supports the idea that recharge of the alluvial groundwater is by infiltration from Indian Creek/Whiting Ditch upgradient from the site rather than from infiltration of precipitation directly on the site. The cover system proposed for the Cheney disposal cell has been designed to perform as well or better than the natural soil surface at the site to limit deep infiltration of precipitation through the cover and tailings. Therefore, virtually no moisture should infiltrate through the cover system into the tailings. The cover system design is presented in Section 2.2.1.

2.1.2 Drainage of tailings pore water under transient and steady state conditions

During construction and following completion of the remedial action, moisture within the disposal cell will redistribute to some extent to reach equilibrium with the upper boundary (cover) flux of moisture. An important design consideration is the relationship of tailings drainage to the migration of tailings pore water into the underlying foundation geologic materials.

Extensive characterization of the hydraulic properties of the Mancos Shale (see Section 3.2.4 of Attachment 3) and of the contaminated materials to be placed in the disposal cell (see Section 3.1.6 of Attachment 3), together with two-dimensional saturated/unsaturated finite element modeling of the disposal cell and foundation (see Section 3.2.2) have shown that the Mancos Shale foundation is capable of accepting all of the tailings pore water drained from the cell under transient and steady state conditions. As discussed in further detail in Section 3.2.2, results of the modeling show that, with very conservative assumptions, it is not possible for tailings seepage to discharge to the surface or mix with shallow groundwater in paleochannel aquifers upgradient of the disposal cell. Therefore, the disposal cell has been designed to comply with the groundwater protection standards under both transient and steady state conditions.

[]

2.1.3 Geochemical attenuation of hazardous constituents

Geochemical attenuation has been considered in the design of the disposal cell. Both the alluvium and Mancos Shale possess favorable properties for attenuating hazardous constituents in the tailings pore fluids.

Extensive laboratory testing of the alluvium and Mancos Shale (Calculation GRJ-03-07-90-13-06(01)-00, Appendix A to Attachment 3) shows that hazardous constituent concentrations in the feed solution (representative of the tailings pore fluid) are attenuated by as much as 100 percent in one pore volume passing through a three-foot column of selected alluvium from the disposal site. Additionally, batch testing of the Mancos Shale shows results that are very similar to the column testing of the alluvium. Section 3.2.6 of Attachment 3 describes the geochemical attenuation properties of the alluvium and Mancos Shale at the disposal site in more detail.

2.1.4 Placement of contaminated materials in the disposal cell

Characterization of both the on-site tailings and off-site vicinity property materials (see Attachment 5) indicates that the hydraulic properties of each material are related to their representative particle gradation. The tailings at the processing site consist of approximately 75 percent sand tailings and 25 percent fine material or slimes (material finer than 74 microns). The vicinity property material contains a greater percentage of fines (an average 47 percent) (see Calculation GRJ-02-90-02-02-00, Appendix A to Attachment 3).

The mean saturated hydraulic conductivity of the tailings is 2.4×10^{-4} centimeters per second (cm/s) while the vicinity property materials have a mean saturated hydraulic conductivity of 1.0×10^{-5} cm/s. The unsaturated hydraulic conductivity of the tailings and vicinity property material is specified through capillarity relationships defined by Mualem parameters alpha and N (Van Genuchten and Nielsen, 1985). Alpha is the inverse of the air entry pressure, possessing units of one per meter, and the N parameter (dimensionless) defines the relative rate of change in unsaturated hydraulic conductivity with moisture content. The greater the value of N, the less sensitive are the changes in hydraulic conductivity with moisture content. Laboratory testing resulted in alpha and N values of 0.34 (per meter), and 1.71 respectively, for the tailings, while the vicinity property material have values of 3.3 (per meter) and 1.35, respectively, reflecting the higher fines content (see Calculation GRJ-08-90-12-02-00, Appendix A to Attachment 3).

Contaminated materials will be placed in the disposal cell to minimize infiltration into and through the cell, and to minimize the build-up (ponding) of transient drainage. Therefore, the lower-permeability vicinity property materials will overlie the higher-permeability tailings material to the greatest degree possible.

2.2 DESIGN FEATURES

Careful evaluation of the design considerations discussed in Section 2.1 resulted in the incorporation of the disposal cell design features discussed in this section.

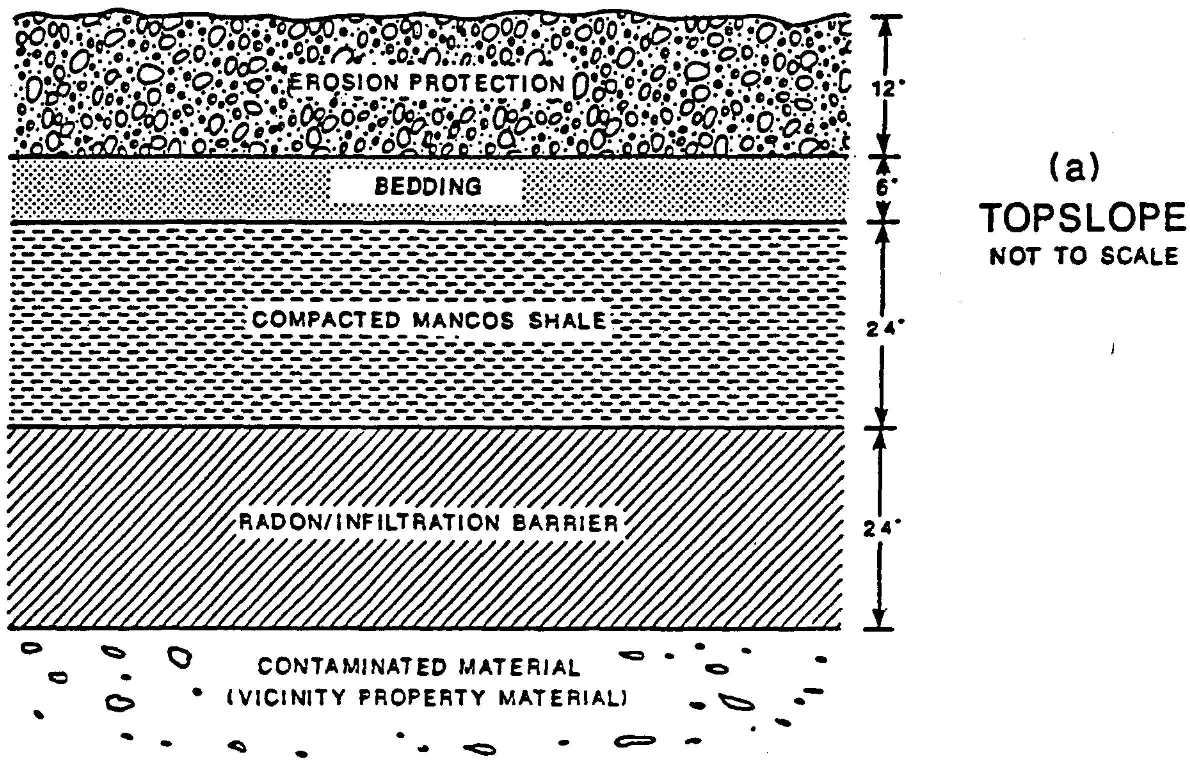
2.2.1 Disposal cell components

The Cheney disposal cell has been designed to protect human health and the environment by controlling infiltration into the cell and seepage out of the cell. Components utilized in the design are listed in Table 2.1. [] The cover system materials and design thicknesses for the topslope and sideslope are shown in Figure 2.3.

2.2.2 Disposal cell longevity

The EPA groundwater protection standards require that the disposal cell be designed to stabilize the contaminated material and protect the environment for 1000 years where reasonably achievable, and in any case for at least 200 years. It must also be demonstrated that design features do not rely upon active maintenance to ensure long-term performance and compliance with the standards.

Natural, stable materials have been proposed for use in construction of the Cheney disposal cell so that long-term performance is ensured. Materials for the rock erosion layer have been selected, based upon durability, suitability, and size, that will perform adequately over the design life of the disposal cell. Bedding materials for the filter layers have been selected using the same durability criteria as for the rock. The filter materials will be sized to drain water rapidly. The radon/infiltration barrier clays will be protected from erosion by the overlying



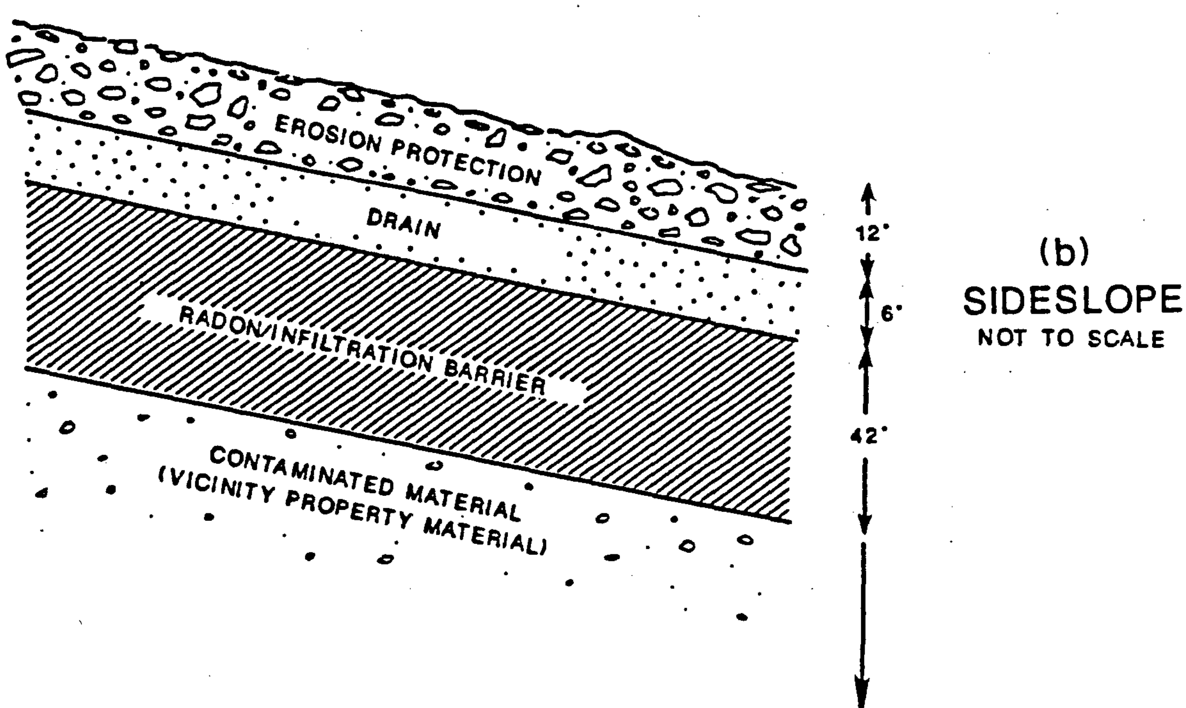


FIGURE 2.3
DETAILS OF THE CHENEY DISPOSAL CELL COVER SYSTEM

Table 2.1 Disposal cell components for protection of water resources at the Cheney disposal site, Colorado

Cell component[a]	Description[b]	Purpose
[] Riprap rock	Type-A riprap	Resists PMP storm events, prevents channelization of rainfall runoff
Sand bedding	Graded sands	Prevents riprap from "punching" through to underlying layers; prevents riprap from migrating into underlying layers
Compacted Mancos Shale	Excess material excavated from the cell	Provides frost protection to underlying radon/infiltration barrier; reduces the quantity of infiltration that will reach the radon/infiltration barrier
Radon/infiltration barrier	Alluvial clay from the disposal site with a saturated hydraulic conductivity of 1×10^{-7} cm/s	Limits infiltration into the tailings during extreme (saturated) cover conditions
Clean fill dikes	Compacted Mancos Shale from the disposal cell excavation	Prevent lateral migration of tailings pore water away from the disposal cell

[a]See Figures 2.3(a) and 2.3(b).
[b]See Section 3.3.5 of the Remedial Action Selection Report for a full description of the disposal cell components.

layers. Uniformity of hydraulic conductivity of the radon/infiltration barrier will be ensured by adherence to design specifications for placement and compaction of the materials at the disposal cell. Frost protection of the radon/infiltration barrier will be provided by the [] three and one-half foot thickness of materials overlying the radon barrier.

3.0 DISPOSAL AND CONTROL OF RADIOACTIVE MATERIALS AND NONRADIOACTIVE CONTAMINANTS

3.1 GROUNDWATER PROTECTION STANDARD

[] The proposed disposal cell at the Cheney site is designed to control radioactive materials and nonradioactive contaminants in conformance with the proposed EPA groundwater protection standards in 40 CFR 192.02(a)(3). The DOE proposes a narrative supplemental standard for the uppermost aquifer at the Cheney disposal site. The basis for the supplemental standard is the limited use (Class III) designation of groundwater in the uppermost aquifer (Dakota Sandstone) beneath the disposal site (see Section 3.2.5, Attachment 3). Groundwater in the Dakota Sandstone meets the EPA criteria for a Class III designation because the TDS content is greater than 10,000 mg/l (40 CFR 192.11(e)). Groundwater in the Dakota Sandstone is not considered a water resource.

There are two basic requirements for a supplemental standard (40 CFR 192, Subpart C) as follows:

1. The standard must assure protection of human health and the environment.

2. The standard must come as close to meeting the otherwise applicable standards as is reasonably achievable under the circumstances.

Protection of human health and the environment at the Cheney disposal site is assured because the uppermost aquifer (Dakota Sandstone) is hydrogeologically isolated from the surface and the disposal cell by approximately 750 feet of confining shales and sandstones of the Mancos Shale (see Section 3.2.3, Attachment 3). The disposal cell has also been located and designed to restrict the migration of any potentially contaminated seepage to the land surface peripheral to the cell, or to isolated alluvial paleochannels in the area (none of which are beneath or immediately adjacent to the disposal cell).

Because compliance with the groundwater protection standards at the Cheney disposal site is based on narrative supplemental standards, concentration limits have not been proposed for hazardous constituents. Since the uppermost aquifer is hydrogeologically isolated from any potential seepage of leachate from the disposal cell, no post-closure groundwater monitoring has been proposed, and no point of compliance will be required. To comply with the concept that the supplemental standard must come as close to meeting the otherwise applicable standards as is reasonably achievable under the circumstances, hypothetical concentration limits have been established, based on the EPA Maximum Concentration Limits (MCLs) or the statistical maximum background concentrations, as appropriate. The DOE is reasonably certain that the hypothetical concentration limits could be met at a hypothetical point of compliance in the uppermost aquifer because of the hydrogeologic isolation of the Dakota Sandstone from any potential contaminated seepage from the disposal cell.

The EPA groundwater protection standards consist of three components: 1) a list of designated hazardous constituents; 2) a corresponding list of proposed concentration limits for the constituents; and 3) a point of compliance (NRC, 1989). These three components are discussed below.

3.1.1 Hazardous constituents

Hazardous constituents at the Grand Junction processing site were identified based upon characterization of the contaminated materials related to uranium recovery operations at the processing site and vicinity properties materials, description of the uranium recovery process, and evaluation of groundwater quality data (see Section 3.1.6, Attachment 3). Hazardous constituents should satisfy the following two criteria: 1) they should be reasonably expected to be in or derived from the residual radioactive material to be stabilized at the disposal site; and 2) they should consist of radium-226 and -228, uranium-234 and -238, nitrate, molybdenum, gross-alpha particle activity, or other constituents listed in Appendix I of 40 CFR 192.02(a)(3)(i) or Table 1 in 40 CFR 192.02(a)(3)(iii), or Appendix IX of 40 CFR 264. Screening for organic chemicals listed in Appendix I or Table 1 was conducted as part of the site characterization.

Hazardous inorganic constituents related to uranium processing activities that exceed laboratory method detection limits in tailings and vicinity property materials pore fluids include (Table 1 in 40 CFR 192.02(a)(3)(iii)): antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, net gross alpha activity, lead, mercury, molybdenum, nickel, nitrate, radium-226 and -228 activities, selenium, silver, tin, vanadium, uranium, and zinc. Hazardous constituents that are elements and elements contained in hazardous constituent compounds that exceed laboratory method detection limits include (Appendix I of 40 CFR 192.02(a)(3)(i)): aluminum, [] cyanide, fluorine (as fluoride), [] strontium, and sulfide. [] Water samples were chemically analyzed for all of these elemental constituents at the Cheney processing site (see Section 3.2.5, Attachment 3). Table 3.1 shows the hazardous constituents and elements contained in hazardous constituent compounds in the Grand Junction contaminated materials. The mean concentrations of these constituents were determined from analyses of lysimeter samples.

3.1.2 Proposed concentration limits

[]

Because compliance with the groundwater protection standards at the Cheney disposal site is based on narrative supplemental standards, concentration limits have not been proposed for hazardous constituents. To comply with the concept that the supplemental standards must come as close to meeting the otherwise applicable standards as is reasonably achievable under the circumstances, hypothetical concentration limits for the Dakota Sandstone (uppermost aquifer) have been established, based on the EPA MCLs or the statistical maximum background concentrations, as appropriate (Table 3.2 and Calculation No. GRJ-01-91-15-02-00).

Table 3.1 Hazardous constituents and elements contained in hazardous constituent compounds at the Grand Junction processing site, Colorado

Hazardous constituents[a]	Mean concentration of element[b]
Antimony	0.006
Arsenic	0.092
Barium	0.034
Beryllium	0.003
Cadmium	0.011
Chromium	0.005
Cobalt	0.090
Copper	0.049
Lead	0.005
Mercury	0.0001
Molybdenum	0.246
Net gross alpha activity[c]	261 pCi/l
Nickel	0.342
Nitrate	1.13
Radium-226 & -228	19.5 pCi/l
Selenium	0.073
Silver	0.005
Uranium	0.778
Vanadium	0.652
Zinc	0.254
Elements contained in hazardous constituent compounds[d]	
Aluminum (aluminum phosphide)	0.103
Cyanide (soluble salts and complexes)	0.071
Fluoride (carbon oxyfluoride)	4.46
Strontium (strontium sulfide)	5.05
Sulfide (strontium sulfide, carbon disulfide)	0.050

[a]Appendix I of 40 CFR 192.02(a)(3)(i), Appendix IX of 40 CFR 264, or Table 1 of 40 CFR 192.02(a)(iii).

[b]Mean concentrations from chemical analysis of lysimeter samples from tailings and vicinity property materials; see Calculation GRJ-07-90-15-01, Appendix A to Attachment 3 for calculation of mean concentrations; concentrations are in mg/l unless noted; pCi/l = picocuries per liter.

[c]Net gross alpha [] (excluding radon and uranium); 1 mg/l uranium = 686 pCi/l activity).

[d]Appendix I of 40 CFR 192.02(a)(3)(i).

Table 3.2 Hypothetical concentration limits for the uppermost aquifer (Dakota Sandstone) at the Cheney disposal site

Hazardous constituents[a]	Concentration limit Value	Source[b]
Antimony	0.003	BG
Arsenic	0.05	MCL
Barium	45.3	BG
Beryllium	0.005	BG
Cadmium	0.01	MCL
Chromium	0.05	MCL
Cobalt	0.05	BG
Copper	1.0	MCL[c]
Lead	0.05	MCL
Mercury	0.091	BG
Molybdenum	0.21	BG
Net gross alpha (pCi/l)	97.0	BG
Nickel	0.04	BG
Nitrate (as nitrogen)	10.0	MCL
Radium-226 and -228 (pCi/l)	75.0	BG
Selenium	0.01	MCL
Silver	0.05	MCL
Uranium	0.044	MCL
Vanadium	0.03	BG
Zinc	5.0	MCL[c]
Elements contained in hazardous constituent compounds[d]		
Aluminum (aluminum phosphide)	0.1	BG
Cyanide (soluble salts and complexes)	0.01	BG
Fluoride (carbon oxyfluoride)	2.2	BG
Strontium (strontium sulfide)	10.1	BG
Sulfide (strontium sulfide, carbon disulfide)	10.0	BG

[a]Hazardous constituents identified in the tailings at the Grand Junction processing site (Table 3.1). Concentration in mg/l unless noted.; pCi/l= picocuries per liter.

[b]MCL = maximum concentration limit (40 CFR 192.02(a)(3), Table 1).
BG = statistical maximum background concentration.

[c]EPA secondary drinking water standard MCL.

[d]Appendix I of 40 CFR 192.02(a)(3)(i).

3.1.3 Point of compliance

Since the uppermost aquifer is hydrogeologically isolated from any potential seepage of leachate from the disposal cell, no post-closure groundwater monitoring has been proposed (see Section 3.4), and no point of compliance will be required.

3.2 PERFORMANCE ASSESSMENT

To demonstrate adequate performance of the disposal cell and protection of human health and the environment, design parameters were evaluated in conjunction with hydrogeologic characteristics (hydrogeologic isolation of the uppermost aquifer from tailings seepage) of the Cheney disposal site to determine: 1) the redistribution of moisture within the disposal cell following construction, and the migration of tailings seepage from the disposal cell; and 2) the geochemical attenuation of hazardous constituents identified in the tailings pore water by natural geologic materials beneath the cell. In order to evaluate these processes, saturated/unsaturated finite element modeling and laboratory testing of geologic materials from the disposal site were conducted as described in the following sections.

3.2.1 Finite element modeling of the disposal cell

A conservative, two-dimensional finite-element method analysis was performed on the Cheney disposal cell (see Calculation GRJ-05-91-12-05-00, Appendix A to Attachment 3) to assess the effects of transient drainage from construction water and to model long-term steady state seepage conditions. The computer code UNSAT2 written by Davis and Neuman (1983) was used. Two-dimensional analyses were employed to allow for inclusion of the effects of lateral drainage off the cell.

The system that was modeled consists of the vicinity property material, the tailings, and the underlying Mancos Shale foundation material. The Mancos Shale is further divided into two material types, a homogeneous, weathered material and an unweathered, fractured, anisotropic material.

For modeling purposes, the upper boundary of the cell receives a constant influx of moisture equal to 1.0×10^{-7} cm/sec, which is the saturated hydraulic conductivity of the radon barrier. The base and sides of the cell were modeled as unsaturated seepage faces which will allow moisture to transit the boundary to the material under non-saturated conditions. As the moisture content increases and saturation is achieved, the material will begin to behave under saturated hydraulic conditions. Saturated hydraulics will therefore control moisture flow from the cell, preventing unrealistic build-up of moisture within the cell.

Saturated hydraulic conductivity values for the weathered and unweathered Mancos Shale material varied, as discussed in detail in Section 3.2.4 of Attachment 3. In order to bound the range of variability in tested conductivity measurements, a sensitivity analysis was performed. This sensitivity analysis involved multiple computer runs with the various conductivity values using the UNSAT2 computer code providing insight into possible moisture redistribution scenarios (see Calculation GRJ-05-91-12-05-00), Appendix A of Attachment 3).

Results indicated that transient drainage of construction water will exit the base of the cell through fractures within five years after completion of construction. Slight ponding of water is possible in tailings overlying weathered portions of the Mancos Shale. Maximum ponded depths range between two to three meters. Drainage occurs into discontinuous fractures where the fluid will remain until accepted into the matrix of the Mancos Shale. The finite-element method mesh generated for the analysis incorporated the above system and extended approximately 15 feet into the Mancos Shale foundation below the lowest point of the disposal cell. The cover was not included in the analysis.

3.2.2 Geochemical attenuation

Extensive laboratory tests were conducted to evaluate the geochemical attenuation capacity of selected on-site geologic materials. The characterization of these materials and results of the laboratory tests are presented and discussed in detail in Section 3.2.6 of Attachment 3.

In summary, the petrologic, mineralogic, and geochemical characteristics of the alluvium and Mancos Shale at the disposal site show that they will attenuate the hazardous constituents (including cadmium, lead, molybdenum, selenium, vanadium, uranium, and zinc) present in the tailings pore water. The experimental column and batch leaching results of tests on composite alluvium samples show that foundation material would attenuate concentrations of contaminants in tailings pore water to below detection limits and/or MCLs for those constituents that have MCLs. In addition, reducing conditions exist in the underlying Mancos Shale.

3.3 CLOSURE PERFORMANCE ASSESSMENT

The DOE has demonstrated that the proposed remedial action plan for the Cheney disposal site will comply with the proposed EPA groundwater protection standards. The DOE has assessed the performance of the proposed disposal unit at the Cheney disposal site in conjunction with the hydrogeologic system, and has shown that the disposal cell will minimize and control releases of hazardous constituents to groundwater and surface water, and radon emanations to the atmosphere to the extent necessary to protect human health and the environment (40 CFR 192.02(a)(4)).

Natural, stable materials have been proposed for use in construction of the Cheney disposal cell so that long-term performance is ensured (see Section 2.2). The DOE has also demonstrated that the design features necessary for compliance with the groundwater protection standards minimize the need for further maintenance at the disposal site.

3.4 GROUNDWATER MONITORING PROGRAM

[] 3.4.1 Uppermost aquifer

Groundwater in the uppermost aquifer (Dakota Sandstone) beneath the Cheney disposal site is not a current or potential source of drinking water and meets the EPA criterion for Class III (limited use) designation because the concentration of TDS is in excess of 10,000 mg/l (40 CFR 192.11(e)(1)). Post-closure monitoring of groundwater in the uppermost aquifer is not proposed because of the Class III designation. Also, any groundwater at depth is protected because it is hydrogeologically isolated from potential seepage of leachate from the disposal cell by approximately 750 feet of confining shales and sandstones of the Mancos Shale, and there is an upward vertical gradient from confined groundwater in the Dakota.

3.4.2 Alluvial paleochannels

Small quantities of groundwater occur in isolated narrow alluvial paleochannels incised into the upper surface of the eroded and weathered Mancos Shale bedrock (see Section 3.2.3 of Attachment 3 of the RAP). Recharge to the paleochannels is very limited, and there is no evidence of discharge of groundwater from the paleochannels to the surface in the vicinity of the disposal site. Also, it is unlikely that groundwater from the paleochannels would enter the disposal cell and cause any impact. Existing or anticipated use of shallow groundwater in the paleochannels is minimal because of the insignificant yield to a well and the low population density resulting in low demand for water.

The disposal cell has been located and designed to restrict migration of any potentially contaminated seepage to isolated paleochannels peripheral to the cell (no paleochannels are beneath or immediately adjacent to the disposal cell) or to the land surface in the area. It is not likely that leachate from the disposal cell would move a sufficient lateral distance to reach paleochannels in the area. There is also evidence that any potential leachate migrating from the disposal cell would percolate into the surrounding weathered/fractured bedrock (Mancos Shale) rather than preferentially seeking the paleochannels. Even if leachate did get into the paleochannels, it should not cause any significant impact to human health and the environment.

Although is seems very unlikely that the seepage of leachate from the disposal cell will interact with groundwater in the alluvial paleochannels and impact human health and the environment, an indirect monitoring program will be implemented as a best management practice to provide an indication that the disposal cell is operating as designed and that human health and the environment are being protected to the extent required and practicable.

The monitoring program would consist of two monitor wells located in paleochannels downgradient from the disposal cell (adjacent to the northwest and southwest corners of the cell--Figure 2.1). The monitor wells would be screened in the basal part of the paleochannels to monitor the presence and variability of water in the system. Water levels would be measured periodically to detect changes in groundwater quantity, which could result from natural recharge or from seepage of leachate from the disposal cell. Water samples from the monitor wells could be analyzed periodically for anticipated hazardous constituents to determine if groundwater in the paleochannels is being affected by leachate from the cell. If any excursions are noted, the data would be evaluated and assessed to determine the extent of the potential impact and risk involved, and mitigating measures would be considered in conjunction with discussions with the NRC. Details of the monitoring program will be discussed in the long-term surveillance plan.

3.4.3 Processing site

Groundwater samples will be collected semiannually from selected monitor wells at the Grand Junction processing site, until completion of disposal activities, to monitor the effects of the remedial action on water quality. Groundwater monitoring during the interim between completion of disposal activities and start of groundwater remediation will be determined and implemented under the groundwater restoration phase of the Project.

3.5 CORRECTIVE ACTION PLAN

The DOE is required by 40 CFR 192.02(c) to provide an evaluation of alternative corrective actions that could be implemented if the disposal cell monitoring program indicates that the unit is not performing adequately. The DOE should consider reasonable failure scenarios of the disposal unit and demonstrate that corrective actions could be implemented no later than 18 months after detecting an excursion.

Since no groundwater monitoring has been proposed at the Cheney disposal site (see Section 3.4), the only monitoring will be visual inspection of surface conditions during routine surveillance and maintenance. Should previously unnoticed seeps or other surface exposures of groundwater be observed during routine surveillance of the site, it shall be noted and appropriate water samples shall be collected and analyzed to assess if the water is contaminated. Should the analyses indicate that the water is contaminated, an assessment of the source of the water may be made, and an assessment of the threat to human health and the environment shall be conducted. If appropriate and necessary, the DOE may perform corrective actions to arrest the source of the contaminated water and/or to limit exposure of the water at land surface. Such corrective actions may include, but are not limited to: 1) constructing a sump or other device to collect the contaminated groundwater before it reaches land surface, and treating or evaporating the collected water as necessary; or 2) controlling access to the contaminated water by covering it with graded, large-diameter rock until it can reinfiltrate or evaporate. The DOE has assessed that the probability of surface exposure of tailings seepage is nearly zero (see Section 3.2); therefore, the necessity for corrective actions at the Cheney disposal site is highly improbable.

4.0 CLEANUP AND CONTROL OF EXISTING CONTAMINATION

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

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

Based upon the current level of site characterization at the Grand Junction processing site, cleanup of groundwater in the uppermost aquifer (alluvium) may be unnecessary because of the relatively high transmissivity of the aquifer (see Section 3.1.4, Attachment 3), and therefore the ability of the aquifer to flush and disperse contaminants to acceptable concentrations. Additionally, by removing the tailings and vicinity property materials from the processing site, the source of groundwater contamination will be removed and the concentrations of contaminants in the alluvium will begin to decrease rapidly.

By deferring groundwater cleanup in the uppermost aquifer (alluvium) until the processing site can be adequately evaluated, human health and the environment will not be affected because: 1) no wells currently exist within the affected environment in the vicinity of the processing site that withdraw groundwater from the alluvium (based on a recent well inventory adjacent to the processing site); 2) no wells are anticipated to be drilled to exploit groundwater within this area in the near future; and 3) during the interim period between surface remedial action and groundwater restoration, efforts will be made to prevent groundwater use in the vicinity of the processing site through institutional controls, and residents will be notified of potentially contaminated groundwater. Recent analyses of groundwater indicate that concentrations are remaining relatively stable with time, and Colorado River surface water samples (at low water stage) indicate that no concentrations of hazardous constituents exceed the proposed concentration limits adjacent to or downstream from the site. Deferral of groundwater cleanup until the tailings and all contaminated materials are removed, and the site can be fully evaluated, does not preclude the possibility of the DOE performing active restoration at the site, if warranted.

[]

REFERENCES

Baca, B. G., and Swen, M. O., 1990. Independent Verification and Benchmark Testing of the UNSAT-H Computer Code, Version 2.0, Idaho National Engineering Laboratory, EG&G Idaho, Inc., prepared for Westinghouse Hanford Company and U.S. Department of Energy.

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

Davis, L. A., and Neuman, S. P., 1983. "Documentation and Users Guide: UNSAT2 Variably-Saturated Flow Model," WWL/TM-1791-1, Water, Waste and Land, Inc., Ft. Collins, Colorado.

NRC (U.S. Nuclear Regulatory Commision), 1989. Staff Technical Position, "Standard Format and Content for Documentation of Remedial Action Selection at Title I Uranium Mill Tailings Sites," Division of Low-level Waste Management and Decommissioning, Office of Nuclear Materials Safety and Safeguards, Washington, D.C.

Richards, L. A., 1931. "Capillary Conduction of Liquids in Porous Mediums," in Physics, Vol. 1, pp. 318-333.

Van Genuchten, M. Th., and Nielson, D. R., 1985. "On Describing and Predicting the Hydraulic Properties of Unsaturated Soils," in Annales Geophysical, Vol. 3, No. 5, pp. 615-628.

1

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. 4RJ03-07-90-13-06 (01)-00   DISCIPLINE Hydrology   NO. OF SHEETS 77

PROJECT:

UMTRA

SITE: GRJ03: Cheney disposal site for The GRJ Tailings, Grand Junction, CO

FEATURE: Geochemical Attenuation of Contaminations by soil: Attenuation capacities of the geologic materials beneath the proposed disposal cell

SOURCES OF DATA:

All included in the attachments

SOURCES OF FORMULAE & REFERENCES:

None

Standard arithmetic calculations

PRELIMINARY CALC. [✓]   FINAL CALC. [ ]   SUPERSEDES CALC. NO. ______

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		[signature]	9/1/90	[signature]	9/90	[initials]	9/90

6/86

SEP '90

GEOCHEMICAL ATTENUATION OF CONTAMINANTS BY SOIL: ATTENUATION CAPACITIES OF THE GEOLOGIC MATERIALS BENEATH THE PROPOSED DISPOSAL CELL AT THE CHENEY, GRAND JUNCTION, SITE.

CALCULATION NUMBER: GRJ03-07-90-13-06(01)-00.

A. Purpose

The purpose of this calculation is to develop quantitatively the capacities for attenuation of the hazardous constituents in the tailings pore water by the geologic materials beneath the Grand Junction tailings disposal cell at the proposed Cheney site.

The attenuation capacities thus determined will be incorporated in the overall design data base for the tailings disposal cell, and will be used in particular to develop a groundwater protection strategy at the Cheney site.

B. Overview of Method

The attenuation capacities were determined using data from column and batch tests performed following the general procedures described in Attachment A of this calculation. Several composite samples for the Quaternary alluvium and the Mancos shale were tested. The composite samples were prepared using the available drill cuttings, and grab samples from the freshly opened pits at the Cheney site. The composite samples are described in Attachment B. Additionally, samples of a peat from a bog near grand Junction and supplied by local vendor were also tested, in the event a geochemical barrier with peat were needed for contaminant attenuation. Two types of samples containing the peat were tested: one containing 100 percent peat and the other composed of 10 percent peat mixed with one of the alluvium composite samples (sample 179-4).

The composite samples of alluvium and Mancos shale were characterized for the physical and chemical parameters that control attenuation capacities. These parameters include grain size distribution, acid neutralization potential, soil pH, cation exchange capacities, and content of various reactive minerals and chemical constituents. The physical and chemical parameters on the composite samples are provided in Attachment C.

Two test fluids were used during the tests. The groundwater from the monitor well 589 at the Grand Junction processing site spiked with known amounts of arsenic, cadmium, molybdenum, lead and selenium were used for the batch tests, and also for the initial column tests. The composition of this groundwater after spiking is shown in Attachment D-1. The test fluid used for the subsequent tests was a composite water sample prepared by mixing the water samples collected using lysimeters installed at the bottom of the

9/12/90

tailings but within the unsaturated zone of the Grand Junction tailings pile. The concentrations of the hazardous constituents arsenic, beryllium, cadmium, cobalt, chromium, nickel, selenium, uranium, vanadium and zinc in this test fluid were elevated by spiking with known amounts of soluble salts of these constituents. Attachment D-2 shows the composition of this test fluid.

In order to estimate reproducibility of the column tests, triplicate columns were tested for several of the composite sample. The reproducibility data are provided in Attachment D-3.

A complete chemical analysis was conducted on each of the leachates from the batch and the column tests. For the column tests, each effluent pore volume was separately analyzed. The chemical analysis was performed using the EPA approved analytical methods by the Core Laboratories, an EPA Contract Laboratory Participant, under a subcontractors agreement to the Jacobs Engineering Group.

C. Assumptions

1. The composite samples used for the tests represent the Quaternary alluvium and the Mancos Shale beneath the disposal site at Cheney. This is a reasonable assumption given the fact that a) the composites were prepared thoroughly mixing all available drill cuttings from a large number of wells that are geographically well distributed at the site and b) in case of the composites from the experimental pits, these composites were prepared mixing several randomly collected subsamples; however, these latter composites do not reflect the special variability unlike the drill-cuttings composites.

2. The simulated test fluids represent the chemistry of the tailings pore water expected to present at the bottom of the stabilized tailings pile.

This is a reasonable assumption for both of the test fluids used because of the following reasons. The chemistry of the groundwater from the well 589 is generally similar to that of the tailings pore water. The composite test solution prepared by mixing water samples from the lysimeters installed in the tailings should closely represent the chemistry of the tailings pore water. The first test fluid (groundwater from well 589) was not spiked with all of the hazardous constituents present in the tailings. This fact however, does not affect the chemical behavior of the test fluid.

3. The flow rates used in the column tests is applicable to the flow rate of the tailings leachate through the subsurface materials at the Cheney site.

The flow rate used in the column tests were more rapid than the expected flow rate of tailings leachate in the alluvium and the Mancos Shale underlying the proposed disposal cell. This fact however, indicates that the hazardous constituents are likely to be attenuated more effectively than in the laboratory tests due to longer residence time of the pore fluid in the alluvium and the Mancos Shale at the Cheney site. (this is a conservative assumption)

D. Material Properties

The physical and chemical properties of the composite samples used in the batch and column tests are presented in Attachment C.

E. Data Sources

All data used in calculations of the attenuation capacities are presented in the text and Attachments D. Additional supporting data are presented in Attachments A, B, C and E.

F. Calculation

Assume that the concentration of a hazardous constituent "X" in test fluid is A mg/l, and the concentration of "X" in the leachate from the batch or column test is B mg/l. The percent of "X" attenuated is calculated as follows:

$$\text{Percent "X" attenuated} = \frac{A - B}{A} \times 100.$$

For example, the concentration of As in test solution is 2.3 mg/l and that in the batch leachate of the Mancos Shale composite is 0.007 mg/l (Table 1). Percent As attenuated is calculated as follows:

$$\text{Percent As attenuated} = \frac{2.3 - 0.007}{2.3} \times 100 = 99.7.$$

The concentration of the hazardous constituents in the test fluid and the percent attenuation of these constituents for the batch test is given in Table 1.

Table 2 shows the concentrations of the hazardous constituents in the first effluent pore volumes for the column tests and Table 3 shows the corresponding percent attenuation data for arsenic, cadmium, molybdenum, nickel, selenium, uranium and zinc. Because of the very slow flow rate through the shale samples, column test data are vailable only for the alluvium samples.

G. Conclusions and Recommendations

The test solution for the batch tests was spiked with only four hazardous constituents: arsenic, cadmium, selenium and molybdenum. The data show that arsenic and cadmium were almost completely attenuated by the alluvium and the Mancos Shale. Both selenium and molybdenum are partially attenuated by the Mancos Shale. The alluvium also partially attenuated selenium, but shows no

SEP '90

measurable attenuation for molybdenum.

Chemical analysis of the first effluent pore volumes through the columns of the alluvium samples are shown in Table 2. The data show that all hazardous constituents that were detected in the tailings pore water (Attachment D-4) are below or close to their detection limits in the first effluent pore volumes except arsenic, cadmium, molybdenum, nickel, selenium, uranium, zinc, strontium, fluoride and nitrate; small amounts of strontium and fluoride were released by the test materials except the two samples containing peat which partially attenuated fluoride; all materials released nitrate.

The concentrations of strontium, fluoride and nitrate in the groundwater of the Mancos Shale and the Dakota Sandstone (Attachment E) at the Cheney disposal site are below or close to those in the first effluent pore volumes (Table 2). This implies that strontium, fluoride and nitrate leached naturally by meteoric water from the geologic materials above the groundwater at the Cheney disposal site do not significantly elevate their concentrations in the groundwater.

Table 3 shows that all column test materials attenuated arsenic and cadmium below their EPA MCLs; attenuated more than 85 percent of uranium, vanadium and zinc, and attenuated variable but significant amounts of molybdenum, selenium and nickel. It should be noted that the concentrations of all of these hazardous constituents in the test fluid were higher than those in the tailings pore water (Attachment D-4). If the tailings pore water concentrations were used in the column tests, it is likely that the concentrations of these constituents in the effluent solutions of the first pore volumes would be close to, or below, the EPA groundwater standards.

In summary, the batch and column test data demonstrate that the alluvium and the Mancos Shale underlying the proposed disposal site will attenuate the hazardous constituents present in the tailings pore water; and it is likely that the concentrations of the hazardous constituents in the tailings leachate would be reduced to below the EPA standards due to attenuation by the alluvium.
some constituents, but not all

Results

the results are presented in tables 1, 2 and 3. See the last paragraph above for conclusions.

References

All included in the attachments.

SEP '90

TABLES AND ATTACHMENTS

Tables

Table	Description
1 ✓	Results of the batch tests... Test fluid composition and hazardous constituents attenuation data from batch tests.
2 ✓	Chemical analysis of the first effluent pore volumes in column tests
3 ✓	Percent hazardous constituents attenuated from the first effluent pore volumes in column tests.

Attachment	Description
A ✓	Batch and column test procedures.
B ✓	Description of the composite samples used in the batch and column tests.
C	Mineralogical and Chemical Characterization... Physical and chemical properties of the composite samples.
D-1 ✓	Composition of the spiked groundwater from well 589.
D-2	Hazardous constituents detected in the pore water of the Grand Junction tailings.
D-3	Compositions of the test fluids prepared by mixing water samples from the lysimeters installed in the tailings pile, and spiking with known concentrations of hazardous constituents.
D-4	Reproducibility of column tests: Chemical analyses of the first effluent pore volumes of the triplicate columns of individual test materials.
E ✓	Groundwater quality of the Mancos Shale and the Dakota Sandstone.

Table 1

Results of the batch tests, cheney disposal site, Grand Junction, Colorado

	Concentration of hazardous constituents, mg/l (percent attenuated)			
	As	Cd	Mo	Se
Test solution	2.30	0.076	6.20	8.4
Test pad Alluvium (GCM-2, -3 and -4)	0.016 (99.3)	<0.005 (93.4)	6.20 (0)	4.80 (42.9)
Homogenized Alluvium (GCM-1)	0.024 (99.0)	0.006 (92.1)	6.30 (0)	3.50 58.5)
Mancos Shale (GCM-5)	0.007 (99.7)	0.005 (93.4)	5.25 (15.3)	2.10 (75)

9/ /90

L.M. COCKS FE...
SEP '90

Table 2

Chemical analysis of the first effluent pore volume from column tests, Cheney disposal site, Grand Junction, Colorado.

Concentration in mg/l

Hazardous constituents	Sample No 179-1	179-2	179-3	179-4	179-4+10% peat	Peat
Al	< 0.50	<0.50	<0.50	<0.50	0.533	0.566
Sb	<0.001	<0.004	0.0013	0.006	<0.001	0.001
As	0.003	0.005	0.0057	0.005	0.006	0.012
Ba	0.100	<0.10	<0.10	0.10	<0.1	0.10
Be	<0.050	<0.05	<0.05	<0.05	<0.05	0.05
B	3.583	2.85	2.75	4.23	3.867	0.1
Br	0.420	0.85	14.33	5.47	2.077	0.2133
Cd	0.0006	0.0009	0.001	0.0008	0.001	0.0012
Ca	548.33	503	908	503	650	1600
Cl	1900	2033	3433	3067	1966	1400
Cr	<0.100	<0.1	<0.10	<0.10	<0.1	0.1
Co	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Cu	0.20	0.10	<0.10	0.167	<0.133	0.10
F	1.6	1.67	1.733	2.533	0.467	0.20
Fe	<0.2	<0.2	<0.20	<0.20	0.133	0.433
Pb	<0.001	<0.001	<0.001	<0.001	,0.001	0.001
Mg	531.77	500	423	673	505	473
Mn	0.533	0.50	0.10	<0.10	0.60	2.933
Hg	<.0002	<.0001	<.0001	<.0001	<.0001	0.0001
Mo	3.033	2.6	1.10	1.67	0.633	0.50
Ni	1.2	1.167	1.033	1.33	1.533	0.90
NO3	340.20	77.43	438.4	584	668	1935
PO4	0.167	0.167	0.233	0.10	0.233	0.967
K	26.67	20.0	5.0	25.0	16.70	26.67
Se	0.567	0.67	0.20	1.43	0.70	0.03
SiO2	26.16	22.0	17.83	26.83	36.0	55.83
Ag	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
Na	3076	3720	4193	5682	3358	458
Sr	8.92	8.8	11.92	10.32	7.7	9.33
SO4	7486	8150	7066	11566	6130	2879
Tl	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Sn	<0.02	<0.02	<0.02	<0.02	<0.02	0.02
TDS	14528	15589	16286	21822	13220	8755
U	0.5633	0.114	0.0427	0.108	0.094	0.0057
V	<0.100	<0.10	<0.1	<0.10	<0.10	0.10
Zn	0.233	0.167	0.20	0.133	0.267	0.267

(1) Arithmetic mean of three column-effluents for each material

9/12/90

SEP '90

Table 3

Percent hazardous constituents attenuated from the first pore volumes in the column tests, Cheney disposal site, Grand Junction, Colorado

Hazardous constituents	Percent hazardous constituents attenuated					
Sample No	179-1	179-2	179-3	179-4	179-4+10% peat	peat
As	99.4	99.91	99.99	99.91	99.89	99.76
Cd	99.91	99.86	99.86	99.89	99.83	99.86
Mo	31.14	40.91	96.07	62.05	85.61	86.64
Ni	78.95	79.53	97.32	80.12	73.10	84.21
Se	82.82	79.79	93.94	56.58	78.79	99.09
U	85.38	97.04	99.96	97.20	97.56	99.84
Zn	96.97	97.83	97.40	98,27	96.53	97.40

L.M. COONS PE, PHG

SEP '90

PSL 29 JUNE 90

7/2/90

7/5/90

(The Original signed copy of Attachment A is in Attachment A of Calc # GUN08-05-90-13-06(01)-00 for the Gunnison Landfill disposal site)

ATTACHMENT A

BATCH AND COLUMN TESTING PROCEDURES

L.M. COONS PE, PHG
SEP '90

Date: March 7, 1990

REVISED PROCEDURE: Section 16-1-8 Date: 09-12-88 Effective: 10-27-88

TITLE: Batch and Column Testing

1.0 PURPOSE

Provide a procedure to perform batch and column leach tests on uranium mill tailings, soils, sediments, or combinations and mixtures thereof.

2.0 SCOPE

This procedure is applicable to TAC and its contractors or subcontractors who have responsibilities and duties to perform batch or column leach experiments. Further, portions of Section 10.8.2 entitled "Packaging and Shipping Procedure for Unassayed Tailings Samples", Section 14.4.1 entitled "Soil and Rock Core Borehole and Test Pit Logging", Section 16.1.10 entitled "Field Measurements of Water Samples for Temperature, Conductivity, pH, Alkalinity, and Total Acid", and Section 16.1.13 entitled "Field Measurements of Oxidation/Reduction Potential (E_h) in Water Samples", are also applicable to this procedure.

3.0 SAFETY GUIDANCE

Safety procedures outlined in this section must be followed when applicable to sample collection, moisture content determination, batch leach experiments and column leach experiments. Exposures to hazardous chemicals and radioactive materials must be kept as low as reasonably achievable in accordance with the ALARA principle. All hazardous and radioactive materials must be properly stored and transported (Section 10.8.2).

3.1 Analysts handling hazardous and/or radioactive samples must wear appropriate attire (e.g., rubber gloves, lab coat, glasses and dust masks) to limit unnecessary exposure.

3.2 Attire, where practicable, shall be disposable and will be disposed of in a designated container.

3.3 All analysts working at the Rad Lab must have and wear a TLD badge to document radiation exposure(s).

3.4 Analysts must be properly trained in the use of radiation survey meters prior to conducting sample or contamination surveys.

3.5 All radioactive materials stored in the North Bay or Geotech areas must be signed out using the Log Books for each area.

3.6 Analysts must exercise caution and provide controls when practicable to prevent unnecessary exposure, contamination of laboratory equipment and release of hazardous and/or radioactive materials.

3.7 All hazardous chemicals such as acids must be properly stored when not in use.

3.8 Containment must be provided when liquids containing hazardous and/or radioactive materials are being used.

3.9 Every attempt must be made to avoid production of mixed wastes by separating chemical and radioactive wastes whenever possible.

3.10 Analysts must immediately notify the Radiation Protection Officer if radioactive materials are released and notify the Laboratory Manager if hazardous chemicals are released.

3.11 Spilled or released hazardous and/or radioactive materials must be cleaned up as quickly as possible following notification procedures of 3.10.

3.12 Contaminated labware and decontamination wash solutions must be placed in separate designated disposal containers.

4.0 CHEMICALS AND REAGENTS

4.1 Laboratory Reagent(s)–Consult with Geochemist or Hydrologist to determine reagent grade chemicals, reagents, or other solutions required for experiment.

4.2 Synthetic Ground Water–an aqueous solution comprised of reagent grade chemicals or solutions that approximate ground water sample concentrations based on previous laboratory results. See 8.1 and 9.1.

A. ALTERNATE. Mix distilled water with tailings, soil, sediments, or other combination(s) and mixture(s) of samples. Filter and use the filtrate for the experiment. Record weight of sample and volume of distilled water used.

4.3 Lixiviants–an aqueous solution that contains a compound which will promote the dissolution or desorption of soluble constituents within the aquifer matrix. See 8.1 and 9.1.

A. Prepare lixiviant solution(s) as required by the Geochemist or Hydrologist. Record weight of lixiviant(s) added to liquid and volume of liquid used to prepare solution. Specify lixiviant(s) used. NOTE: Liquid may be distilled water, ground water, or other suitable liquid.

B. Prepare lixiviant(s) in solid form, as required by the Geochemist or Hydrologist. Weigh lixiviant(s), mix with sample or add lixiviant to column. See B.1 or B.2 below. Record weight of lixiviant(s) and sample used. Specify lixiviant(s) used. NOTE: Sample may consist of tailings, soil, sediment, or a pre-determined combination and mixture of these media. See 8.1 and 9.1.

1. Determine lixiviant(s) to be used, weigh out appropriate aliquot, and mix well with sample. Add mixture to column as directed in 9.4.

L.M. COON SEP '90

2. Determine lixiviant(s) to be used, weigh out an appropriate aliquot, and add to column as a single unmixed layer. NOTE: Place lixiviant on top or bottom of column.

4.4 Water, deionized (ASTM Class II or better). See Reference 11.2.

4.5 Nitric Acid: HNO_3. Reagent Grade (~70%: ~16 M or ~16 N).

4.6 Silica sand

4.7 Radiac Wash or equivalent (Use for radioactive decontamination).

A. 30% (v/v) Radiac Wash Solution: Add ~600 mL of Radiac Wash to a 2,000 mL graduate cylinder containing ~1300 mL of deionized water and mix well. Add deionized water to the 2,000 mL mark and mix well. Pour solution into a polyethylene container labelled with "~30% (v/v) Radiac Wash Solution", "600 mL Radiac Wash/2,000 mL deionized water", date, and initials.

B. ALTERNATE. 5% (w/v) Na_4EDTA Solution: Add 50 grams of Tetrasodium EDTA reagent powder to a 1000 mL volumetric flask and add ~500 mL of distilled water to dissolve the EDTA powder. Add distilled water to the 1000 mL mark on the flask and mix solution well. Pour solution into plastic container. Label container with "DeCon Solution", "~5% (W/V) Na_4EDTA Solution", "50 g Na_4EDTA/liter of distilled water", add date, and initial. Dispose of solution into toxic or hazardous waste container after 6-8 weeks and replenish solution with a fresh batch of EDTA solution.

5.0 EQUIPMENT AND SUPPLIES

5.1 Portable Radiation Survey Meters:

A. Beta-Gamma

B. Alpha Scintillation

5.2 Top Loading Balance, 0.1 g

5.3 Analytical Balance, 0.10 mg.

5.4 Wrist Action Shaker: with timer and automatic/manual operation

5.5 Conductivity Meter with thermometer

5.6 pH Meter, with automatic temperature compensator (ATC) and with expandable readout.

5.7 Thermometer

5.8 Refrigerator set at 4° C.

5.9 Drying Oven: 0-200° C. Range

5.10 Pump, peristaltic: with variable speed, with 3/16" i.d. tubing.

5.11 Pyrex or polyethylene beakers: 50, 100, 150, 250, 400 mL

5.12 Pyrex or polyethylene Erlenmeyer flasks: 125, 250, 500, 1000 mL

5.13 Pyrex or polythylene graduate cylinders: 50, 100, 250, and 500 mL

5.14 Pyrex filter flask, heavy duty: 2000 mL

5.15 Pyrex or polyethylene filter apparatus: 50 , 300, 500 mL

5.16 Filters:

A. Membrane filter; 0.45 u , 2" diameter

B. Glass fiber filter (for column(s); 75 mm diameter, Micron Separations, Inc.

C. Polyethylene filter disc (for column(s); ~4" diameter and with 15-25 holes in the disc.

D. Mini-Capsule filter (No. 12123) or equivalent: 0.45 um, Gelman Sciences

5.17 Stoppers:

A. Rubber: Nos. 7, 8, 9, and 10

B. Bakelite or equivalent (for columns); machined, 4" diameter with 3/16" o.d. x ~3" length glass or polyethylene tube located in center of stopper. Two (2) each for each column.

5.18 Column(s), polycarbonate. Purchase from local supplier and cut into appropriate lengths.

A. ~12" x ~4" i.d.

B. ~48" x ~4" i.d.

5.19 Tygon tubing or equivalent:

A. 3/16" i.d. x 1/16" wall

B. 1/2" i.d. x 1/8" wall

5.20 Plastic Pans: ~12" width x ~14" length x ~8" height

5.21 Aluminum pans (to hold sample): disposable

5.22 Laboratory Log Book

6.0 PROCEDURE: Sample Collection

o Safety guidance provided in 3.0 must be followed, as applicable, for this procedure.

o If the samples are contaminated, portions of Section 10.8.2, are applicable to this procedure. If the samples are uncontaminated, portions of Section 14.4.1 are applicable to this procedure. Sample collectors must be familiar with and use appropriate portions of Section 10.8.2 and Section 14.4.1.

6.1 Collect tailings, soil, or sediment samples with clean utensils and store in sample containers. Mix sample well.

6.2 Determine radioactivity of sample and record value in uR/hr on sample data sheet and on sample container. NOTE: Use calibrated portable radiation survey meter(s).

6.3 Prepare logs of test pits and core holes according to Section 14.1.4 of the Albuquerque Operations Manual.

6.4 The methods for cleaning labware used to collect the sample(s) will be dependent upon the components of interest, (e.g., samples collected for organic analyses should not come in contact with plastic, etc).

7.0 PROCEDURE: Moisture Content Determination or Preparation of a Dried Sample

o Safety guidance provided in 3.0 must be followed, as applicable, for this procedure.

o Use ASTM Method 2216, see Reference 11.1.

7.1 Weigh 100 g aliquot of sample into a sample container labelled with sample identification number. Record net weight as "wet weight". Sample consists of tailings, soil, sediments or any combination and mixture thereof.

A. ALTERNATE. If sample is to be analyzed as a wet sample, omit all of 7.0 and proceed directly with 8.2 or 9.2.

7.2 Place sample container into a drying oven, set temperature controller to 100° C., close oven door, and turn oven on. Check temperature reading on the thermometer periodically.

A. Oven should be located in an exhaust hood or should be vented out of the building with appropriate exhaust tubing.

7.3 Dry sample for 4-12 hours. Upon completion of drying time, shut off oven, and allow sample to cool to room temperature. NOTE: Length of drying time depends on type of sample and amount of moisture in the sample.

7.4 Weigh sample and record net weight as "Dry Weight". Record the following information in the laboratory log book: A) date and time of determination, B) sample number, location, and description, C) mass of sample before drying ("Wet Weight"), D) drying time and temperature, and E) mass of dry sample ("Dry Weight").

7.5 Calculate and report percent moisture as follows:

$$\% = (\text{Wet Weight} - \text{Dry Weight}) \div \text{Wet Weight} \times 100\%.$$

7.6 Pulverize dried sample by placing sample into 3 or 4 heavy duty plastic bags and crush sample into fine dust by beating bag with a rubber mallet. Mix sample by shaking and tumbling bag. NOTE: If necessary, use additional bags if bag(s) are punctured.

A. ALTERNATE. Use a mortar and pestle to pulverize the sample.

7.7 Sample now ready for analysis.

8.0 PROCEDURE: Batch Leach Experiments

- Safety guidance provided in 3.0 must be followed, as applicable, for this procedure.
- Perform Batch Leach Experiments according to the JEG-modified version of ASTM Method 4319-83. See Reference 11.2.

8.1 Consult with Geochemist or Hydrologist to determine method of batch preparation and use of solution.

A. Should sample(s) be analyzed in wet or dry form? Should solid lixiviant(s) be mixed with the sample?

B. What kind of lixiviant(s) will be used? Will lixiviants require mixing before use? What is the composition of the lixiviant(s)? Mixtures? What will "groundwater" consist of (i.e, distilled water, synthetic groundwater, site specific groundwater, or other solution)?

C. What volume in mL will constitute a "Pore Volume?" After what pore volume(s) should samples be collected?

8.2 Weigh 200 g of a wet sample into a 1000 mL Erlenmeyer flask labelled with sample number. Weigh sample to the nearest 0.01 g and record weight as wet weight. NOTE: Sample is tailings, soil, sediment, or a combination and mixture thereof.

A. ALTERNATE. Weigh out 75 ± 5 g of a dried and pulverized sample into a 500 mL Erlenmeyer flask. Weigh sample to the nearest 0.01 and record weight as dry weight.

8.3 Add ~800 mL of distilled water to the flask and mix solution. Record volume in log book. Stopper flask. NOTE: Use, if required, synthetic ground water (see 3.2), site specific ground water, or lixiviant solution (see 3.3) as a leach medium. Add liquid volume equal to ~four (4) times the amount of solid sample.

A. ALTERNATE. Add ~300 mL of distilled water to the flask of 8.2A. Stopper flask. Record volume in log book. See NOTE of 8.3.

8.4 Mount flasks on Wrist Action Shaker and tighten clamps so that flasks do not move. Place a plastic pan beneath flasks so that leaks or spills may be caught in the pans. CAUTION: Neck of flask or clamp may break due to excess pressure.

L.M. COONS

SEP '90

8.5 Turn on shaker and shake samples for 60 minutes. During shaking period, check flasks periodically to make sure they are secure and to see if liquid and samples are mixing well. If necessary, stop shaker and tighten clamps. After shaker stops, allow samples to set for 2-4 hours.

8.6 Repeat 8.5 once more. Allow samples to set overnight. Check stoppers and flasks for leakage.

8.7 Repeat 8.5 and 8.6 each day for two (2) more days. NOTE: Samples must be shaken twice a day for three (3) days.

8.8 Without agitating sample solution, loosen clamps and carefully remove flasks from the shaker, loosen stoppers, and place samples on lab bench.

8.9 Filter sample solution into a clean 1000 mL erlenmeyer flask labelled with sample number and gently mix solution. Observe and record physical description of the filtrate (e.g., clear, cloudy, color, etc.). NOTE: Record date and time of sample collection, sample number, and description.

A. NOTE: Assemble filter apparatus as follows: Place ~ 5-6 feet of clean 3/16" i.d. tygon tubing into peristaltic pump and hand tighten screws. To outlet end of filter apparatus, add Mini-Capsule filter (see 5.16D) and tighten hose clamp. Rinse unit with ~1000 mL of distilled water. Unit now ready for sample and filtration. NOTE: Adjust pump rate to desired speed.

8.10 Divide filtrate into appropriate aliquots for field or laboratory analysis.

A. Pour a 200 mL aliquot into a pre-cleaned 16 oz. sample bottle. Acidify aliquot to pH 2.0 with 2-3 mL of HNO_3 and mix well. Label bottle with sample identification, "M", "HNO_3 added", date, initials and comments (if any). Refrigerate sample at 4° C. Ship samples to the laboratory for metals determination.

B. Pour a 200 mL aliquot into a pre-cleaned 16 oz. sample bottle. Label bottle with sample identification, "A-1", "No preservative added", date, initials, and comments (if any). Refrigerate sample at 4° C. Ship samples to the laboratory for anion determinations.

C. Pour a 100 mL aliquot into a pre-cleaned 16 oz. sample bottle. Label bottle with sample identification, "Parameters", "No preservative added", date, initials, and comments (if any). Refrigerate sample at 4° C.

8.11 Perform chemical measurements at the time of collection according to sample analysis requirements (e.g., pH, E_h, Conductivity, excess lixiviant, and alkalinity). Use aliquot from 8.10C above. Use paragraphs 7.0, 8.0, and 9.0 of Section 16.1.10 for these measurements.

A. Calibrate pH Meter. Record standard(s) used as well as date and time of calibration. Measure sample pHs and record data.

B. Calibrate Redox Potential (E_h) Meter. Record standard used as well as date and time of calibration. Measure sample E_{hs} and record data. NOTE: Use Section 16.1.13 for these measurements.

C. Calibrate Conductance Meter. Record date and time of calibration as well as standard(s) used. Measure sample conductance and record data.

D. If sample volume permits, determine alkalinity of sample. Record data on sample analysis sheet.

8.12 Dispose of sample by adding ~50 mL of distilled water to flask and swirling sample mixture until sample is suspended. Quickly pour sample solution into a radwaste container. Rinse flask with ~50 mL of distilled water and repeat swirling. Pour solution into a radwaste container labelled with "Radioactive Waste", Site name, and date. Add contaminated labware and sample waste solution(s). Store in Radwaste storage area.

8.13 Clean uncontaminated labware (e.g., beakers, flasks, etc.) by soaking labware overnight in ~30% (v/v) Radiac Wash and by washing them with a laboratory detergent. Rinse labware a minimum of three (3) times with hot water followed by a minimum of three (3) rinses of deionized water (see 3.1) and allow labware to air dry.

A. Soak uncontaminated labware overnight in a 30% (v/v) Radiac Wash Solution. Save solution for 6-8 weeks. Dispose of solution into designated radwaste containers and fill the soak container with fresh solution of diluted Radiac Wash. NOTE: As an alternate, use ~5% (w/v) Na_4EDTA Solution.

9.0 PROCEDURE: Column Leach Experiment

o Safety guidance provided in 3.0 must be followed, as applicable, for this procedure.

9.1 Consult with Geochemist or Hydrologist to determine method of column preparation and collection of eluates.

A. Should sample(s) be analyzed in wet or dry form? Should solid lixiviant(s) be mixed with the sample and added to the column or added to the column as a single layer? Should vacuum be used during part or all of column procedure? Should groundwater or lixiviant be added to the top or bottom of the column? Should sample be eluted from the top or bottom of the column?

B. What kind of lixiviant(s) will be used? Will lixiviants require mixing before use? What is the composition of the lixiviant(s)? Mixtures?

C. What volume in mL will constitute a "Pore Volume?" After what pore volume(s) should samples be collected? What liquid, if required, will be contained in the reservoir (e.g., distilled water, synthetic groundwater, site specific groundwater, lixiviant solution, etc.)

9.2 Determine radioactivity of the sample in uR/hr. Record value on sample data sheet and on sample container. NOTE: Compare radioactivity values of that on the sample container to the sample to be processed. If necessary, consult with Geochemist/Hydrologist to determine laboratory precautions to be exercised when processing the sample.

L.M. COONS

SEP '90

9.3 Assemble column for experiment.

A. Take a clean column (~12" x 4" I.d.) and insert a machined stopper. NOTE: Apply a small amount of inert lubricant on the side of the stopper and push stopper into column. Use same procedure for longer column (i.e., ~48" x ~4" I.d.).

B. Place column onto column rack and tighten clamp.

C. Place a plastic pan directly underneath the column so that any leaks or spills from the column may be collected.

D. Through the open end of the column, add a filter disc (~4" dia.).

E. Add a glass fiber filter (75mm dia.). Place the filter so that it is adjacent to and lies flat on the filter disc. NOTE: Use a rod or other suitable instrument to properly insert and place the filter.

F. Add ~100 g of silica sand onto filter and level layer of sand.

G. Column now ready for sample (i.e., tailings, soil, sediment, or pre-determined combination and mixture).

9.4 Weigh out a predetermined amount of sample and add sample to the column. Record weight of sample. Pack column. This is one "lift".

A. In the event that solid lixiviants are to be added, prepare sample according to 3.3 B.

9.5 Continue 9.4 until ten (10) lifts or ~10" of sample have been added to and packed in the column. NOTE: The density should result in a transmissivity factor equal to 10^{-3} to 10^{-5} cm/sec. The upper two inches of the column will serve as a fluid reservoir.

9.6 Complete filling of the column by adding ~100 g of silica sand onto the topmost layer of the sample.

9.7 Place a 4" diameter glass fiber filter on top of the silica sand layer and a filter disc on top of the filter.

9.8 Place a Bakelite stopper into the top of the column and push stopper into the column. NOTE: Lubricate the sides of the stopper with petroleum or silicone jelly.

9.9 Connect one end of the column to a 2000 mL filter flask with 9/16 I.d. tygon tubing and the other end of the column to a reservoir with 3/16" I.d. tygon tubing. Adjust reservoir height to ~60 inches from top of column. This is sometimes called "head". NOTE: Reservoir will contain a solution specified by the Geochemist or Hydrologist. See 9.1.

9.10 Open reservoir and allow liquid to flow into column. Allow the column to fill with liquid and the solids to become saturated with the liquid. When column has been saturated with liquid and liquid begins collecting in the collection flask, adjust column exit flow rate to one pore volume per day OR to flow rate specified by Geochemist or Hydrologist. Adjust the head to ensure a minimum flow rate of one

SEP '90

pore volume per five days. NOTE: A pore volume is the amount of liquid required to saturate the sample in the column.

9.11 Collect sample(s) for analysis directly from the column effluent stream and after elution of the following pore volumes: 2, 5, 10, and immediately before termination of the experiment. NOTE: Determine and record effluent characteristics [e.g., date and time of sample collection, sample number and description, physical description (i.e., clear, cloudy, brown, yellow, etc.), excess lixiviant, or any other parameters that may be specific to the type of experiment].

9.12 Divide sample into appropriate aliquots for field or laboratory analysis.

A. Pour a 100 mL aliquot into a pre-cleaned 16 oz. sample bottle. Acidify aliquot to pH 2.0 with 1-2 mL of HNO_3 and mix well. Label bottle with sample identification, "M", "HNO_3 added", date, initials and comments (if any). Refrigerate sample at 4° C.

B. Pour a 100 mL aliquot into a pre-cleaned 16 oz. sample bottle. Label bottle with sample identification, "A-1", "No preservative added", date, initials, and comments (if any). Refrigerate sample at 4° C.

C. Pour a 100 mL aliquot into a pre-cleaned 16 oz. sample bottle. Label bottle with sample identification, "Parameters", "No preservative added", date, initials, and comments (if any). Refrigerate sample at 4° C.

9.13 Perform chemical measurements at the time of collection according to sample analysis requirements (e.g., pH, E_h, Conductivity, excess lixiviant, and alkalinity). Use aliquot from 9.12C above. Use paragraphs 7.0, 8.0, and 9.0 of Section 16.1.10 for these measurements.

A. Calibrate pH Meter. Record standard(s) used as well as date and time of calibration. Measure sample pHs and record data.

B. Calibrate Redox Potential (E_h) Meter. Record standard used as well as date and time of calibration. Measure sample E_hs and record data. NOTE: Use Section 16.1.13 for these measurements.

C. Calibrate Conductance Meter. Record date and time of calibration as well as standard(s) used. Measure sample conductance and record data.

D. If sample volume permits, determine alkalinity of sample. Record data on sample analysis sheet.

9.14 Conclude the experiment at the end of 20 days or upon addition and elution of a specified number of pore volumes.

9.15 Disassemble column apparatus and dispose of sample into a radwaste container labelled with "Radioactive Waste", Site name, and date. Add sample waste solution(s) and contaminated labware.

9.16 Clean uncontaminated labware (e.g., beakers, flasks, etc.) by soaking labware overnight in ~30% (v/v) Radiac Wash and by washing them with a laboratory detergent. Rinse labware a minimum of three (3) times with hot water followed by a

L.M. ... SEP '90 ... 6/11/92

minimum of three (3) rinses of deionized water (see 3.1) and allow labware to air dry.

A. Soak uncontaminated labware overnight in a 30% (v/v) Radiac Wash Solution. Save solution for 6-8 weeks. Dispose of solution into designated radwaste containers and fill the soak container with fresh solution of diluted Radiac Wash. NOTE: As an alternate, use ~5% (w/v) Na_4EDTA Solution.

10.0 ATTACHMENTS

11.0 REFERENCES

11.1 ASTM, 1984. "Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil Aggregate Mixtures", Method D2216. Soil and Rock, Building Stones: Volume 04.08. ASTM, 1916 Race St., Philadelphia, PA.

11.2 ASTM, 1984. "Distribution Ratios by the Short-Term Batch Method", Method 4319. Soil and Rock, Building Stones: Volume 04.08. ASTM, 1916 Race St., Philadelphia, PA.

12.0 PROCEDURE REVIEW AND APPROVAL

Prepared By: ______________________ Date
TAC Representative

Reviewed By: ______________________ Date
Task Manager

Reviewed By: ______________________ Date
Quality Assurance Manager

Approved By: ______________________ Date
Project Manager/
Deputy Project Manager

22

ATTACHMENT B

L.M. COONS PE, PHG

ATTACHMENT B

Description of the composite samples used in the batch and column tests.

Sample No	Sample Type
GCM-1	Drill cuttings composite of the alluvium: well 835 cuttings were used
GCM-2	Test pad composite for the alluvium; the composite was prepared by mixing several subsamples of the alluvium collected from the test pad 2 used for the infiltrometer tests
GCM-3	Same as GCM-2 but from a different location within the test pad 2
GCM-4	Same as GCM-3 above but from another location within the test Pad 2.
GCM-5	Mancos Shale composite prepared by using several subsamples form the test pad 1 used for the infiltrometer test.
179-1	Alluvium composite without the clayey gravel (GC) and the low plastic clay (CL) fractions prepared using drill cuttings from several drill holes at the Cheney disposal site.
179-2	The 179-1 composite mixed with 10 percent Mancos Shale.
179-3	Top Soil composite prepared using the available cuttings from the drill holes at the Cheney disposal site.
179-4	Alluvium composite prepared using the available grill cuttings and screened to finer than one inch.

9/14/90

L.M. COONS
SEP '90

ATTACHMENT C

9/12/90

L.M. COONS PE, PHB 25

SEP '90

PREPARED FOR:

JACOBS ENGINEERING GROUP, INC.
ALBUQUERQUE OPERATIONS

MINERALOGICAL AND CHEMICAL CHARACTERIZATION OF SEDIMENT SAMPLES FROM COLORADO

FOR SAMPLES GCM-1, GCM-2, GCM-3, GCM-4 AND GCM-5

(See Attachment B for sample description)

By

Wolfgang Baum

August 21, 1989

Project 9 M 12

9/17/90

TABLE OF CONTENTS

9/5/90

BACKGROUND AND OBJECTIVE

Jacobs Engineering Group, Inc. requested a chemical and mineralogical characterization of five sediment samples from Colorado. ~~The samples originated from a lake bed and a weathered shale outcrop.~~

The objective of the study was as follows:

- Bulk Mineralogy

  Includes a preliminary stereomicroscopic examination with a description of the overall mineralogical features and bulk x-ray diffraction analysis. Special attention will be given to any minerals other than clays or zeolites which could exhibit sorptive capacity (e.g. hydrous Fe/Mn oxides, jarosites, Al-hydroxides).

- Detailed Clay Mineralogy

  Includes the identification of clay and clay-like minerals by x-ray diffraction analysis on the clay fraction in various sample mounts (random, oriented, glycolated, heat-treated mounts). SEM analysis may be used to assist in microchemical characterization.

- Size Analysis for Sand, Silt and Clay Fractions

  Size analysis for sand, silt and clay fractions will be made followed by x-ray diffraction analysis of the size fractions.

- Cation Exchange Capacity
- Acid Neutralization
- Acid-Soluble Fe and Mn
- Gypsum Content
- Pyrite Content
- Total Carbon and Organic Carbon

The laboratory work was performed under Jacobs Engineering Purchase Order No. Subcontract 34-6705-S-89-0052.

SEP '90

SAMPLES RECEIVED AND METHODS OF STUDY

Five sediment samples were received at the PMET laboratories on August 3, 1989. The samples were subjected to routine chain of custody procedures (PMET letter of August 7, 1989). The sample designations are given in Table 1 below.

Table 1

Sample Designations

PMET No.	Customer I.D.	Weight(g)
108-1	GCM-1 : Alluvium Composite	807.11
108-2	GCM-2 : Test Pad Alluvium [illegible]	809.60
108-3	GCM-3 : " " " [illegible]	809.60
108-4	GCM-4 : " " " [illegible]	288.98
108-5	⇒ GCM-5 : ~~Weathered~~ Mancos Shale Test Pad	804.15

See Attachment B for additional description

The laboratory work included sample preparation, chemical analyses, optical microscopy, x-ray diffraction analyses, and micro-screen analyses.

The as-received samples were weighed and thoroughly blended. Thereafter, adequate portions were split out for the laboratory work. The methodology of the chemical and mineralogical analyses as well as the quality control procedures were according to our report of July 10, 1989.

[illegible] 6/?/90

Chemical Characterization

The samples are characterized by a low cation exchange capacity which ranges from 15.1 to 17.4 meq/100 g and reflects a clay mineralogy which is dominated by micas, illite and kaolinite with minor amounts of swelling clays. Due to elevated carbonate contents, the samples exhibit a high neutralization potential. The sulfide content is very low whereas sulfate concentrations are elevated. However, substantial amounts of the sulfates are due to iron sulfates.

The results of the chemical characterization are presented in Table 2.

Table 2

Chemical Characterization of Sediment Samples

Element	Sample Designations GCM-1	GCM-2	GCM-3	GCM-4	GCM-5
Total C,%	1.80	1.02	1.38	0.91	3.18
Organic C,%	0.35	0.41	0.06	0.03	0.64
Total S,%	0.64	0.37	0.25	0.37	0.08
Sulfide S,%	0.04	<0.01	<0.01	<0.01	<0.01
Sulfate S,%	1.73	1.07	0.87	1.01	0.13
Acid Sol. Fe,%	2.82	2.26	2.26	2.81	1.77
Acid Sol. Mn,%	0.055	0.062	0.086	0.051	0.03
Cat.Ex.Cap., (meq/100 g)	17.2	17.4	15.1	16.2	15.6
Exchangeable Ca, (meq/100 g)	98.3	79.6	80.3	58.6	71.1
Exchangeable Mg, (meq/100 g)	5.13	4.48	5.57	7.09	4.80
Exchangeable Na, (meq/100 g)	4.54	4.76	4.58	2.79	4.53
Exchangeable K, (meq/100 g)	0.82	0.75	0.88	1.39	0.71
Neutr. Potent. (t $CaCO_3$/ 1000 t soil)	170	107	155	94.3	271
Potential Acidity (t H^+/1000 t soil)	0.13	0.06	0.16	0.10	0.22

9/12/90

SEP '90

Mineralogical Characterization

The (alluvial?) sediment samples (GCM-1 to GCM-4) consist of gray-brown, sandy, calcareous material which contains significant amounts of heavily altered volcanic rocks. The alteration has resulted in the formation of various clay minerals and considerable amounts of (hydrous) iron oxidation products. Except for sample GCM-2, all samples including the shale are characterized by substantial amounts of carbonates.

Sample GCM-5 consists of a slick, laminated heavily altered gray-green clay shale containing noticeable amounts of disseminated mica.

The UV-light examination did not indicate the presence of fluorescent minerals. Minor to trace amounts of magnetite and ferromagnetic rock fragments (mostly of volcanic origin) were found in Samples GCM-1 to GCM-4. A microchemical staining test with 4-hydroxyaniline indicates the presence of minor amounts of swelling clay in all samples. A Geiger counter scan showed a very weak response level in samples GCM-1 and GCM-2.

Mineralogically all samples contain major amounts of quartz and clay minerals with variable concentrations of calcite and feldspar (albite). Very low concentrations (<1% volume) of ultrafine sulfides (pyrite) were found in samples GCM-1, -2 and -3. Most of the disseminated and matrix sulfides have been oxidized into hematite and magnetite both of which locally act as a cementing matrix to brecciated/agglomerated gangue.

The sediment samples also contain noticeable amounts of zeolites (primarily analcite and minor wairakite). Zeolites are common authigenic silicates in (saline) lake sediments. It is tentatively concluded that the wairakite (hydrated Ca-Al-silicate) may have formed through zeolite alteration.

Following are the petrographic sample descriptions.

Sample GCM-1

Brown-gray, calcareous sediment with high calcite content. The calcite is in part well crystallized. The sample contains considerable amounts of altered volcanic rock fragments which consist of dark gray to red porphyritic fine grained rocks. The fine particle fraction contains considerable amounts of micaceous clay minerals with minor amount of swelling clay, iron oxidation products and carbonaceous matter as grain coatings. Approximately less than 1% volume of ultrafine (<10 micron) disseminated pyrite. The clay minerals contain large amounts of pigment-like hematite. Some brecciated and/or agglomerated particles which are cemented by hydrous iron oxides, hematite and magnetite. A minor amount of the iron

9/12/90

oxides contain unoxidized residual sulfides. Noticeable levels of spinels in the heavy mineral fraction.

Sample GCM-2

Gray, sandy gravel with moderately rounded rock fragments which include tuffs, pyroclastic breccias, sandstones, lava flows, chert and quartz particles as well as ferruginous carbonate concretions (caliche-like). The finer particle fractions contain minor amounts of bleached mica and chlorite-bearing volcanic rock fragments. Most of the rock particles contained in the sample are heavily altered - some beyond the possibility of conclusive identification. Contains small aggregates of swelling clay. Major source of clay minerals appears to be heavily altered fragments of volcanic rocks and/or their pyroclastics.

Sample GCM-3

Gray-brown, calcareous gravel fraction with angular to subrounded, heavily altered rock fragments. This sample is petrographically similar to sample GCM-2. Many of the limonitic particles exhibit coatings of manganese dentrites. Alteration of rock fragments appears to be more intense than in sample GCM-2. Considerable amounts of clay agglomerations and clay coatings on larger rock particles. Approximately 30% of brecciated/agglomerated rock material which is cemented by iron oxides.

Sample GCM-4

Light brown, calcareous, fine grained sandy sediment with high carbonate (calcite) content. Distinctly more quartz. Sample contains traces of cinnabar. The rock fragments consist of heavily altered volcanic rocks and clay-sand agglomerations. Most of the quartz fragments are angular. Minor amounts of hornblende and traces of carbonaceous matter and bleached mica. Many of the rock fragments exhibit clay coatings which are 30 to 100 microns in thickness.

Sample GCM-5

Gray-green, heavily altered shale containing fine disseminations of less than 20 micron mica flakes. The sample shows some lamination and disintegration. Minor to trace amounts of swelling clay minerals and a very high carbonate content. Small amounts of jarosite.

The petrographic and mineralogical characteristics are summarized and quantified in Tables 3A and 3B.

9/14/90

L.M. ...

SEP '97

32

Table 3

Overall Petrographic and Mineralogical Characteristics of Sediment/Shale Samples

A. Petrographic Characteristics*

Component	GCM-1	GCM-2	GCM-3	GCM-4	GCM-5
		(in % volume)			
Rock fragments	35-45	>50	>50	30	<10
Clay	8-15	10-20	20-25	8-15	>>50
Iron Oxidation	15-20	20	10-20	20-25	<10
Carbonates	10-15	<10	10-20	20-30	20-30

B. Mineralogical Characteristics** BULK MINERALOGY (other than clay minerals)

Mineral					
Quartz	Major	Major	Major	Major	Major
Calcite	Moderate	Minor	Moderate	Moderate	Major
Dolomite	Minor	Minor	Minor	Minor	Minor
Zeolites	Minor	Moderate	Minor	Min-Mod.	-
Muscovite	Min-Tr.	Trace	Trace	Minor	Min-Mod.
Albite	Moderate	Major	Min-Mod.	Minor	Trace

Major = 30->50%
Moderate = 10-30%
Minor = 5-10%
Trace = <5%

* Based on stereomicroscope examination

** Based on bulk x-ray diffraction analysis
Further details would require petrographic thin section study and subsequent modal analyses.

Clay Mineralogy

Prior to the x-ray diffraction analyses of the clay fraction, the total amounts of sand, silt and clay were determined by wet screen analyses of large (50-100 g) blended and split sample portions. The results are summarized in Table 4.

6/17/40

L.M. COONS PE, PHG

SEP '90

Table 4

Total Amounts of Sand, Silt and Clay Fractions

Sample	Sand (+63 micron)	Silt (-63+5 micron)	Clay (-5 micron)
GCM-1	57 % wt.	21 % wt.	22 % wt.
GCM-2	90 "	4 "	6 "
GCM-3	86 "	7 "	7 "
GCM-4	70 "	14 "	16 "
GCM-5	2 "	23 "	75 "

When evaluating the total clay content as established in Table 4 by physical classification, the following features should be considered. In soil/sediment samples containing larger feldspathic rock fragments and which are partially or completely altered to clay or clay-like minerals, the actual total clay content may be slightly higher than obtained by sizing. This is due to the fact that many of the gravel and sand-sized rock fragments contain alteration-related, encapsulated clay which will not report to the clay fraction in a sedimentation or screen analysis. Furthermore, the occurrence of iron oxide-cemented coarse clay aggregates will also retain some of the clay in the sand or silt fractions.

For any clay analysis of sediments or soil samples containing rock fragments which have been exposed to clay-producing alteration (i.e. argillic, sericitic, propylitic, alunitic), a petrographic thin section study concurrent with the sedimentation screen analysis is recommended.

Based upon the x-ray analysis of the size fractions and microscopic work, the following semi-quantitative clay distribution has been established.

	Contained Clay (% distribution)		
Sample	Sand Fraction	Silt Fraction	Clay Fraction
GCM-1	<5	15-20	75
GCM-2	20-25	20	60
GCM-3	15	20	65-70
GCM-4	10-15	15	60-70
GCM-5	<5	10	85-90

The determination of clay minerals was facilitated through x-ray diffraction analysis of various sample mounts (random, oriented, glycolated, heat-treated) prepared from -2 micron clay fractions.

This work showed that the samples investigated contain a complex clay mineralogy which is dominated by micas, illite and kaolinite. Swelling clays (montmorillonite, interstratified

9/17/90

kaolinite-smectite, smectite-illite) occur mostly in minor amounts. The clay minerals in samples GCM-1 and GCM-4 exhibit poor crystallinity and/or submicron particle sizes. The major clay minerals in the weathered shale sample GCM-5, i.e. kaolinite and dioctahedral illite, show a good degree of crystallization.

Samples GCM-2, -3 and -4 contain minor but distinct amounts of zeolites (analcite). The presence of the analcite-related zeolite (alteration?) mineral wairakite in samples GCM-1 to GCM-4 was already described earlier in this report. In addition, minor to trace amounts of a interstratified chlorite-mica were found in Sample GCM-2.

A summary of the clay mineralogy and a semi-quantitative assessment of the clays is shown in Table 5.

Table 5

Semi-Quantitative Clay Mineralogy of Sediment Samples (-2 micron fraction)

Clay Minerals	Samples GCM-1	GCM-2	GCM-3	GCM-4	GCM-5
Montmorillonite	Minor	Moder.	Minor	-	Minor
Muscovite (Sericite)	Major	Major	Moder.	Trace	Trace
Kaolinite-Smectite*	Moder.	Trace	Trace	-	-
Kaolinite	Moder.	Major	Major	Major	Major
Dioctahedral Illite	-	-	-	Major	Major
Smectite-Illite*	-	-	-	Major	-
Analcite	-	Trace	Minor	Trace	-

* interstratified

9/11/90

- The sediment samples (GCM-1 to GCM-4) analyzed during this chemical-mineralogical characterization contain clay fractions representing 5 to 20% of the sample. However, clay-type alteration is also prevalent in the silt and sand fractions due to argillic/sericitic alteration of feldspathic (volcanic) rock fragments. The overall clay content may therefore be slightly higher than indicated by the size classification alone. The weathered shale sample exhibits a clay content of 75%.

- All samples are characterized by a complex clay mineralogy which consists primarily of micas, illite and kaolinite with minor amounts of swelling clays (montmorillonite, interstratified kaolinite-smectite, smectite-illite). In addition, there are noticeable amounts of zeolites (analcite and wairakite).

- The cation exchange measurements are in agreement with the clay mineralogy which showed that kaolinite, muscovite and illite are the dominating clay phases. These minerals exhibit low cation exchange capacities of less than 20 meq/100 g. The analyzed cation exchange capacity of the five samples ranged from 15.1 to 17.4 meq/100 g.

- A typical feature of the samples is a significant carbonate content which consists of calcite and dolomite.

- The presence of minor to trace amounts of zeolites may increase the selective sorption potential for solubilized heavy metals.

- In addition to clay minerals and zeolites, minor adsorptive effects can be expected from hydrous iron oxidation products which occur in pigment-like disseminations and as particle coatings throughout the sample material.

WB/mkf

9/12/90

SEP '90

PREPARED FOR:

JACOBS ENGINEERING GROUP INC.

ALBUQUERQUE OPERATIONS

CHEMICAL AND MINERALOGICAL CHARACTERIZATION OF 17 SOIL SAMPLES FROM THE CHENEY RESERVOIR SITE

<u>FOR SAMPLES 179-1, 179-2, 179-3 AND 179-4</u>

(See Attachment B for sample description)

By

Wolfgang Baum

January 16, 1990

Project 9 M 12

9/14/90

L.M. COONS PE, PHS

SEP '90

37

TABLE OF CONTENTS

Page

9/17/90

BACKGROUND AND OBJECTIVE

Jacobs Engineering Group Inc. requested a chemical and mineralogical characterization of seventeen soil samples from the Cheney Reservoir site near Grand Junction, Colorado.

The objective of the work was as follows:

- Bulk Mineralogy

  Includes a preliminary stereomicroscopic examination with a description of the overall petrographic and mineralogical features and a bulk x-ray analysis. Special attention will be given to any minerals other than clays or zeolites which could exhibit sorptive capacity (e.g., hydrous Fe/Mn oxides, jarosites, Al-hydroxides).

- Detailed Clay Mineralogy

  Includes the identification of clay and clay-like minerals by x-ray diffraction analysis on the clay fraction in various sample mounts (random, oriented, glycolated, heat-treated). SEM analysis may be used to assist in microchemical characterization.

- Size Analysis for Sand, Silt and Clay Fractions

  Size analysis for sand, silt and clay fractions will be made followed by mineralogical analysis of the size fractions.

- Total Clay Content
- Cation Exchange Capacity
- Acid Neutralization
- HCl-Soluble Fe
- HCl-Soluble Mn
- Gypsum Content
- Pyrite Content
- Calcium Carbonate Content
- Total Carbon
- Organic Carbon
- Soil pH & Eh
- Determine the Overall Mineralogy of an Unknown Rock Sample

The laboratory work was performed under Jacobs Engineering subcontract purchase order 34-6705-S-90-0014.

9/11/90

SAMPLES RECEIVED AND METHODS OF STUDY

Seventeen samples were received at the PMET laboratories on December 13, 1989. The samples were subjected to routine chain of custody procedures (PMET letter of December 18, 1989). The sample designations are given in Table 1 below.

Table 1

Sample Designations

PMET No.	Jacobs	Designation	Weight(g)
179-1	GRJ-03	5-Mancos Contact w/o CL&GC Comp.	1111.0
-2	"	" " " " + 10% Mancos Shale	1091.25
-3	"	1-5' Composite Top Soil	952.66
-4	"	Screened Alluvium MK	1047.46
-5	GRJ-03	818	170.0
-6	"	821	140.0
-7	"	825	199.0
-8	"	833 1-5'	193.0
-9	"	901 1-5'	142.0
-10	"	933 1-5'	190.0
-11	"	938 1-5'	244.0
-12	"	941 1-5'	179.0
-13	"	953	232.0
-14	"	958	166.0
-15	"	959 1-5'	190.0
-16	"	964 1-5'	183.0
-17	"	Flint/Chalcedony	65.8

For samples 179-1 to 179-4, a complete chemical characterization was requested. Samples 179-5 to 179-16 were submitted for measurement of soil pH, Eh and carbonate content. One sample, 179-17, was submitted for bulk x-ray diffraction analysis only.

The laboratory work included sample preparation, chemical analyses, optical microscopy with modal analyses, microchemical staining, screen analyses, x-ray diffraction analyses, and SEM microscopy.

The samples as received were examined microscopically prior to any separation work. Thereafter, each sample was thoroughly blended and adequate portions were split out for the laboratory work. In addition to the standard microscopic carbonate analyses of samples 179-5 to 179-16, bulk x-ray diffraction

9-11450

analyses were also performed on each of these samples. This work was done free of charge. The carbonate and gypsum contents of samples 179-1 to 179-16 were cross-examined by selective microchemical staining tests (Alizarin Red S and Clayton Yellow respectively) followed by microscopic quantification of the stained particles. The pH of the drill core samples was determined on -10 mesh material using ASTM method 9045 for measuring soil pH. The Eh was measured according to ASTM procedure D 1498-76 (electrometric measurement of oxidation-reduction potential). For solution extraction, a saturated soil paste was prepared. The methodology of the chemical and mineralogical analyses as well as the quality control procedures were according to our report submitted to JE on July 10, 1989.

9/14/90

DISCUSSION OF RESULTS

Chemical Characterization

Samples 179-1 to 179-4 are characterized by increased carbonate carbon contents ranging from 1.2 to 1.86%. Virtually all of the sulfur occurs as sulfate sulfur. The potential acidity is very low. Significant amounts of HCl-soluble iron (3.6 to 5.4%) were found in all samples. The cation exchange capacity in the four samples is low, ranging from 11.7 to 17.8 meq/100 g. However, all samples exhibit a high neutralization potential ranging from 110 to 183 tons $CaCO_3$/1000 tons of soil due to the presence of vast amounts of carbonates. The pH measurements indicate weakly alkaline soil pH.

The results of the chemical characterization are presented in the following Table 2.

9/12/90

Table 2

Chemical Analysis of Sediment Samples
From Cheney Reservoir

Sample Designations

Element	179-1	179-2	179-3	179-4
Total C, %	1.44	1.61	2.07	1.51
Carbonate C, %	1.23	1.38	1.86	1.42
Organic C, %	0.21	0.23	0.21	0.09
Total S, %	0.70	0.75	0.78	0.77
Sulfide S, %	<0.02	<0.02	<0.02	<0.02
Sulfate S, %	0.70	0.75	0.78	0.77
HCl-Sol Fe, %	3.4	3.0	3.6	3.6
HCl-Sol Mn, %	0.091	0.083	0.057	0.062
Eh, mV*	108	100	102	110
pH	7.85	7.97	8.05	8.12
Cation Exch. Capacity**	11.7	13.2	17.8	15.6
Exchangeable Ca**	62.4	73.6	137	69.4
Exchangeable Mg**	2.82	3.78	5.64	4.31
Exchangeable Na**	0.563	2.28	2.77	3.56
Exchangeable K**	0.297	0.377	0.373	0.345
Exchangeable Na Percentage	4.83	17.3	15.6	22.8
Neutraliz. Potential (Tons $CaCO_3$/1000 Tons Soil)	176	110	183	110
Potential Acidity (Tons H^+/1000 Tons Soil)	0.03	0.02	<0.01	0.02

Element	179-5	179-6	179-7	179-8	179-9	179-10	179-11	179-12	179-13	179-14	179-15
Total C, %	1.35	3.64	2.47	4.31	1.48	1.49	1.27	2.28	1.86	2.53	2.04
Carbonate C, %	1.01	3.33	2.22	3.97	1.11	1.18	1.11	2.05	1.67	2.26	1.82
Organic C, %	0.34	0.31	0.25	0.34	0.37	0.31	0.16	0.23	0.19	0.27	0.22
Eh, mV*	85	108	112	88	118	115	70	80	87	90	85
pH	7.79	8.18	8.28	8.49	7.81	7.99	8.17	8.25	8.14	8.11	8.34

*Relative to Hydrogen, American Sign Convention
**In meq/100g

9/14/90

L.M. COONS P.E.
SEP '90

Mineralogical Characterization

All four samples represent similar petrographic characteristics and can be classified as lithic, calcareous-clayey, sandy soils. The samples contain substantial amounts of rock fragments most of which appear to be of basic igneous or volcanic origin. The rock fragments also contain substantial amounts of ultrafine hematite with minor magnetite. Some of the lithic components are complex and would require thin section study for further characterization.

The samples contain large amounts of carbonates most of which consist of fine-grained calcite which is often intimately admixed with clay or iron oxidation products. Sample 179-4 contains distinctly more ferruginous carbonates. Microchemical staining tests did not give any evidence for the presence of dolomite. This conclusion was also confirmed through subsequent x-ray analysis.

Considerable amounts of the carbonates constitute a cementing matrix for silica sand particles. Some of the carbonates have originated from the alteration of feldspathic and/or ferromagnesian rock-forming minerals. Certain amounts of the carbonates occur as calcareous nodules and layers known to be typical products of caliche (calcrete) formation. During megascopic examination and effervescence testing, the carbonate content of the samples appears to be extremely high which is primarily due to the presence of fine carbonate coatings on coarser, noncarbonate particles.

Another characteristic feature of the samples is the presence of moderate amounts of gypsum which occur primarily as rosette-like aggregates. Minor amounts of acicular-fibrous gypsum were also found.

The soil sample material exhibits poor consolidation. Minor to trace amounts of zeolites are associated with the dark (volcanic?) rock fragments primarily in form of vesicular occurrences.

A summary of the overall petrographic characteristics is given in Table 3 and additional details of the mineralogical features are described in the following petrographic sample characteristics.

9/17/90

Table 3

Overall Petrographic Characteristics of Soil Samples from the Cheney Reservoir Site

Petrographic Feature	Sample Designations 179-1	179-2	179-3	179-4
Color	Gray-green	Gray-black	Red-brown	Brown-gray
Geiger Counter Response	-	-	-	-
Effervescence Carbonate Test	High	High	High	High
Short-wave UV Response	Gypsum Calcite	Gypsum Calcite	Gypsum Calcite	Gypsum Calcite
Presence of Ferromagnetics	1-3%	1-3%	1-3%	3-4%
Rock Fragments	30%	30-35%	25-30%	30-35%
Carbonate Content*	10-15%	10-15%	15-18%	15%
Gypsum Content*	5-10%	5-10%	3-5%	10-15%
Classification	Lithic Calcareous-Clayey Sand	Lithic Calcareous-Clayey Sand with High Shale Content	Lithic Ferruginous Calcareous-Clayey Sand	Lithic Ferrugin. Calcar.-Clayey Sand

All data in volume %.
* Estimate based on selective staining.

Sample 179-1

Black to light brown sample material with considerable amounts of rock fragments. The sample is characterized by a high calcite content and consists primarily of a micaceous sand with relict feldspar. The rock fragments consist of ferruginous porphyritic fine-grained volcanic (or igneous) rocks, limonite aggregates, basic igneous or volcanic rocks, chert, calcareous

9/17/90

sandstone and rhyolite. Significant amounts of the rock fragments exhibit attachments/coatings of clay minerals. Relatively coarse-grained gypsum occurs as light brown, rosette-like aggregates.

Sample 179-2

Black to light brown lithology characterized by large amounts of basic volcanic (or igneous) rock fragments, calcite and significant amounts of shale fragments (15%). Due to the higher amounts of clay introduced by the shale, this sample exhibits considerably more particle agglomerations. The suite of rock fragments is virtually identical with the lithic material found in Sample 179-2. Zeolite minerals appear to occur in the vesicular volcanic rocks. Most of the limonite particles are coated with manganese dentrites. Noticeable amounts of heavily oxidized clayey to feldspathic rock fragments with hematite dispersion. Minor amounts of rosette-like, coarse-grained gypsum particles. Some of the heavily altered, carbonate-bearing material may represent volcanic ash.

Sample 179-3

Light brown, clayey sand with greenish dark gray rock fragments some of which are several centimeters in diameter. Considerable amounts of gypsum. The rock fragments consist primarily of heavily altered porphyritic volcanic (or igneous) rocks which contained significant amounts of biotite and/or hornblende. The sample contains swelling clays most of which appear to be iron-bearing. Presence of zeolites is indicated in association with vesicular volcanic rocks. The sand fraction contains large amounts of roots and wood particles. Minor amounts of volcanic glass (obsidian-like material). The clay content in the coarser size fractions is primarily related to argillized rock fragments. Minor amounts of limonite nodules with admixed clay and carbonates. Moderate amounts of chalcedony. The silt size particle fraction is high in mica minerals (=mostly muscovite).

Sample 179-4

Light brown, sulfate and carbonate-rich silica sand with large amounts of heavily altered rock fragments. Most of the rock particles appear to be from basic to intermediate volcanics and/or igneous rocks which have been exposed to argillization of feldspars and iron oxidation and bleaching of the ferromagnesian minerals. The sample contains noticeable

9/14/90

amounts of rosette-like and acicular gypsum as well as sandstone fragments with calcite cement.

The bulk x-ray diffraction analyses of the as-received material confirmed that quartz and calcite are major sample constituents followed by moderate amounts of feldspar (anorthite), gypsum, and titanite. In addition, minor amounts the Ca-carbonate-silicate tilleyite and traces of portlandite (Ca-hydroxide) were detected. Tilleyite is almost exclusively of metamorphic origin where it forms in calc-silicate rocks or in contact marbles.

Additional Samples

In addition to the four main characterization samples, eleven soil samples were submitted for determination of pH, Eh, and carbonate content only. One sample, 179-17, was submitted for x-ray diffraction analysis. The eleven samples exhibit overall mineralogical-petrographic characteristics which are similar to sample 179-1 to 179-4.

X-Ray Diffraction Analysis of Sample 179-17

This sample was received as a two-inch specimen described as flint or chalcedony. The megascopic examination showed that the sample consisted of a gray to light gray, moderately hard, slightly porous material which exhibited precipitation texture and contained embedded (fossil?) wood fragments (branches). The XRD analysis showed that this sample contains large amounts of portlandite (Ca-hydroxide). Table 4 summarizes the mineral phases identified in this sample.

Table 4

Mineralogy of Sample 179-17

Mineral	Frequency
Portlandite	Major
Calcite	Minor
Wermlandite (Ca-Mg-Al-Fe-carbonate hydrate)	Minor
Ca-Silicate (hydrated)	Minor

g 9/17/90

L.M. COONS PE, PhD
SEP '90
47

The mineralogical modal analysis of the soil samples are summarized in Table 5.

Table 5

Mineralogical Modal Analyses of Cheney Reservoir Samples

Sample	Vol.% Sulfide*	Vol.% Total Clay**	Vol.% Carbonate	Vol.% Gypsum
179-1	2	26	17	12
-2	1	30	13	10
-3	<1	40	10	5
-4	<1	29	19	15
-5	n.a.	n.a.	9	n.a.
-6	"	"	19	"
-7	"	"	17	"
-8	"	"	16	"
-9	"	"	10	"
-10	"	"	11	"
-11	"	"	17	"
-12	"	"	20	"
-13	"	"	12	"
-14	"	"	11	"
-15	"	"	18	"
-16	"	"	11	"

Based on point count and cross-count analyses of dry bulk samples, oil immersion grain mounts and polished sections.

* Primarily pyrite

** Includes all clay and clay-like minerals contained in all size fractions

n.a. = not analyzed

Clay Mineralogy

Prior to the x-ray diffraction analyses of the -2 micron clay fraction, the total amounts of sand, silt and clay were determined by wet screening of a 50-gram blended sample split. All size fractions were thoroughly examined by optical and x-ray methods for major and minor mineral constituents. The results of the screen analyses are summarized in Table 6.

9/17/90

SEP '90

Table 6

Total Amounts of Sand, Silt and Clay Fractions

Sample	Sand Fraction (+63 micron) Wt. %	Silt Fraction (-63+5 micron) Wt. %	Clay Fraction (-5 micron) Wt. %
179-1	66.09	11.84	22.07
-2	66.96	11.62	21.27
-3	44.75	12.34	42.91
-4	63.72	13.29	22.99

The subsequent optical microscope analyses showed the following mineralogical characteristics of the sand, silt and clay fractions.

Sand Fractions

Contains primarily rock fragments and silica sand particles with minor amounts of sulfates and mixed argillic/iron oxide/hydroxide particles. Minor clay concentrations occur in this fraction due to partially altered feldspathic rock fragments and/or clay minerals being aggregated with other sand fraction constituents. The sand fractions of samples 179-1 and 179-2 consist basically of rock fragments (>60%) whereas sample 179-3 is dominated by silica sand with only 5-10% rock fragments. Sample 179-4 is characterized by increased amounts of iron alteration products admixed with silica sand particles and 10-20% rock fragments.

Silt Fractions

The silt fractions consist predominantly of quartz particles with considerable amounts (25-45%) of mica (muscovite), carbonates and minor sulfates. The clay content of the silt fractions is low ranging from 1 to 5%.

9/17/90

L.M. COONS PE, PHG
SEP '90

7

Clay Fractions

The -5 micron clay fractions are characterized by major amounts of clay minerals (25 to 59 vol. %) admixed with substantial concentrations of clay-sized quartz and minor to trace amounts of calcite and gypsum. The determination of the clay minerals was facilitated through x-ray diffraction analyses of various sample mounts (random, oriented, glycolated, heat-treated) prepared from -2 micron clay fractions.

This work showed that the Cheney Reservoir samples are characterized by the dominance of montmorillonite, mica (muscovite) and kaolinite. A summary of the clay mineralogy and a semi-quantitative assessment is given in Table 7.

Table 7

Semi-Quantitative Clay Mineralogy of Cheney Reservoir Samples (-2 micron fraction)

Sample	Major	Frequency Major-Moderate	Minor-Trace
179-1	Montmorillonite	Muscovite* Kaolinite	Dioct. Illite Smectite-mica
179-2	Montmorillonite**	Kaolinite Muscovite	Dioct. Illite Smectite-mica
179-3	-	Montmorillonite Kaolinite*** Dioct. Illite	Muscovite
179-4	Montmorillonite	Muscovite Kaolinite	

---

* Mixed layering of the mica is indicated by a series of reflections on the low-angle side of the 10 Å spacing.

** When compared to sample 179-1, sample 179-2 has a slightly higher (5%) montmorillonite and muscovite content.

*** Both the montmorillonite as well as the kaolinite show distinctly less crystallinity than in the other samples.

9/19/90

L.M. CO...

SEP '90

CONCLUSIONS

- The four soil samples received from the Cheney Reservoir site represent calcareous-clayey and sandy soils with a high amount of rock fragments and gypsum. The additional eleven soil samples exhibit a similar mineralogical composition. The hand specimen sample (179-17) consists primarily of portlandite with minor amounts of calcite and hydrated calcium silicates. The portlandite formation may be due to the decomposition of calcium silicates.

- The clay mineralogy of the four soil samples is characterized by the dominance of montmorillonite, muscovite and kaolinite. Minor amounts of dioctahedral illite and smectite-mica were also observed.

- The samples are characterized by a very low potential acidity, low cation exchange capacities ranging from 11 to 17 meq/100 g, weakly alkaline pH and high neutralization potentials ranging from 110 to 183 tons $CaCO_3$/1000 tons of soil. The determination of the quantitative significance of zeolites introduced by certain vesicular volcanic rocks would require additional laboratory work.

WB/mkf

9/12/90

L.M. COOKS PE, PHR
SEP '90

ATTACHMENT D

9/14/90

D-1 Composition of the spiked groundwater from well 589 PH3

L.M. COCHS PE PH3
SEP '90

:e Code: GRJ03
:ation ID: 528 : Dopped Feed Solution
nple ID: 01
nple Date Time: 08/07/89

Lab No. : 89-W1/04855
Date Received: 08/08/89

Parameters

Chloride	1100.	mg/l	pH - 8.08
Sulfate	3589.	mg/l	Eh -222 mv
Sodium, dissolved	990	mg/l	
Potassium, dissolved	54.	mg/l	Zobell - 233 mv
Magnesium, dissolved	305	mg/l	Temp - 24.0 °C
Calcium, dissolved	500	mg/l	Ec - 8,000 mmhos
Boron, dissolved	.55	mg/l	
Fluoride	.3	mg/l	Alkalinity - 444 at 4.50
Nitrogen, ammonia	132.	mg/l	
Nitrate as NO3	-.1	mg/l	
Silica, dissolved	16	mg/l	
Phosphate	.5	mg/l	
Aluminum, dissolved	.21	mg/l	
Antimony, dissolved	.002	mg/l	
Arsenic, dissolved	2.3	mg/l	
Barium, dissolved	.03	mg/l	
Cadmium, dissolved	.076	mg/l	
Chromium, dissolved	-.01	mg/l	
Cobalt, dissolved	.01	mg/l	
Copper, dissolved	.01	mg/l	
Iron, dissolved	-.02	mg/l	
Lead, dissolved	-.001	mg/l	
Manganese, dissolved	1.67	mg/l	
Mercury, dissolved	-.0002	mg/l	
Molybdenum, dissolved	6.20	mg/l	
Nickel, dissolved	-.02	mg/l	
Selenium, dissolved	8.4	mg/l	
Silver, dissolved	.01	mg/l	
Strontium, dissolved	5.	mg/l	
Tin, dissolved	-.1	mg/l	
Vanadium, dissolved	-.01	mg/l	
Zinc, dissolved	.02	mg/l	
Solids, total dissolved	6554.	mg/l	

emarks:

ote: Negative sign "-" denotes that the value is less than "<"

:h V. Poulsen, Laboratory Director

Ralph V. Poulsen / S.H.

9/17/90

D-2 ✓

Compositions of the test fluids prepared by mixing water samples from the lysimeters installed in the tailings pile, and spiking with known concentrations of hazardous constituents.

Hazardous constituents	Analysis date and concentration, mg/l December 19, 1989	December 28, 1989
AG	< .05	< .1
AL	< .50	< .5
AS	5.9	5.4
B	.65	.8
BA	< .10	< .1
BE	.180	< .05
BR	.99	.08
CA	675.	670.
CD	.9000	.7000
CL	900.	710.
CO	5.25	< .1
CR	.10	< .1
CU	1.10	.2
F	.7	.7
FE	.30	< .2
HG	< .0001	< .0001
K	85.	90.
MG	305.	340.
MN	7.10	5.6
MO	5.00	4.4
NA	820.	896.
NI	8.90	5.7
NO3	256.1	< .1
PB	< .001	< .01
PO4	.5	.7
SB	.008	.004
SE	4.0	3.3
SIO	49.5	48.
SN	< .020	< .020
SO4	4017.	4042.
SR	7.40	5.5
TDS	6536.	6696.
TL	< .010	< .010
U	4.760	3.851
V	21.3	15.8
ZN	13.1	7.7

9/12/90

(1) The composite water sample was prepared by mixing water samples from the tailings lysimeters

D-~~1~~ 3 Reproducibility of column tests: Chemical analyses of the first effluent pore volumes of the triplicate columns of individual test materials.

L.M. COONS P.E. PHB
SEP '90

Sample # 179-1

COMPARISON OF LEACHATE DATA FROM COLUMN
TESTS FOR ALLUVIUM (-GC,-CL)
FIRST PORE VOLUME

	COLUMN NUMBER 650	COLUMN NUMBER 651	COLUMN NUMBER 652	MEAN	STD
AL	< 0.5	< 0.5	< 0.5	0.5	0
SB	< 0.001	< 0.001	< 0.001	0.001	0
AS	0.002	0.004	0.004	0.003333	0.001154
BA	< 0.1	< 0.1	0.1	0.1	0
BE	< 0.05	< 0.05	< 0.05	0.05	0
B	3.9	3.2	3.65	3.583333	0.354729
BR	0.6	0.51	0.15	0.42	0.238117
CD	0.0007	0.0006	0.0005	0.0006	0.0001
CA	570	545	530	548.3333	20.20725
CL	2200	1700	1800	1900	264.5751
CR	< 0.1	< 0.1	< 0.1	0.1	0
CO	0.05	< 0.05	< 0.05	0.05	0
CU	0.3	0.1	0.2	0.2	0.1
F	1.7	1.5	1.6	1.6	0.1
FE	< 0.2	< 0.2	< 0.2	0.2	0
PB	< 0.001	< 0.001	< 0.001	0.001	0
MG	565	530	500	531.6666	32.53203
MN	0.5	0.6	0.5	0.533333	0.057735
HG	0.0003	0.0001	0.0001	0.000166	0.000115
MO	2.7	3.2	3.2	3.033333	0.288675
NI	1.1	1.2	1.3	1.2	0.1
NO3	154.9	60.7	805	340.2	405.2748
PO4	0.2	0.1	0.2	0.166666	0.057735
K	20	30	30	26.66666	5.773502
SE	0.7	0.5	0.5	0.566666	0.115470
SIO	27	25.5	26	26.16666	0.763762
AG	< 0.05	< 0.05	< 0.05	0.05	0
NA	1795	3510	3925	3076.666	1129.184
SR	8.2	9.35	9.2	8.916666	0.625166
SO4	7837	6651	7969	7485.666	725.8493
TL	< 0.01	< 0.01	< 0.01	0.01	0
SN	< 0.02	< 0.02	< 0.02	0.02	0
TDS	15696	12898	14990	14528	1455.089
U	0.463	0.865	0.362	0.563333	0.266087
V	< 0.1	< 0.1	< 0.1	0.1	0
ZN	0.3	0.2	0.2	0.233333	0.057735

[illegible]
9/12/90

Sample # 174 - 2

L.M. COU...
SEP '90

COMPARISON OF LEACHATE DATA FROM COLUMN
TESTS FOR ALLUVIUM (-GC,-CL)+10% MANCOS SHALE
FIRST PORE VOLUME

	653	654	655	MEAN	STD
AL	< 0.5	< 0.5	< 0.5	0.5	0
SB	0.01	< 0.001	< 0.001	0.004	0.005196
AS	0.004	0.005	0.005	0.004666	0.000577
BA	0.1	< 0.1	0.1	0.1	0
BE	< 0.05	< 0.05	< 0.05	0.05	0
B	3.05	2.8	2.7	2.85	0.180277
BR	0.82	0.93	0.81	0.853333	0.066583
CD	0.001	0.0007	0.0009	0.000866	0.000152
CA	540	500	470	503.3333	35.11884
CL	2000	2100	2000	2033.333	57.73502
CR	< 0.1	< 0.1	< 0.1	0.1	0
CO	< 0.05	< 0.05	< 0.05	0.05	0
CU	< 0.1	0.1	0.1	0.1	0
F	1.6	1.7	1.7	1.666666	0.057735
FE	< 0.2	< 0.2	< 0.2	0.2	0
PB	< 0.001	< 0.001	< 0.001	0.001	0
MG	530	470	500	500	30
MN	0.5	0.5	0.5	0.5	0
	0.0001	0.0001	0.0001	0.0001	0
MO	2.8	2.4	2.6	2.6	0.2
NI	1.2	1.2	1.1	1.166666	0.057735
NO3	13.6	0.9	217.8	77.43333	121.7268
PO4	0.2	0.2	0.1	0.166666	0.057735
K	35	15	10	20	13.22875
SE	0.7	0.7	0.6	0.666666	0.057735
SIO	24	21.5	20.5	22	1.802775
AG	< 0.05	< 0.05	< 0.05	0.05	0
NA	4125	3855	3720	3900	206.2159
SR	7.6	8.15	8.8	8.183333	0.600694
SO4	7508	8257	8150	7971.666	405.0954
-TL	< 0.01	< 0.01	< 0.01	0.01	0
SN	< 0.02	< 0.02	< 0.02	0.02	0
TDS	14662	16324	15780	15588.66	847.3590
- U	0.176	0.068	0.099	0.114333	0.055608
V	< 0.1	< 0.1	< 0.1	0.1	0
ZN	0.2	0.1	0.2	0.166666	0.057735

g. 9/12/90

,17,25,33,41,49,57,65,73,81,89,97,A5,B3,C1,C9,D7.

L.M. COONS PE, PHg

SEP '90

57

Sample #

179-3

[illegible]ON OF LEACHATE DATA FROM COLUMN
TESTS FOR TOP SOIL
FIRST PORE VOLUME

	659	660	661	MEAN	STD
AL	< 0.5	< 0.5	< 0.5	0.5	0
SB	< 0.001	0.001	0.002	0.001333	0.000577
AS	0.006	0.006	0.005	0.005666	0.000577
BA	< 0.1	< 0.1	0.1	0.1	0
BE	< 0.05	< 0.05	< 0.05	0.05	0
B	3.2	2.9	2.15	2.75	0.540832
BR	14	14	15	14.33333	0.577350
CD	0.001	0.0009	0.001	0.000966	0.000057
CA	900	900	925	908.3333	14.43375
CL	3200	3500	3600	3433.333	208.1665
CR	< 0.1	0.1	< 0.1	0.1	0
CO	< 0.05	< 0.05	< 0.05	0.05	0
CU	< 0.1	< 0.1	0.1	0.1	0
F	1.8	1.6	1.8	1.733333	0.115470
FE	< 0.2	< 0.2	< 0.2	0.2	0
PB	0.001	< 0.001	< 0.001	0.001	0
[illegible]	435	400	435	423.3333	20.20725
[illegible]	0.1	< 0.1	0.1	0.1	0
HG	0.0001	0.0001	0.0001	0.0001	0
MO	1.2	1.2	0.9	1.1	0.173205
NI	0.9	1.2	1	1.033333	0.152752
NO3	440	427.7	447.5	438.4	9.996499
PO4	0.1	0.1	< 0.5	0.233333	0.230940
K	5	5	5	5	0
SE	0.2	0.2	0.2	0.2	0
SIO	21	18	14.5	17.83333	3.253203
AG	< 0.05	< 0.05	< 0.05	0.05	0
NA	4135	4210	4235	4193.333	52.04164
SR	11.5	13	11.25	11.91666	0.946484
SO4	7055	7080	7063	7066	12.76714
TL	< 0.01	< 0.01	< 0.01	0.01	0
SN	< 0.02	< 0.02	< 0.02	0.02	0
TDS	15920	16226	16714	16286.66	400.4614
U	0.043	0.044	0.041	0.042666	0.001527
V	0.1	< 0.1	< 0.1	0.1	0
ZN	0.2	0.2	0.2	0.2	0

[illegible] 9/14/90

L.M. COONS PE. PHD
SEP '90

Sample # 179-4

COMPARISON OF LEACHATE DATA FROM COLUMN
TESTS FOR ALLUVIUM (<1")
FIRST PORE VOLUME

	656	657	658	MEAN	STD
AL	< 0.5	< 0.5	< 0.5	0.5	0
SB	0.015	< 0.001	< 0.001	0.005666	0.008082
AS	0.004	0.006	0.005	0.005	0.001
BA	0.1	0.1	< 0.1	0.1	0
BE	< 0.05	< 0.05	< 0.05	0.05	0
B	3.8	3.75	5.15	4.233333	0.794250
BR	7	0.22	9.2	5.473333	4.680612
CD	0.0008	0.001	0.0006	0.0008	0.0002
CA	465	520	525	503.3333	33.29164
CL	2400	3700	3100	3066.666	650.6407
CR	< 0.1	0.1	< 0.1	0.1	0
CO	< 0.05	< 0.05	< 0.05	0.05	0
CU	0.2	< 0.1	0.2	0.166666	0.057735
F	2.5	2.6	2.5	2.533333	0.057735
FE	< 0.2	< 0.2	< 0.2	0.2	0
PB	< 0.001	< 0.001	< 0.001	0.001	0
MG	675	780	565	673.3333	107.5096
[illegible]	< 0.1	< 0.1	< 0.1	0.1	0
HG	0.0001	0.0001	0.0002	0.000133	0.000057
MO	1.7	1.2	2.1	1.666666	0.450924
NI	1.1	1.1	1.2	1.133333	0.057735
NO3	492.8	641.5	617.8	584.0333	79.89407
PO4	0.1	0.1	0.1	0.1	0
K	35	20	20	25	8.660254
SE	1.6	1.8	0.9	1.433333	0.472581
SIO	22	30	28.5	26.83333	4.252450
AG	< 0.05	< 0.05	< 0.05	0.05	0
NA	5670	6365	5010	5681.666	677.5753
SR	10.2	10.5	10.25	10.31666	0.160727
SO4	10496	12570	11632	11566	1038.574
TL	< 0.01	< 0.01	< 0.01	0.01	0
SN	< 0.02	< 0.02	< 0.02	0.02	0
TDS	19298	24470	21698	21822	2588.228
U	0.076	0.152	0.096	0.108	0.039395
V	0.1	0.1	0.1	0.1	0
ZN	0.1	0.2	0.1	0.133333	0.057735
PH	7.23	8.18	8.20	7.87	—
Eh				0.181	
Cond				119	
Alk					

[illegible]

.17,25,33,41,49,57,65,73,81,89,97,A5,B3,C1,C9,D7.

L.M. COONS PE, PHg
SEP '90

59

Sample : 10% Peat in sample 179-4

COMPARISON OF LEACHATE DATA FROM COLUMN
TESTS FOR ALLUVIUM ((1")+10% PEAT
FIRST PORE VOLUME

	665	666	667	MEAN	STD
AL	< 0.5	< 0.5	0.6	0.533333	0.057735
SB	< 0.001	0.001	< 0.001	0.001	0
AS	0.003	< 0.005	0.01	0.006	0.003605
BA	0.1	< 0.1	< 0.1	0.1	0
BE	< 0.05	< 0.05	< 0.05	0.05	0
B	3.3	3	5.3	3.866666	1.250333
BR	0.96	0.57	4.7	2.076666	2.280226
CD	0.0012	0.0012	0.0011	0.001166	0.000057
CA	600	650	700	650	50
CL	1800	1300	2800	1966.666	763.7626
CR	0.1	< 0.1	< 0.1	0.1	0
CO	< 0.05	< 0.05	< 0.05	0.05	0
CU	0.2	< 0.1	< 0.1	0.133333	0.057735
F	0.5	0.5	0.4	0.466666	0.057735
FE	< 0.001	0.2	0.2	0.133666	0.114892
[illegible]	< 0.001	< 0.001	0.001	0.001	0
[illegible]	405	410	700	505	168.8934
MN	0.5	0.6	0.7	0.6	0.1
HG	<0.0001	<0.0001	0.0001	0.0001	0
MO	< 0.5	0.9	< 0.5	0.633333	0.230940
NI	1.4	1.6	1.6	1.533333	0.115470
NO3	609.8	407.9	986.9	668.2	293.8846
PO4	0.2	0.2	0.3	0.233333	0.057735
K	15	15	20	16.66666	2.886751
SE	0.4	0.4	1.3	0.7	0.519615
SIO	36.5	34	37.5	36	1.802775
AG	< 0.05	< 0.05	< 0.05	0.05	0
NA	3075	2600	4400	3358.333	932.8495
SR	6.8	7.05	9.25	7.7	1.348146
SO4	6075	5038	7277	6130	1120.512
TL	< 0.01	< 0.01	< 0.01	0.01	0
SN	< 0.02	< 0.02	< 0.02	0.02	0
TDS	12766	10254	16642	13220.66	3218.179
U	0.076	0.072	0.135	0.094333	0.035275
V	< 0.1	< 0.1	0.1	0.1	0
ZN	0.2	0.3	0.3	0.266666	0.057735

9/12/90

COMPARISON OF LEACHATE DATA FROM COLUMN
TESTS FOR PEAT
FIRST PORE VOLUME

Peat

L.M. COONS PE. PHD

SEP '90

	662	663	664	MEAN	STD
AL	< 0.5	0.7	< 0.5	0.566666	0.115470
SB	< 0.001	0.001	< 0.001	0.001	0
AS	0.011	0.016	0.011	0.012666	0.002886
BA	0.1	0.1	0.1	0.1	0
BE	< 0.05	< 0.05	< 0.05	0.05	0
B	< 0.1	< 0.1	< 0.1	0.1	0
BR	0.28	0.08	0.28	0.213333	0.115470
CD	0.0013	0.0011	0.0013	0.001233	0.000115
CA	1600	1600	1600	1600	0
CL	1400	1400	1400	1400	0
CR	0.1	< 0.1	0.1	0.1	0
CO	< 0.05	< 0.05	< 0.05	0.05	0
CU	< 0.1	< 0.1	< 0.1	0.1	0
F	0.2	0.2	0.2	0.2	0
FE	0.4	0.5	0.4	0.433333	0.057735
PB	< 0.001	< 0.001	< 0.001	0.001	0
MG	490	440	490	473.3333	28.86751
[illegible]	2.9	3	2.9	2.933333	0.057735
HG	0.0001	0.0002	0.0001	0.000133	0.000057
MO	< 0.5	< 0.5	< 0.5	0.5	0
NI	0.8	1.1	0.8	0.9	0.173205
NO3	1935.4	1934.1	1935.4	1934.966	0.750555
PO4	1	0.9	1	0.966666	0.057735
K	25	30	25	26.66666	2.886751
SE	0.03	0.03	0.03	0.03	0
SIO	56.5	54.5	56.5	55.83333	1.154700
AG	< 0.05	< 0.05	< 0.05	0.05	0
NA	460	455	460	458.3333	2.886751
SR	9.7	8.6	9.7	9.333333	0.635085
-SO4	2824	2988	2824	2878.666	94.68544
TL	< 0.01	< 0.01	< 0.01	0.01	0
SN	< 0.02	< 0.02	< 0.02	0.02	0
- TDS	8778	8710	8778	8755.333	39.25981
U	0.007	< 0.003	0.007	0.005666	0.002309
V	0.1	< 0.1	0.1	0.1	0
ZN	0.3	0.2	0.3	0.266666	0.057735

3/12/90

D-4

Hazardous constituents detected in the pore water of the Grand Junction tailings.

Tailings Pore Water Quality Statistics
Lysimeters 550-556, 600-604, 640-646
SITE: GRJ01 GRAND JUNCTION
08/17/89 TO 01/15/90
REPORT DATE: 07/07/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
11	7.0000	679.0000	175.0000	173.6411	3.6401	NA	0.0	59.0920	509.0678	LOGNORMAL	7,8
ALUMINUM			MG/L								
14	0.0500	78.9667	0.1033	NA	NA	NA	25.0	0.0500	5.7000	NONPARAMETRIC	2
AMMONIUM			MG/L								
13	27.0000	892.3333	305.5000	243.9303	2.8709	NA	0.0	111.3508	534.3649	LOGNORMAL	7,8
ANTIMONY			MG/L								
14	0.0015	0.0173	0.0062	NA	NA	NA	46.4	0.0015	0.0095	NONPARAMETRIC	2
ARSENIC			MG/L								
14	0.0050	1.3125	0.1067	0.0918	5.4562	NA	3.6	0.0276	0.3052	LOGNORMAL	7,8
BARIUM			MG/L								
14	0.0100	0.0733	0.0342	NA	NA	NA	32.1	0.0233	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
14	0.0025	0.1730	0.0031	NA	NA	NA	50.0	0.0025	0.0125	NONPARAMETRIC	2
BORON			MG/L								
13	0.2600	2.0400	0.6600	0.6234	1.7047	NA	0.0	0.4193	0.9269	LOGNORMAL	7,8
CADMIUM			MG/L								
14	0.0005	0.2873	0.0118	0.0111	12.0844	NA	14.3	0.0019	0.0667	LOGNORMAL	7,8
CALCIUM			MG/L								
14	445.5000	1005.0000	523.5000	547.0648	1.2475	NA	0.0	467.7507	639.8279	LOGNORMAL	7,8

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Tailings Pore Water Quality Statistics
Lysimeters 550-556, 600-604, 640-646
SITE: GRJ01 GRAND JUNCTION
08/17/89 TO 01/15/90
REPORT DATE: 07/07/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHLORIDE			MG/L								
12	296.7500	1830.0000	1044.7500	925.9731	1.6570	NA	0.0	623.0485	1376.1789	LOGNORMAL	7,8
CHROMIUM			MG/L								
14	0.0050	0.0525	0.0050	NA	NA	NA	82.1	0.0050	0.0367	NONPARAMETRIC	2
COBALT			MG/L								
14	0.0250	0.6300	0.0900	NA	NA	NA	32.1	0.0250	0.3800	NONPARAMETRIC	2
COPPER			MG/L								
14	0.0100	3.0333	0.0492	NA	NA	NA	17.9	0.0100	2.6050	NONPARAMETRIC	2
CYANIDE			MG/L								
14	0.0400	0.1600	0.0800	0.0710	1.6920	NA	4.8	0.0489	0.1030	LOGNORMAL	7,8
FLUORIDE			MG/L								
14	0.7000	15.2000	4.7000	4.4638	2.6410	NA	0.0	2.2438	8.8801	LOGNORMAL	7,8
GROSS ALPHA			PCI/L								
9	113.0000	8020.0000	558.0000	794.7962	4.9612	NA	0.0	169.3478	3730.1988	LOGNORMAL	7,8
GROSS BETA			PCI/L								
9	109.0000	2675.0000	666.0000	585.5358	3.4625	NA	0.0	176.5463	1941.9950	LOGNORMAL	7,8
IRON			MG/L								
14	0.0150	213.5000	8.3000	4.4329	20.7171	NA	14.3	0.5181	37.9285	LOGNORMAL	7,8
LEAD			MG/L								
14	0.0040	0.0670	0.0050	NA	NA	NA	53.6	0.0050	0.0453	NONPARAMETRIC	2

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Tailings Pore Water Quality Statistics
Lysimeters 550-556, 600-604, 640-646
SITE: GRJ01 GRAND JUNCTION
08/17/89 TO 01/15/90
REPORT DATE: 07/07/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM			MG/L								
14	158.0000	512.5000	246.5000	265.8329	1.4847	NA	0.0	200.9294	351.7013	LOGNORMAL	7,8
MANGANESE			MG/L								
14	1.9300	8.3333	4.6975	4.6087	1.6435	NA	0.0	3.2416	6.5524	LOGNORMAL	7,8
MERCURY			MG/L								
9	0.0001	0.0003	0.0001	NA	NA	NA	85.7	0.0001	0.0003	NONPARAMETRIC	2
MOLYBDENUM			MG/L								
14	0.0617	4.3500	0.2462	NA	NA	NA	21.4	0.0950	0.8567	NONPARAMETRIC	2
NICKEL			MG/L								
14	0.0200	3.7133	0.5400	0.3420	5.2409	NA	7.1	0.1058	1.105[illegible]	LOGNORMAL	7,8
NITRATE			MG/L								
12	0.3500	3465.0000	1.1333	NA	NA	NA	42.1	0.4000	1420.0000	NONPARAMETRIC	2
PHOSPHATE			MG/L								
13	0.2000	4.0000	0.9000	0.8700	2.7700	NA	5.0	0.4078	1.8557	LOGNORMAL	7,8
POTASSIUM			MG/L								
14	21.0000	233.5000	67.5000	70.7768	1.9421	NA	0.0	44.2308	113.2551	LOGNORMAL	7,8
RADIUM-226			PCI/L								
10	0.0000	668.9000	18.9667	NA	NA	NA	0.0	1.0565	413.0500	NONPARAMETRIC	9
RADIUM-228			PCI/L								
10	0.0000	3.8000	0.5500	NA	NA	NA	30.0	0.0000	2.9000	NONPARAMETRIC	2

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

Tailings Pore Water Qu... Statistics
Lysimeters 550-556, 600-604, 640-646
SITE: GRJ01 GRAND JUNCTION
08/17/89 TO 01/15/90
REPORT DATE: 07/07/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SELENIUM			MG/L								
14	0.0025	0.8700	0.0732	NA	NA	NA	25.0	0.0025	0.4600	NONPARAMETRIC	2
SILICA - SIO2			MG/L								
13	17.1000	83.0000	39.7500	35.6165	1.6407	NA	0.0	24.6466	51.4691	LOGNORMAL	7,8
SILVER			MG/L								
14	0.0026	0.0208	0.0050	NA	NA	NA	71.4	0.0035	0.0189	NONPARAMETRIC	2
SODIUM			MG/L								
14	390.5000	1205.0000	775.0000	740.6519	1.3977	NA	0.0	584.2911	938.8560	LOGNORMAL	7,8
SPECIFIC CONDUCTANCE			UMHO/CM								
15	6200.0000	15880.0000	9180.0000	10147.0110	1.3377	NA	0.0	8331.5067	12358.1246	LOGNORMAL	7,8
STRONTIUM			MG/L								
14	3.9133	5.9200	5.4325	5.0564	1.1635	NA	0.0	4.5421	5.6289	LOGNORMAL	7,8
SULFATE			MG/L								
12	2198.5000	4487.0000	3327.5000	3378.3908	1.2494	NA	0.0	2836.7667	4023.4271	LOGNORMAL	7,8
SULFIDE			MG/L								
14	0.0300	60.0000	0.0500	NA	NA	NA	82.4	0.0500	0.0500	NONPARAMETRIC	2
TEMPERATURE			C - DEGREE								
15	6.3000	16.7000	12.5000	12.2622	1.2539	NA	0.0	10.5192	14.2939	LOGNORMAL	7,8
THALLIUM			MG/L								
14	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Tailings Pore Water Quality Statistics
Lysimeters 550-556, 600-604, 640-646
SITE: GRJ01 GRAND JUNCTION
08/17/89 TO 01/15/90
REPORT DATE: 07/07/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
THORIUM-230			PCI/L								
5	3.5900	29.6000	18.8800	12.9673	2.5996	NA	0.0	2.6157	64.2843	LOGNORMAL	7,8
TIN			MG/L								
8	0.0025	0.0170	0.0025	NA	NA	NA	75.0	0.0025	0.0170	NONPARAMETRIC	2
TOTAL DISSOLVED SOLIDS			MG/L								
13	4563.0000	10345.0000	6457.0000	6609.3040	1.2970	NA	0.0	5447.3447	8019.1178	LOGNORMAL	7,8
TOTAL KJELDAHL NITROGEN			MG/L								
13	0.5000	731.0000	223.0000	103.2699	9.6318	NA	7.7	19.1652	556.4608	LOGNORMAL	7,8
URANIUM			MG/L								
14	0.0750	29.7000	0.9850	0.7777	5.3430	NA	0.0	0.2373	2.5484	LOGNORMAL	7,8
VANADIUM			MG/L								
14	0.0050	27.6333	1.3058	0.6522	14.0823	NA	7.1	0.1002	6.2653	LOGNORMAL	7,8
ZINC			MG/L								
14	0.0025	7.0533	0.2798	0.2544	15.8659	NA	7.1	0.0359	1.8019	LOGNORMAL	7,8

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

INPUT DATA FILENAME: J:\DART\GRJ01\GW010005.DAT

L.M. COONS

ATTACHMENT E

Groundwater quality of the Mancos Shale and the Dakota Sandstone.

Table Background water quality in the Mancos Shale at the Cheney disposal site, Colorado
SITE: GRJ03 CHENEY RESERVOIR
07/27/86 TO 06/27/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
7	260.0000	1219.0000	577.0000	454.6454	1.8947	NA	0.0	212.8025	971.3346	LOGNORMAL	7,8
ALUMINUM			MG/L								
7	0.0500	0.6300	0.1750	NA	NA	NA	45.0	0.0500	0.6300	NONPARAMETRIC	2
AMMONIUM			MG/L								
7	0.0500	4.5000	0.5000	NA	NA	NA	55.0	0.0500	4.5000	NONPARAMETRIC	2
ANTIMONY			MG/L								
6	0.0015	0.0410	0.0072	NA	NA	NA	36.4	0.0015	0.0410	NONPARAMETRIC	2,6
ARSENIC			MG/L								
7	0.0044	0.0085	0.0050	NA	NA	NA	80.0	0.0044	0.0085	NONPARAMETRIC	2
BARIUM			MG/L								
7	0.0200	0.0600	0.0400	NA	NA	NA	52.9	0.0200	0.0600	NONPARAMETRIC	2
BERYLLIUM			MG/L								
6	0.0037	0.0050	0.0037	NA	NA	NA	100.0	0.0037	0.0050	NONPARAMETRIC	2,6
BORON			MG/L								
4	0.0650	1.7200	0.7900	NA	NA	NA	33.3	0.0650	1.7200	NONPARAMETRIC	2,4
BROMIDE			MG/L								
3	1.0000	5.5000	1.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, a = 0.01
1) Data from a minimum of 4 locations must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

L.M. COONS PE PHG SEP 90

Table 3.36 Background water quality in the Mancos Shale at the Cheney disposal site, Colorado
SITE: GRJ03 CHENEY RESERVOIR
07/27/86 TO 06/27/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CADMIUM			MG/L								
7	0.0005	0.0050	0.0018	NA	NA	NA	52.9	0.0005	0.0050	NONPARAMETRIC	2
CALCIUM			MG/L								
7	11.5000	442.0000	204.2000	185.5234	3.9072	NA	0.0	20.9058	532.6573	LOGNORMAL	7,8
CATION/ANION BALANCE			%								
3	-2.7900	0.0000	-1.5000	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
CHLORIDE			MG/L								
7	29.4000	2400.0000	230.0000	313.3838	5.4014	NA	0.0	42.2576	2324.0672	LOGNORMAL	7,8
CHROMIUM			MG/L								
7	0.0050	0.0100	0.0050	NA	NA	NA	85.0	0.0050	0.0100	NONPARAMETRIC	2
COBALT			MG/L								
6	0.0250	0.0250	0.0250	NA	NA	NA	100.0	0.0250	0.0250	NONPARAMETRIC	2,6
COPPER			MG/L								
7	0.0100	0.0300	0.0150	NA	NA	NA	76.5	0.0100	0.0300	NONPARAMETRIC	2
CYANIDE			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
FLUORIDE			MG/L								
7	0.1900	1.6000	0.4325	0.5457	2.1611	NA	0.0	0.2185	1.3630	LOGNORMAL	7,8

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
1) Data from a minimum of 4 locations must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Table 3.36 Background water quality in the Mancos Shale at the Cheney disposal site, Colorado
SITE: GRJ03 CHENEY RESERVOIR
07/27/86 TO 06/27/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
GROSS ALPHA			PCI/L								
7	6.8000	73.5000	18.0000	20.3795	2.5760	NA	5.9	6.6225	62.7143	LOGNORMAL	7,8
GROSS BETA			PCI/L								
7	9.8500	69.0000	18.5500	21.6626	1.9410	NA	5.9	9.8527	47.4276	LOGNORMAL	7,8
IRON			MG/L								
7	0.0500	0.5100	0.1450	0.1654	2.0809	NA	5.0	0.0693	0.3950	LOGNORMAL	7,8
LEAD			MG/L								
6	0.0050	0.0200	0.0088	NA	NA	NA	69.2	0.0050	0.0200	NONPARAMETRIC	2,6
MAGNESIUM			MG/L								
7	12.6500	260.0000	91.7667	61.4801	2.9755	NA	0.0	16.8332	224.5452	LOGNORMAL	7,8
MANGANESE			MG/L								
7	0.0250	0.6900	0.2210	0.1594	3.0795	NA	5.0	0.0419	0.6064	LOGNORMAL	7,8
MERCURY			MG/L								
6	0.0001	0.0002	0.0001	NA	NA	NA	91.7	0.0001	0.0002	NONPARAMETRIC	2,6
MOLYBDENUM			MG/L								
6	0.0125	0.1150	0.0675	NA	NA	NA	31.3	0.0125	0.1150	NONPARAMETRIC	2,6
NICKEL			MG/L								
7	0.0200	0.0280	0.0200	NA	NA	NA	94.7	0.0200	0.0280	NONPARAMETRIC	2
NITRATE			MG/L								
7	0.5000	3.8000	1.7200	NA	NA	NA	60.0	0.5000	3.8000	NONPARAMETRIC	2

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Table 3.36 Backgro[illegible] water quality in the Mancos Shale at the Cheney disposal site, Colorado

SITE: GRJ03 CHENEY RESERVOIR

07/27/86 TO 06/27/90

REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	MEDIAN	UNITS	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
PHOSPHATE				MG/L								
4	0.0750	0.3100	0.1775		NA	NA	NA	33.3	0.0750	0.3100	NONPARAMETRIC	2,4
POTASSIUM				MG/L								
7	2.7380	19.0000	5.9500		5.7098	2.0295	NA	0.0	2.4630	13.2366	LOGNORMAL	7,8
RADIUM-226				PCI/L								
7	0.0750	1.3500	0.3000		NA	NA	NA	31.3	0.0750	1.3500	NONPARAMETRIC	2
RADIUM-228				PCI/L								
7	0.0500	1.0000	0.4500		NA	NA	NA	35.3	0.0500	1.0000	NONPARAMETRIC	2
SELENIUM				MG/L								
7	0.0039	0.1095	0.0155		NA	NA	NA	35.0	0.0039	0.1095	NONPARAMETRIC	2
SILICA - SIO2				MG/L								
5	8.6000	42.0000	10.6500		16.9153	2.2525	NA	0.0	4.3383	65.9543	LOGNORMAL	7,8
SILVER				MG/L								
6	0.0050	0.0075	0.0050		NA	NA	NA	92.3	0.0050	0.0075	NONPARAMETRIC	2,6
SODIUM				MG/L								
7	80.6800	2465.0000	1125.0000		502.3447	6.0892	NA	0.0	94.2786	2676.4506	LOGNORMAL	7,8
SPECIFIC CONDUCTANCE				UMHO/CM								
7	666.6667	6500.0000	1873.0000		1808.9055	2.4363	NA	0.0	628.0524	5209.9774	LOGNORMAL	7,8

Note the data at each location was averaged before the statistical calculations were performed

* Statistical maximum is the 99 percent one sided confidence interval, a = 0.01

2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.

6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

7) The lognormal distribution was used because the data failed the normal distribution test.

8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Table 3.39 Da[illegible]ndstone water quality statistics at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME [UNITS]	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE [illegible] CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SELENIUM [MG/L]	6	0.0025	0.0050	0.0025	NA	NA	NA	83.3	0.0025	0.0050	NONPARAMETRIC	2,6
SILICA - SIO2 [MG/L]	6	8.0000	46.0000	18.3500	21.2333	13.1767	0.6206	0.0	3.1317	39.3350	NORMAL	
SILVER [MG/L]	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
SODIUM [MG/L]	6	4210.0000	7020.0000	5930.0000	5756.6667	1012.9692	0.1760	0.0	4365.0947	7148.2387	NORMAL	
SPECIFIC CONDUCTANCE [UMHO/CM]	2	15.5900	21000.0000	10507.7950	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
STRONTIUM [MG/L]	6	3.5900	9.0500	7.7200	7.1850	2.0867	0.2904	0.0	4.3184	10.0516	NORMAL	
SULFATE [MG/L]	6	6.2000	175.0000	54.3000	67.0167	61.8021	0.9222	0.0	-17.8843	151.9176	NORMAL	
SULFIDE [MG/L]	6	0.0500	10.0000	0.1700	NA	NA	NA	50.0	0.0500	10.0000	NONPARAMETRIC	2,6
TEMPERATURE [C - DEGREE]	5	16.9000	22.1000	19.0000	19.4200	1.8939	0.0975	0.0	16.2463	22.5937	NORMAL	
THALLIUM [MG/L]	3	0.0500	0.1000	0.0500	NA	NA	NA	66.7	NA	NA	UNKNOWN	1

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

Strontium - proposed concent. limit is based on statistical maximum of background concen. 10.1 mg/l

Sulfide. proposed conc. limit is based on statistical maximum of background concentration 10.0 mg/l

Table 3.39 Dakota Sandstone water quality statistics at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM	MG/L	6	13.7000	42.0000	22.5000	26.7167	10.7682	0.4031	0.0	11.9238	41.5095	NORMAL	
MANGANESE	MG/L	6	0.0200	0.3900	0.1100	0.0809	3.5524	NA	0.0	0.0142	0.4615	LOGNORMAL	7,8
MERCURY	MG/L	6	0.0001	0.0910	0.0001	NA	NA	NA	83.3	0.0001	0.0910	NONPARAMETRIC	2,6
MOLYBDENUM	MG/L	6	0.0050	0.2100	0.0500	NA	NA	NA	33.3	0.0050	0.2100	NONPARAMETRIC	2,6
NICKEL	MG/L	6	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,6
NITRATE	MG/L	6	0.5000	10.0000	1.7500	NA	NA	NA	50.0	0.5000	10.0000	NONPARAMETRIC	2,6
PHOSPHATE	MG/L	6	0.1200	11.4000	2.6000	1.4390	5.4103	NA	0.0	0.1415	14.6324	LOGNORMAL	7,8
POTASSIUM	MG/L	6	14.0000	111.0000	71.6500	67.2167	39.0866	0.5815	0.0	13.5212	120.9121	NORMAL	
RADIUM-226	PCI/L	6	1.5000	32.0000	2.8500	4.7334	3.6747	NA	0.0	0.7920	28.2906	LOGNORMAL	7,8
RADIUM-228	PCI/L	6	3.4000	48.0000	23.5000	25.0667	15.7915	0.6300	0.0	3.3730	46.7603	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Molybdenum - proposed concentration limit is based statistical maximum concentration of background (In this case it is observed maximum)

-461-

Proposed Concentration limit is based on statistical maximum concentration of background

= 28.3 + 46.8
= 75

Table 3.39 Dak[illegible]stone water quality statistics at the Cheney disp[illegible] site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHLORIDE			MG/L								
6	3040.0000	4850.0000	4310.0000	4085.0000	731.7035	0.1791	0.0	3079.8183	5090.1817	NORMAL	
CHROMIUM			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
COBALT			MG/L								
6	0.0250	0.0250	0.0250	NA	NA	NA	100.0	0.0250	0.0250	NONPARAMETRIC	2,6
COPPER			MG/L								
6	0.0100	0.0200	0.0100	NA	NA	NA	66.7	0.0100	0.0200	NONPARAMETRIC	2,6
CYANIDE			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
FLUORIDE			MG/L								
6	1.2000	2.2000	1.6000	1.6667	0.3724	0.2234	0.0	1.1551	2.1782	NORMAL	
GROSS ALPHA			PCI/L								
6	0.0000	98.0000	37.5000	NA	NA	NA	33.3	0.0000	98.0000	NONPARAMETRIC	2,6
GROSS BETA			PCI/L								
6	0.0000	160.0000	102.5000	NA	NA	NA	16.7	0.0000	160.0000	NONPARAMETRIC	2,6
IRON			MG/L								
6	0.2500	0.8900	0.4850	0.5067	0.2106	0.4156	0.0	0.2174	0.7960	NORMAL	
LEAD			MG/L								
6	0.0050	0.0100	0.0050	NA	NA	NA	83.3	0.0050	0.0100	NONPARAMETRIC	2,6

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

fluoride - proposed one. limit is based on statistical maximum of background concentration .2 mg/l

(16)

Table 3.39 Dako… stone water quality statistics at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
5	5667.0000	9139.0000	7861.0000	7439.2000	1329.8636	0.1788	0.0	5210.7352	9667.6648	NORMAL	
ALUMINUM			MG/L								
6	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,6
AMMONIUM			MG/L								
6	5.2000	8.0000	6.0500	6.2667	1.0690	0.1706	0.0	4.7982	7.7352	NORMAL	
ANTIMONY			MG/L								
3	0.0015	0.0015	0.0015	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ARSENIC			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
BARIUM			MG/L								
6	4.4400	38.0000	33.3000	27.2567	13.1413	0.4821	0.0	9.2037	45.3096	NORMAL	
BERYLLIUM			MG/L								
3	0.0025	0.0025	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BORON			MG/L								
6	1.5000	3.1300	2.0450	2.2633	0.6217	0.2747	0.0	1.4093	3.1174	NORMAL	
CADMIUM			MG/L								
6	0.0005	0.0005	0.0005	NA	NA	NA	100.0	0.0005	0.0005	NONPARAMETRIC	2,6
CALCIUM			MG/L								
6	14.5000	42.0000	33.8000	31.6833	9.7016	0.3062	0.0	18.3557	45.0110	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the [illegible]% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

-459-

Barium-
…posed conc. limit is
…sd on statistical
…aximum of background
45.3 mg/l

JE JACOBS ENGINEERING

DATE ________ SUBJECT ________ SHEET NO. ________

BY ________ CHKD. ________ JOB NO. ________

Cny
2/1/91
JK 2/1/91

(15)

Table 3.39

Background water quality statistics

(14)

Table 3.38 Dakot[illegible]stone water quality by parameter at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
TEMPERATURE	0977	06/28/90	F014	KD	D	C - DEGREE		22.1	-	-
	0978	02/12/90	0001	KD	D			19.0	-	-
THALLIUM	0971	02/19/90	0001	KD	D	MG/L	<	0.1	0.1	-
	0977	02/02/90	0001	KD	D		<	0.1	0.1	-
	0978	02/12/90	0001	KD	D			0.1	0.1	-
TOTAL DISSOLVED SOLIDS	0971	02/19/90	0001	KD	D	MG/L		15300.	10.0	-
	0971	06/28/90	F014	KD	D			18300.	10.0	-
	0977	02/02/90	0001	KD	D			12100.	10.0	-
	0977	06/28/90	F014	KD	D			10500.	10.0	-
	0978	02/12/90	0001	KD	D			15410.	10.0	-
	0978	06/29/90	F014	KD	D			15500.	10.0	-
TOTAL KJELDAHL NITROGEN	0971	02/19/90	0001	KD	D	MG/L	<	1.	1.0	-
	0977	02/02/90	0001	KD	D			5.	1.0	-
	0978	02/12/90	0001	KD	D		<	1.	1.0	-
URANIUM	0971	02/19/90	0001	KD	D	MG/L	<	0.003	0.003	-
	0971	06/28/90	F014	KD	D			0.0032	0.003	-
	0977	02/02/90	0001	KD	D		<	0.003	0.003	-
	0977	06/28/90	F014	KD	D			0.0004	0.003	-
	0978	02/12/90	0001	KD	D		<	0.003	0.003	-
	0978	06/29/90	F014	KD	D			0.0004	0.003	-
VANADIUM	0971	02/19/90	0001	KD	D	MG/L	<	0.01	0.01	-
	0971	06/28/90	F014	KD	D			.03	0.01	-
	0977	02/02/90	0001	KD	D		<	0.01	0.01	-
	0977	06/28/90	F014	KD	D		<	.01	0.01	-
	0978	02/12/90	0001	KD	D		<	0.01	0.01	-
	0978	06/29/90	F014	KD	D		<	.01	0.01	-
ZINC	0971	02/19/90	0001	KD	D	MG/L		1.36	0.005	-
	0971	06/28/90	F014	KD	D			1.41	0.005	-
	0977	02/02/90	0001	KD	D			4.06	0.005	-
	0977	06/28/90	F014	KD	D			.039	0.005	-
	0978	02/12/90	0001	KD	D		<	0.005	0.005	-
	0978	06/29/90	F014	KD	D		<	.005	0.005	-

MCL = 0.044 mg/l

Vanadium see table 3.39

MCL = 5.0 mg/l (Secondary drinking water standard)

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < = LESS THAN DETECTION LIMIT

DATA FILE NAME: J:\DART\GRJ03\GWQ10020.DAT

Table 3.38 Dakota S[illegible] e water quality by parameter at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

D.L. 0.05 mg/l

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
SILVER	0977	02/02/90	0001	KD	D	MG/L	<	0.01	0.01	-
	0977	06/28/90	F014	KD	D		<	.01	0.01	-
	0978	02/12/90	0001	KD	D		<	0.01	0.01	-
	0978	06/29/90	F014	KD	D		<	.01	0.01	-
SODIUM	0971	02/19/90	0001	KD	D	MG/L		6100.	0.002	-
	0971	06/28/90	F014	KD	D			7020.	0.002	-
	0977	02/02/90	0001	KD	D			5010.	0.002	-
	0977	06/28/90	F014	KD	D			4210.	0.002	-
	0978	02/12/90	0001	KD	D			6440.	0.002	-
	0978	06/29/90	F014	KD	D			5760.	0.002	-
SPECIFIC CONDUCTANCE	0971	06/28/90	F014	KD	D	UMHO/CM		21000.	-	-
	0977	06/28/90	F014	KD	D			15.59	-	-
STRONTIUM	0971	02/19/90	0001	KD	D	MG/L		9.00	0.1	-
	0971	06/28/90	F014	KD	D			7.43	0.1	-
	0977	02/02/90	0001	KD	D			3.59	0.1	-
	0977	06/28/90	F014	KD	D			6.03	0.1	-
	0978	02/12/90	0001	KD	D			9.05	0.1	-
	0978	06/29/90	F014	KD	D			8.01	0.1	-
SULFATE	0971	02/19/90	0001	KD	D	MG/L		94.2	0.1	-
	0971	06/28/90	F014	KD	D			18.1	0.1	-
	0977	02/02/90	0001	KD	D			175.	0.1	-
	0977	06/28/90	F014	KD	D			6.2	0.1	-
	0978	02/12/90	0001	KD	D			66.2	0.1	-
	0978	06/29/90	F014	KD	D			42.4	0.1	-
SULFIDE	0971	02/19/90	0001	KD	D	MG/L		10.	0.1	-
	0971	06/28/90	F014	KD	D		<	.1	0.1	-
	0977	02/02/90	0001	KD	D		<	1.	0.1	-
	0977	06/28/90	F014	KD	D		<	.1	0.1	-
	0978	02/12/90	0001	KD	D			3.	0.1	-
	0978	06/29/90	F014	KD	D			0.29	0.1	-
TEMPERATURE	0971	02/19/90	0001	KD	D	C - DEGREE		16.9	-	-
	0971	06/28/90	F014	KD	D			20.1	-	-
	0977	02/02/90	0001	KD	D			19.0	-	-

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

Table 3.38 Dak[illegible] stone water q[illegible] by parameter at the Cheney disp[illegible] site, Grand Ju[illegible], Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
PHOSPHATE	0978	06/29/90	F014	KD	D	MG/L		11.4	0.1	-
POTASSIUM	0971	02/19/90	0001	KD	D	MG/L		30.	0.01	-
	0971	06/28/90	F014	KD	D			67.3	0.01	-
	0977	02/02/90	0001	KD	D			14.	0.01	-
	0977	06/28/90	F014	KD	D			111.	0.01	-
	0978	02/12/90	0001	KD	D			76.	0.01	-
	0978	06/29/90	F014	KD	D			105.	0.01	-
RADIUM-226	0971	02/19/90	0001	KD	D	PCI/L		3.5	1.0	0.6
	0971	06/28/90	F014	KD	D			1.7	1.0	0.5
	0977	02/02/90	0001	KD	D			32.0	1.0	2.2
	0977	06/28/90	F014	KD	D			2.2	1.0	0.5
	0978	02/12/90	0001	KD	D			17.9	1.0	1.6
	0978	06/29/90	F014	KD	D			1.5	1.0	0.5
RADIUM-228	0971	02/19/90	0001	KD	D	PCI/L		3.4	1.0	1.9
	0971	06/28/90	F014	KD	D			18.	1.0	2.
	0977	02/02/90	0001	KD	D			35.6	1.0	3.3
	0977	06/28/90	F014	KD	D			48.	1.0	2.
	0978	02/12/90	0001	KD	D			16.4	1.0	2.6
	0978	06/29/90	F014	KD	D			29.	1.0	2.
SELENIUM	0971	02/19/90	0001	KD	D	MG/L	<	0.03	0.005	-
	0971	06/28/90	F014	KD	D			0.005	0.005	-
	0977	02/02/90	0001	KD	D		<	0.03	0.005	-
	0977	06/28/90	F014	KD	D		<	.005	0.005	-
	0978	02/12/90	0001	KD	D		<	0.03	0.005	-
	0978	06/29/90	F014	KD	D		<	.005	0.005	-
SILICA - SIO2	0971	02/19/90	0001	KD	D	MG/L		13.7	2.0	-
	0971	06/28/90	F014	KD	D			46.	2.0	-
	0977	02/02/90	0001	KD	D			17.1	2.0	-
	0977	06/28/90	F014	KD	D			8.	2.0	-
	0978	02/12/90	0001	KD	D			19.6	2.0	-
	0978	06/29/90	F014	KD	D			23.	2.0	-
SILVER	0971	02/19/90	0001	KD	D	MG/L	<	0.01	0.01	-
	0971	06/28/90	F014	KD	D		<	.01	0.01	-

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

a. 226/228
ee table 3.39

MCL = 0.01 mg/l

MCL = 0.05 mg/l

Table 3.38 Da[illegible]dstone water quality by parameter at the Cheney disp[illegible] site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
MOLYBDENUM	0977	02/02/90	0001	KD	D	MG/L		0.21	0.01	-
	0977	06/28/90	F014	KD	D			.07	0.01	-
	0978	02/12/90	0001	KD	D		<	0.05	0.01	-
	0978	06/29/90	F014	KD	D			.05	0.01	-
NET GROSS ALPHA *	0971	02/19/90	0001	KD	D	PCI/L		84.97	-	-
	0971	06/28/90	F014	KD	D			-2.20	-	-
	0977	02/02/90	0001	KD	D			96.97	-	-
	0977	06/28/90	F014	KD	D			74.73	-	-
	0978	02/12/90	0001	KD	D			-1.03	-	-
	0978	06/29/90	F014	KD	D			-0.27	-	-
NICKEL	0971	02/19/90	0001	KD	D	MG/L	<	0.04	0.04	-
	0971	06/28/90	F014	KD	D		<	.04	0.04	-
	0977	02/02/90	0001	KD	D		<	0.04	0.04	-
	0977	06/28/90	F014	KD	D		<	.04	0.04	-
	0978	02/12/90	0001	KD	D		<	0.04	0.04	-
	0978	06/29/90	F014	KD	D		<	.04	0.04	-
NITRATE	0971	02/19/90	0001	KD	D	MG/L	<	0.1	1.0	-
	0971	06/28/90	F014	KD	D			3.	1.0	-
	0977	02/02/90	0001	KD	D		<	0.1	1.0	-
	0977	06/28/90	F014	KD	D			10.	1.0	-
	0978	02/12/90	0001	KD	D		<	0.1	1.0	-
	0978	06/29/90	F014	KD	D			4.	1.0	-
PH	0971	02/19/90	0001	KD	D	SU		7.80	-	-
	0971	06/28/90	F014	KD	D			7.44	-	-
	0977	02/02/90	0001	KD	D			7.21	-	-
	0977	06/28/90	F014	KD	D			7.66	-	-
	0978	02/12/90	0001	KD	D			7.43	-	-
PHOSPHATE	0971	02/19/90	0001	KD	D	MG/L		3.2	0.1	-
	0971	06/28/90	F014	KD	D			2.6	0.1	-
	0977	02/02/90	0001	KD	D			0.12	0.1	-
	0977	06/28/90	F014	KD	D			2.6	0.1	-
	0978	02/12/90	0001	KD	D			0.3	0.1	-

* NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

See table 3.39

Max observed at Background = 97

<MDL 0.04 mg/l

MCL = 44.0 mg/l

Table 3.38 Dakota Sandstone u..ter quality by parameter at the Cheney disposal site ...d Junction, Colorado
SITE: GRJ03 CHENEY RESER...
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
GROSS BETA	0978	06/29/90	F014	KD	D	PCI/L		77.	0.5	95.
IRON	0971	02/19/90	0001	KD	D	MG/L		0.50	0.03	-
	0971	06/28/90	F014	KD	D			.51	0.03	-
	0977	02/02/90	0001	KD	D			0.42	0.03	-
	0977	06/28/90	F014	KD	D			.25	0.03	-
	0978	02/12/90	0001	KD	D			0.89	0.03	-
	0978	06/29/90	F014	KD	D			.47	0.03	-
LEAD	0971	02/19/90	0001	KD	D	MG/L	<	0.01	0.01	-
	0971	06/28/90	F014	KD	D			0.01	0.01	-
	0977	02/02/90	0001	KD	D		<	0.05	0.01	-
	0977	06/28/90	F014	KD	D		<	.01	0.01	-
	0978	02/12/90	0001	KD	D		<	0.01	0.01	-
	0978	06/29/90	F014	KD	D		<	.01	0.01	-
MAGNESIUM	0971	02/19/90	0001	KD	D	MG/L		42.	0.001	-
	0971	06/28/90	F014	KD	D			37.6	0.001	-
	0977	02/02/90	0001	KD	D			23.	0.001	-
	0977	06/28/90	F014	KD	D			13.7	0.001	-
	0978	02/12/90	0001	KD	D			22.	0.001	-
	0978	06/29/90	F014	KD	D			22.0	0.001	-
MANGANESE	0971	02/19/90	0001	KD	D	MG/L		0.02	0.01	-
	0971	06/28/90	F014	KD	D			.03	0.01	-
	0977	02/02/90	0001	KD	D			0.21	0.01	-
	0977	06/28/90	F014	KD	D			.03	0.01	-
	0978	02/12/90	0001	KD	D			0.39	0.01	-
	0978	06/29/90	F014	KD	D			.19	0.01	-
MERCURY	0971	02/19/90	0001	KD	D	MG/L	<	0.0002	0.0002	-
	0971	06/28/90	F014	KD	D		<	.0002	0.0002	-
	0977	02/02/90	0001	KD	D		<	0.0002	0.0002	-
	0977	06/28/90	[illegible]	KD	D		<	.0002	0.0002	-
	0978	02/12/90	[illegible]	KD	D		<	0.0002	0.0002	-
	0978	06/29/90	F014	KD	D			.091	0.0002	-
MOLYBDENUM	0971	02/19/90	0001	KD	D	MG/L	<	0.01	0.01	-
	0971	06/28/90	F014	KD	D			.05	0.01	-

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

UCL= 0.05 mg/l

UCL: 0.09
Max Obs from Background(?)

see table 3.39

Table 3.38 Dakota Sandstone water quality by parameter at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
COBALT	0971	06/28/90	F014	KD	D	MG/L	<	.05	0.05	-
	0977	02/02/90	0001	KD	D		<	0.03	0.05	-
	0977	06/28/90	F014	KD	D		<	.05	0.05	-
	0978	02/12/90	0001	KD	D		<	0.03	0.05	-
	0978	06/29/90	F014	KD	D		<	.05	0.05	-
COPPER	0971	02/19/90	0001	KD	D	MG/L		0.02	0.02	-
	0971	06/28/90	F014	KD	D		<	.02	0.02	-
	0977	02/02/90	0001	KD	D		<	0.01	0.02	-
	0977	06/28/90	F014	KD	D		<	.02	0.02	-
	0978	02/12/90	0001	KD	D			0.01	0.02	-
	0978	06/29/90	F014	KD	D		<	.02	0.02	-
CYANIDE	0971	02/19/90	0001	KD	D	MG/L	<	0.02	0.01	-
	0971	06/28/90	F014	KD	D		<	.01	0.01	-
	0977	02/02/90	0001	KD	D		<	0.02	0.01	-
	0977	06/28/90	F014	KD	D		<	.01	0.01	-
	0978	02/12/90	0001	KD	D		<	0.02	0.01	-
	0978	06/29/90	F014	KD	D		<	.01	0.01	-
FLUORIDE	0971	02/19/90	0001	KD	D	MG/L		1.6	0.1	-
	0971	06/28/90	F014	KD	D			1.6	0.1	-
	0977	02/02/90	0001	KD	D			2.0	0.1	-
	0977	06/28/90	F014	KD	D			2.2	0.1	-
	0978	02/12/90	0001	KD	D			1.2	0.1	-
	0978	06/29/90	F014	KD	D			1.4	0.1	-
GROSS ALPHA	0971	02/19/90	0001	KD	D	PCI/L		86.	1.0	94.
	0971	06/28/90	F014	KD	D			0.	1.0	120.
	0977	02/02/90	0001	KD	D			98.	1.0	71.
	0977	06/28/90	F014	KD	D			75.	1.0	72.
	0978	02/12/90	0001	KD	D			0.0	1.0	76.
	0978	06/29/90	F014	KD	D			0.	1.0	140.
GROSS BETA	0971	02/19/90	0001	KD	D	PCI/L		146.	0.5	79.
	0971	06/28/90	F014	KD	D			100.	0.5	100.
	0977	02/02/90	0001	KD	D			105.	0.5	48.
	0977	06/28/90	F014	KD	D			160.	0.5	60.
	0978	02/12/90	0001	KD	D			0.0	0.5	68.

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

<MDL 0.05 mg/l

according MCL = 1.0 mg/l

<MDL 0.01 mg/l

See table 3.39

Table 3.38 Dakota Sandstone water quality by parameter at the Cheney disposal site, Grand Junction, [illegible]rado
SITE: GRJ03 CHENEY RESERVOIR
02/0[illegible]/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
BERYLLIUM	0977	02/02/90	0001	KD	D	MG/L	<	0.005	0.005	-
	0978	02/12/90	0001	KD	D		<	0.005	0.005	-
BORON	0971	02/19/90	0001	KD	D	MG/L		1.96	0.1	-
	0971	06/28/90	F014	KD	D			2.1	0.1	-
	0977	02/02/90	0001	KD	D			1.99	0.1	-
	0977	06/28/90	F014	KD	D			1.5	0.1	-
	0978	02/12/90	0001	KD	D			3.13	0.1	-
	0978	06/29/90	F014	KD	D			2.9	0.1	-
CADMIUM	0971	02/19/90	0001	KD	D	MG/L	<	0.001	0.001	-
	0971	06/28/90	F014	KD	D		<	.001	0.001	-
	0977	02/02/90	0001	KD	D		<	0.01	0.001	-
	0977	06/28/90	F014	KD	D		<	.001	0.001	-
	0978	02/12/90	0001	KD	D		<	0.001	0.001	-
	0978	06/29/90	F014	KD	D		<	.001	0.001	-
CALCIUM	0971	02/19/90	0001	KD	D	MG/L		32.	0.01	-
	0971	06/28/90	F014	KD	D			38.0	0.01	-
	0977	02/02/90	0001	KD	D			28.	0.01	-
	0977	06/28/90	F014	KD	D			14.5	0.01	-
	0978	02/12/90	0001	KD	D			42.	0.01	-
	0978	06/29/90	F014	KD	D			35.6	0.01	-
CHLORIDE	0971	02/19/90	0001	KD	D	MG/L		4640.	1.0	-
	0971	06/28/90	F014	KD	D			4490.	1.0	-
	0977	02/02/90	0001	KD	D			3360.	1.0	-
	0977	06/28/90	F014	KD	D			3040.	1.0	-
	0978	02/12/90	0001	KD	D			4130.	1.0	-
	0978	06/29/90	F014	KD	D			4850.	1.0	-
CHROMIUM	0971	02/19/90	0001	KD	D	MG/L	<	0.01	0.01	-
	0971	06/28/90	F014	KD	D		<	.01	0.01	-
	0977	02/02/90	0001	KD	D		<	0.01	0.01	-
	0977	06/28/90	F014	KD	D		<	.01	0.01	-
	0978	02/12/90	0001	KD	D		<	0.01	0.01	-
	0978	06/29/90	F014	KD	D		<	.01	0.01	-
COBALT	0971	02/19/90	0001	KD	D	MG/L	<	0.03	0.05	-

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

(BACKGROUND WATER QUALITY)

Table 3.38 Dakota Sandstone water quality by parameter at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	DETECTION LIMIT	PARAMETER UNCERTAINTY
ALKALINITY	0971	02/19/90	0001	KD	D	MG/L CACO3		7899.	-	-
	0971	06/28/90	F014	KD	D			9139.	-	-
	0977	02/02/90	0001	KD	D			6630.	-	-
	0977	06/28/90	F014	KD	D			5667.	-	-
	0978	02/12/90	0001	KD	D			7861.	-	-
ALUMINUM	0971	02/19/90	0001	KD	D	MG/L	<	0.05	0.1	-
	0971	06/28/90	F014	KD	D		<	.1	0.1	-
	0977	02/02/90	0001	KD	D		<	0.05	0.1	-
	0977	06/28/90	F014	KD	D		<	.1	[illegible]	-
	0978	02/12/90	0001	KD	D		<	0.05	0.1	-
	0978	06/29/90	F014	KD	D		<	.1	0.1	-
AMMONIUM	0971	02/19/90	0001	KD	D	MG/L		6.1	0.1	-
	0971	06/28/90	F014	KD	D			8.	0.1	-
	0977	02/02/90	0001	KD	D			5.3	0.1	-
	0977	06/28/90	F014	KD	D			6.	0.1	-
	0978	02/12/90	0001	KD	D			5.2	0.1	-
	0978	06/29/90	F014	KD	D			7.	0.1	-
ANTIMONY	0971	06/28/90	F014	KD	D	MG/L	<	.003	0.003	-
	0977	06/28/90	F014	KD	D		<	.003	0.003	-
	0978	06/29/90	F014	KD	D		<	.003	0.003	-
ARSENIC	0971	02/19/90	0001	KD	D	MG/L	<	0.03	0.01	-
	0971	06/28/90	F014	KD	D		<	.01	0.01	-
	0977	02/02/90	0001	KD	D		<	0.03	0.01	-
	0977	06/28/90	F014	KD	D		<	.01	0.01	-
	0978	02/12/90	0001	KD	D		<	0.03	0.01	-
	0978	06/29/90	F014	KD	D		<	.01	0.01	-
BARIUM	0971	02/19/90	0001	KD	D	MG/L		4.44	0.1	-
	0971	06/28/90	F014	KD	D			18.5	0.1	-
	0977	02/02/90	0001	KD	D			38.	0.1	-
	0977	06/28/90	F014	KD	D			34.1	0.1	-
	0978	02/12/90	0001	KD	D			36.	0.1	-
	0978	06/29/90	F014	KD	D			32.5	0.1	-
BERYLLIUM	0971	02/19/90	0001	KD	D	MG/L	<	0.005	0.005	-

<MDL 0.1 mg/l

<MDL 0.003 mg/l

L: 0.05 mg/l

table 3.39

<MDL 0.005 mg/l

FORMATION OF COMPLETION CODE:
KD - DAKOTA SANDSTONE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

JE JACOBS ENGINEERING

DATE ______ SUBJECT ______ SHEET NO. 6

BY ______ CHKD. ______ JOB NO. ______

2/1/91

8k 2/1/91

Table 3.38

Background water quality data

MAXIMUM CONCENTRATION OF CONSTITUENTS for GROUNDWATER PROTECTION

(Summarized from DRAFT FINAL EPA Groundwater Standards (of 1/90))
(40 CFR 192.02)

Table 1 - CONCENTRATION LIMITS

(Concentrations of these constituents shall not exceed the following limits or background, whichever is higher)

Arsenic (As)	0.05 mg/l
Barium (Ba)	1.0
Cadmium (Cd)	.01
Chromium (Cr)	.05
Lead (Pb)	.05
Mercury (Hg)	.002
Molybdenum (Mo)	.1
Nitrate (as N)	10.0 (= 44.0 mg/l NO^3)
Selenium (Se)	.01
Silver (Ag)	.05

Benzene (Cyclohexatriene)	0.005 mg/l	Methoxychlor	0.1 mg/l
Carbon tetrachloride	.005	Methyl chloroform	.20
p-Dichlorobenzene(Benzene,1,4-di-)	.075	Toxaphene	.005
1,1-Dichloroethylene(Ethene,1,1-di-)	.007	2,4-D	.1
Endrin	.0002	2,4,5-TP	.01
Ethylene dichloride	.005	Trichloroethylene	.005
Lindane	.004	Vinyl chloride	.002

Combined Radium (Ra-226 & 228)	5	pCi/l	
Combined Uranium (U-234 & 238)	30	"	(= 0.044 mg/l)
Gross Alpha (excluding Rn & U)	15	"	

Appendix I - LISTED CONSTITUENTS

(Partial list: only inorganics w/o MCLs)

Antimony and compounds,	N.O.S.
Aluminum phosphide	#
Beryllium and compounds,	N.O.S.
Calcium chromate	#
Carbon Disulfide	
Carbon oxyfluoride	#
Cyanides (soluble salts and complexes),	N.O.S.
Nickel and compounds,	N.O.S.
Strontium sulfide	#
Thallium and compounds,	N.O.S.
Vanadic acid, ammonium salt	#
Vanadium pentoxide	#
Zinc phosphide	#

N.O.S. - Not Otherwise Specified; Signifies all members of this general class, including those not specifically named in Append.I

- ADDED when this Appendix replaced Appendix IX, 40 CFR 264

Note - √Cobalt, √Copper, Sulphide, √Tin, √Vanadium, and√Zinc were DELETED when this Appendix replaced Appendix IX

(5)
Ely 7/1/1
EK 2/1/91

JE JACOBS ENGINEERING

DATE ______ SUBJECT SHEET NO. 4

BY ______ CHKD. ______ JOB NO. ______

2/1/91 2/1/91

List of Hazardous Constituents
and their concentration Limits
Constituents underlined in blue are
those which are the EPA MCL.

2/1/91
8R Cof
3/1

(3)

Elements contained in hazardous constituent compounds

Aluminum (Aluminum phosphide)	0.1	<MDL
Cyanide (Soluble salts and complexes)	0.01	<MDL
Fluoride (Carbon oxyfluoride)	2.2	BG
Strontium (Strontium sulfide)	10.1	BG
Sulfide (Strontium sulfide, carbon disulfide)	10.0	BG

* MCL- Maximum concentration limit as defined by the EPA. (Secondary drinking water standards are being used for copper and zinc).

<MDL- Concentrations in background groundwater were less than detection. For these constituents, the concentration limit is the same as the laboratory detection limit.

BG- Concentration limit is based on the statistical maximum concentration of background water quality.

2/1/91

Results

The PCL is the same as the EPA MCL for the following hazardous constituents, arsenic, chromium, lead, nitrate, selenium, silver, and uranium.

The statistical maximum concentrations of barium, molybdenum, and the activities of net gross alpha and radium-226/228 exceed the EPA MCLs and are therefore used as the PCL.

There are certain hazardous constituents and elements in hazardous constituent compounds that do not have any predetermined concentration limits. For these constituents, the PCL will be based on the statistical maximum of background concentrations. This includes the following hazardous constituents, vanadium, fluoride, strontium, and sulfide. In the case where the hazardous constituent was not detected in groundwater, the laboratory detection limit will be used as the PCL. This was done for the following hazardous constituents, antimony, beryllium, cobalt, nickel, aluminum and cyanide.

Conclusions

The proposed concentration limits for hazardous constituents in the Dakota Sandstone at the Cheney disposal site are listed below.

HAZARDOUS CONSTITUENT	CONCENTRATION LIMIT*	
Antimony	0.003	<MDL
Arsenic	0.05	MCL
Beryllium	0.005	<MDL
Barium	45.3	BG
Cadmium	0.01	MCL
Chromium	0.05	MCL
Cobalt	0.05	<MDL
Copper	1.0	MCL
Net gross alpha activity	97.0	BG
Lead	0.05	MCL
Mercury	0.091	BG
Molybdenum	0.21	BG
Nickel	0.04	<MDL
Nitrate	44.0	MCL
Radium-226 & -228	75.0	BG
Selenium	0.01	MCL
Silver	0.05	MCL
Uranium	0.044	MCL
Vanadium	0.03	BG
Zinc	5.0	MCL

SK 2/1/91 2/1/91

1

Purpose of Calculation

The purpose of this calculation is to determine proposed concentration limits for hazardous constituents and elements of hazardous constituent compounds in groundwater at the Cheney disposal site in Grand Junction, Colorado.

Overview of Method

For those hazardous constituents that have an EPA MCL (arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, nitrate, selenium, silver, uranium, and the activities of radium-226/228 and net gross alpha) background concentrations (listed in table 3.38) are compared to the groundwater standards. If concentrations are less than the standard, then the proposed concentration limit (PCL) will be the same as the EPA MCL. When background concentrations exceed the groundwater standards, the statistical maximum of background is used as a replacement to the EPA MCL. There are certain hazardous constituents and elements in hazardous constituent compounds that do not have any predetermined concentration limits. For these constituents, the PCL will be based on the statistical maximum of background concentrations. In the case where the hazardous constituent was not detected in groundwater, the laboratory detection limit will be used as the PCL. The observed maximum for Net Gross Alpha was chosen to represent the statistical maximum.

Assumptions

The assumption being made in this calculation is that the background monitor wells and number of samples are an accurate indication of background groundwater quality.

Data Source

DOE sampling results from UMTRA Data Analysis and Retrieval System (DART). See tables 3.38 and 3.39.

Attachments

1) List of EPA hazardous constituents and their concentration limits. (Those underlined in blue are the constituent whose PCL is the same as the EPA MCL.

2) Table 3.38 is a list of water quality data for the background monitor wells. (Beside each hazardous constituent is a comment on how its PCL was determined.)

3) Table 3.39 is a list of water quality statistics for background monitor wells. For those hazardous constituents that do not have a concentration limit, the statistical maximum is chosen as the PCL.

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. GRJ-01-91-15-02-00 DISCIPLINE Hydro NO. OF SHEETS 20

PROJECT: UMTRA Site Characterization

SITE: GRAND JUNCTION (Cheney Reservoir)

FEATURE: Concentration Limits

SOURCES OF DATA:

Groundwater data is obtained from UMTRA DART (data bank)

SOURCES OF FORMULAE & REFERENCES:

Technical Approach Document (Dec, 1989)

PRELIMINARY CALC. ☑ FINAL CALC. ☐ SUPERSEDES CALC. NO. ____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		S Reinert	1/30/91	C Pr[illegible]	2/1/91	KB	2/1/91

[illegible]	[illegible]	[illegible]	[illegible]
WILLEMIT	-8.7316	16.2670	-24.9985
ZINCOSIT	-38.9909	3.5491	-42.5400
ZNSO4, 1	-38.9923	-.2713	-38.7211
BIANCHIT	-38.9995	-1.7555	-37.2440
GOSLARIT	-39.0039	-2.0527	-36.9483
ZNBR2, 2	-25.8302	5.4209	-31.2511
CD METAL	-7.5705	13.9954	-21.5659
GAMMA CD	-7.5705	14.0993	-21.6699
OTAVITE	-25.2005	-13.7237	-11.4768
CDCL2	-22.6298	-.5545	-22.0753
CDCL2, 1	-22.6313	-1.6589	-20.9724
CDCL2,2.	-22.6334	-1.9880	-20.6454
CD(OH)2	-5.4950	13.6500	-19.1450
CDOHCL	-14.0674	3.7261	-17.7935
CD3(OH)4	-53.0568	22.5600	-75.6168
CD3OH2(S	-89.6286	6.7100	-96.3386
CD4(OH)6	-58.5518	28.4000	-86.9518
MONTEPON	-5.4936	15.8152	-21.3088
CDSIO3	-9.3898	9.5269	-18.9168
CDSO4	-42.0668	.3139	-42.3807
CDSO4, 1	-42.0682	-1.4489	-40.6194
CDSO4,2.	-42.0706	-1.7493	-40.3214
GREENOCK	-50.3747	-51.7380	1.3633
CDBR2, 4	-28.9092	-2.6230	-26.2862
PB METAL	-5.1646	4.2588	-9.4234
COTUNNIT	-20.2239	-4.9272	-15.2966
PHOSGENI	-43.0185	-19.8100	-23.2085
CERRUSIT	-22.7946	-13.2665	-9.5281
MASSICOT	-3.0876	13.3811	-16.4685
LITHARGE	-3.0876	13.1799	-16.2675
PBO, .3H	-3.0881	12.9800	-16.0681
PB2OCO3	-25.8822	-.1782	-25.7040
LARNAKIT	-42.7485	-.0992	-42.6493
PB3O2SO4	-45.8361	10.9826	-56.8187
PB4O3SO4	-48.9237	23.0847	-72.0084
PB3O2CO3	-28.9698	11.7621	-40.7319
PBSIO3	-6.9839	7.5800	-14.5639
PB2SIO4	-10.0715	20.4900	-30.5615
ANGLESIT	-39.6609	-7.8504	-31.8105
GALENA	-47.9688	-51.0233	3.0546
PLATTNER	-1.0107	51.2859	-52.2966
PB2O3	-4.0983	61.0400	-65.1383
MINIUM	-7.1859	76.5753	-83.7612
PB(OH)2	-3.0891	8.5428	-11.6319
LAURIONI	-11.6565	.6200	-12.2765
PB2(OH)3	-14.7455	8.7900	-23.5355
HYDCERRU	-48.6783	-17.4600	-31.2183
PB2O(OH)	-6.1767	26.2000	-32.3767
PBBR2	-26.4973	-5.4074	-21.0899
PB4(OH)6	-48.9283	21.1000	-70.0280
SULFUR	-42.8042	-37.3407	-5.4635
LIME	10.8396	34.0989	-23.2593
PORTLAND	10.8381	23.5317	-12.6936
WUSTITE	3.8903	12.3877	-8.4974
PERICLAS	11.0088	22.5245	-11.5156
MAG-FERR	21.0693	45.2627	-24.1933
WOLLASTO	6.9433	13.5475	-6.6042
P-WOLLST	6.9433	14.4416	-7.4983
CA-OLIVI	17.7829	39.1856	-21.4027
LARNITE	17.7829	40.7472	-22.9643
CA3SIO5	28.6224	76.8555	-48.2331
MONTICEL	17.9521	31.6576	-13.7055
AKERMINI	24.8954	49.6163	-24.7208
[illegible]	[illegible]	[illegible]	[illegible]

9/14/90

9/20/90

NA2SO3	-26.3150	5.0331	-31.3481
K2SO3	-31.7302	8.2712	-40.0014
CASO3.2H	-27.8135	-3.5656	-24.2479
CASO3.5H	-27.8114	-3.1288	-24.6826
MGSO3	-27.6414	7.0149	-34.6563
CH4(GAS)	-28.0177	-42.7928	14.7751
CO2(GAS)	-19.7070	-18.1749	-1.5321
O2(GAS)	4.1539	66.9563	-62.8023
CAMOO4	-14.2861	-7.7397	-6.5464
NAT. SE	59.1517	-63.2575	122.4092
FERROSEL	-116.3714	-129.8086	13.4372
MOLYBDEN	-116.9668	-130.8200	13.8532
MOLYBDIT	-25.1276	-11.7900	-13.3376
ILSEMANN	-77.4598	-77.5900	.1302

9/14/90

9/20/90

1

208	PBCL +	1.0	4.53001D-18	-17.3439	3.56435D-18	-17.4480	7.86531D-01	-.1041
209	PBCL2 AQ	.0	3.43745D-19	-18.4638	3.51392D-19	-18.4542	1.02225D+00	.0096
210	PBCL3 -	-1.0	1.65752D-20	-19.7805	1.30419D-20	-19.8847	7.86531D-01	-.1041
211	PBCL4 2-	-2.0	7.51246D-22	-21.1242	2.87945D-22	-21.5407	3.83289D-01	-.4165
212	PB(CO3)2	-2.0	1.24012D-17	-16.9065	4.75326D-18	-17.3230	3.83289D-01	-.4165
217	PBOH +	1.0	1.08767D-18	-17.9635	8.55811D-19	-18.0676	7.86531D-01	-.1041
218	PB(OH)2	.0	6.04493D-21	-20.2186	6.17941D-21	-20.2091	1.02225D+00	.0096
219	PB(OH)3	-1.0	1.67354D-24	-23.7764	1.31680D-24	-23.8805	7.86531D-01	-.1041
223	PB(HS)2	.0	1.27742D-07	-6.8937	1.30584D-07	-6.8841	1.02225D+00	.0096
224	PB(HS)3	-1.0	1.80328D-08	-7.7439	1.41888D-08	-7.8481	7.86531D-01	-.1041
226	PBBR +	1.0	5.38899D-21	-20.2685	4.24023D-21	-20.3726	7.86831D-01	-.1041
227	PBBR2 AQ	.0	8.57322D-26	-25.0669	8.76395D-26	-25.0573	1.02225D+00	.0096
230	PBCO3 AQ	.0	2.72799D-16	-15.5642	2.78868D-16	-15.5546	1.02225D+00	.0096
231	PB(OH)4	-2.0	1.46407D-28	-27.8344	5.61160D-29	-28.2509	3.83289D-01	-.4165
233	PBHCO3 +	1.0	1.73587D-17	-16.7605	1.36584D-17	-16.8646	7.86831D-01	-.1041
272	HCO3 -	-1.0	1.27782D-02	-1.8935	1.00543D-02	-1.9976	7.86531D-01	-.1041
273	H2CO3 AQ	.0	1.40894D-03	-2.8511	1.44028D-03	-2.8416	1.02225D+00	.0096
274	HSO4 -	-1.0	4.53254D-28	-27.3437	3.56635D-28	-27.4478	7.86531D-01	-.1041
281	H2S AQ	.0	3.97468D-03	-2.4007	4.06311D-03	-2.3911	1.02225D+00	.0096
282	S 2-	-2.0	1.46143D-08	-7.8352	5.60149D-09	-8.2517	3.83269D-01	-.4165
283	UOH +3	3.0	7.44849D-24	-23.1279	8.61000D-25	-24.0650	1.15594D-01	-.9371
284	U(OH)2 +	2.0	6.87319D-19	-18.1628	2.63442D-19	-18.5793	3.83289D-01	-.4165
285	U(OH)3 +	1.0	9.78072D-15	-14.0096	7.69577D-15	-14.1137	7.86531D-01	-.1041
286	U(OH)4 A	.0	3.33336D-11	-10.4771	3.40751D-11	-10.4676	1.02225D+00	.0096
287	U(OH)5 -	-1.0	1.59988D-08	-7.7959	1.25883D-08	-7.9000	7.86531D-01	-.1041
294	UCL +3	3.0	2.23196D-30	-29.6513	2.58001D-31	-30.5884	1.15594D-01	-.9371
301	UO2OH +1	1.0	1.20234D-22	-21.9200	9.46042D-23	-22.0241	7.86831D-01	-.1041
304	UO2CO3 A	.0	9.75658D-20	-19.0107	9.97363D-20	-19.0011	1.02225D+00	.0096
305	UO2(CO3)2	-2.0	1.14968D-17	-16.9394	4.40660D-18	-17.3559	3.83289D-01	-.4165
306	UO2(CO3)3	-4.0	7.50546D-17	-16.1246	1.61988D-18	-17.7905	2.15827D-02	-1.6659
311	UO2CL +1	1.0	1.18816D-25	-24.9252	9.34799D-26	-25.0293	7.86831D-01	-.1041
319	UO2H3SIO	1.0	1.44278D-23	-22.8408	1.13521D-23	-22.9449	7.86831D-01	-.1041
353	HSO3-	-1.0	2.17749D-28	-27.6620	1.71332D-28	-27.7662	7.86531D-01	-.1041
367	SEO-2	-2.0	5.72746D-15	-14.0591	3.34514D-15	-14.4756	3.83289D-01	-.4165
368	SE-2	-2.0	3.60508D-15	-14.4431	1.38179D-15	-14.8596	3.83289D-01	-.4165
369	HSE-	-1.0	[illegible]	-6.7425	1.42343D-07	-6.8467	7.86831D-01	-.1041
370	H2SE	.0	4.58480D-11	-10.3387	4.68680D-11	-10.3291	1.02225D+00	.0096
5 372	MOO2+	1.0	[illegible]D-07	-6.7213	1.49491D-07	-6.8254	7.86831D-01	-.1041
6 373	HMOO4-	-1.0	2.01871D-08	-7.6949	1.58839D-08	-7.7990	7.86831D-01	-.1041

---- LOOK MIN IAP ----

SATURATION INDICES

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-11.4542	-14.3636	2.9094
UO2 (AM	-11.4542	-8.5102	-2.9440
U4O9 (C)	-43.7399	-41.2746	-2.4653
U3O8 (C)	-30.2087	-6.1826	-24.0261
USIO4 (C	-15.3505	-17.3982	2.0477
UO3 (C)	-9.3772	8.2625	-17.6397
GUMMITE	-9.3772	11.0461	-20.4233
B-UO2(OH	-9.3787	5.9255	-15.3042
SCHOEPIT	-9.3801	5.7363	-15.1164
RUTHERFO	-29.0842	-14.4461	-14.6381
URANOPHA	-15.7089	17.4900	-33.1989
ANHYDRIT	-25.7337	-4.5341	-21.1995
ARAGONIT	-8.8674	-8.2419	-.6256
ARTINITE	2.3050	10.4070	-8.1020
BRUCITE	11.0074	17.5155	-6.5081
CALCITE	-8.8674	-8.4193	-.4482
CELESTIT	-26.7376	-6.4568	-20.2808
CHALCEDO	-3.8962	-3.6494	-.2468

9/14/90

9/20/90

DIOPSIDE	14.0559	20.7964	-6.7405
DOLOMITE	-17.5656	-16.7672	-.7983
EPSOMITE	-25.5744	-2.2192	-23.3552
SEPIOLIT	10.3239	16.7800	-6.4561
FERRIHYD	5.0281	18.2006	-13.1727
FE3(OH)8	14.0466	46.8516	-32.8050
FEOH)2.7	2.4579	10.2708	-7.8129
FES PPT	-40.8894	-39.2686	-1.6208
FE2(SO4)	-99.6592	31.8615	-131.5207
FORSTERI	18.1214	29.6621	-11.5406
GOETHITE	5.0295	14.2173	-9.1878
GREENALI	4.1800	20.8100	-16.6300
GREIGITE	-165.4722	-159.8029	-5.6694
GYPSUM	-25.7366	-4.8573	-20.8793
HALITE	-2.4005	1.5542	-3.9547
HEMATITE	10.0605	23.4876	-13.4272
HUNTITE	-34.9619	-29.2467	-5.7151
HYDRMAGN	-23.7909	-7.3041	-16.4868
JAROSITE	-58.0622	29.3908	-87.4530
MACKINAW	-40.8894	-39.9986	-.8908
MAGADIIT	-21.1126	-14.3000	-6.8126
MAGHEMIT	10.0605	33.0116	-22.9510
MAGNESIT	-8.6981	-7.8568	-.8414
MAGNETIT	14.0523	31.7784	-17.7261
MELANTER	-32.5915	-2.5503	-30.0412
MIRABILI	-24.2523	-1.6432	-22.6091
NATRON	-7.3861	-1.7519	-5.6341
NESQUEHO	-8.7024	-5.4574	-3.2450
PYRITE	-83.6935	-89.4945	5.8[illegible]
QUARTZ	-3.8962	-4.1646	[illegible]
SIDERITE	-15.7152	-10.4003	-5.3149
SIO2(A,G	-3.8962	-2.8141	-1.0822
SIO2(A,P	-3.8962	-2.8141	-1.0822
STRONTIA	-9.8713	-9.2306	-.6407
TALC	17.4401	24.0430	-6.6029
THENARDI	-24.2380	-.1640	-24.0740
THERMONA	-7.3732	.2086	-7.5818
TREMOLIT	45.5519	59.2626	-13.7107
PYROLUSI	10.3936	42.9126	-32.5190
BIRNESSI	10.3936	44.3233	-33.9297
NSUTITE	10.3936	43.7333	-33.3397
BIXBYITE	18.7103	52.2745	-33.5642
HAUSMANN	27.0269	63.7902	-36.7633
PYROCROI	8.3152	15.7243	-7.4091
MANGANIT	9.3544	25.9933	-16.6389
RHODOCHR	-11.3903	-10.3516	-1.0387
MNCL2, 4	-8.8253	2.2220	-11.0473
MNS GREE	-36.5645	-31.3860	-5.1784
MNSO4	-28.2566	3.1046	-31.3612
MN2(SO4)	-91.0095	47.8433	-138.8528
ZN METAL	-4.4946	26.7927	-31.2873
ZNCL2	-19.5539	7.5208	-27.0747
SMITHSON	-22.1246	-9.8776	-12.2471
ZNCO3, 1	-22.1261	-10.2600	-11.8661
ZN(OH)2	-2.4191	11.5000	-13.9191
ZN2(OH)3	-13.4056	15.2000	-28.6056
ZN5(OH)8	-29.2303	38.5000	-67.7303
ZN2(OH)2	-41.4100	7.5000	-48.9100
ZN4(OH)6	-46.2482	28.4000	-74.6482
ZNO(ACTI	-2.4177	11.3100	-13.7277
ZINCITE	-2.4177	11.7538	-14.1714
ZN30(SO4	-80.3995	20.7608	-101.1603
ZNS (A)	-47.2988	-44.5016	-2.7971
SPHALERI	-47.2988	-47.2002	-.0985

9/14/90

9/20/90

FOR GROUNDWATER IN WELL #982

BR	4.661917D-05	-4.3314
TOT ALK	2.015774D-02	-1.6956
CA	4.896219D-04	-3.3100
CD	3.582639D-08	-7.4458
CL	6.568193D-02	-1.1812
FE	1.261913D-06	-5.8990
K	2.034040D-04	-3.6916
MG	7.122628D-04	-3.1474
MN	1.632561D-06	-5.7869
NA	1.007219D-01	-.9969
PB	1.457753D-07	-6.8363
S	1.089971D-02	-1.9626
SI	1.236004D-04	-3.9080
SR	5.170595D-05	-4.2865
U	1.603213D-08	-7.7950
ZN	3.080232D-07	-6.5114
MO	2.102457D-07	-6.6773
SE	1.809523D-07	-6.7424

----DESCRIPTION OF SOLUTION----

PH = 7.2700
PE = -6.2308
ACTIVITY H2O = .9967
IONIC STRENGTH = .0956
TEMPERATURE = 14.0000
ELECTRICAL BALANCE = 1.7353D-02
THOR = -1.0000D+05
TOTAL ALKALINITY = 2.0158D-02
ITERATIONS = 15
TOTAL CARBON = 1.4615D-02

DISTRIBUTION OF SPECIES : DISSOLVED SPECIES :—

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	6.825250D-08	-7.1659	5.370320D-08	-7.2700	7.868310D-01	-.1041
2	E-	-1.0	1.701370D+06	6.2308	1.701370D+06	6.2308	1.000000D+00	.0000
3	H2O	.0	9.967130D-01	-.0014	9.967130D-01	-.0014	1.000000D+00	.0000
9	BR-	-1.0	4.661920D-05	-4.3314	3.668140D-05	-4.4356	7.868310D-01	-.1041
10	CO3 2-	-2.0	1.770350D-05	-4.7519	6.785660D-06	-5.1684	3.832890D-01	-.4165
11	CA 2+	2.0	4.693760D-04	-3.3285	1.999800D-04	-3.6990	4.260550D-01	-.3705
12	CD 2+	2.0	2.422900D-20	-19.6157	9.286730D-21	-20.0321	3.832890D-01	-.4165
13	CL-	-1.0	6.588180D-02	-1.1812	5.025210D-02	-1.2988	7.627620D-01	-.1176
17	FE 2+	2.0	7.407580D-11	-10.1303	2.839250D-11	-10.5468	3.832890D-01	-.4165
19	K+	1.0	2.034040D-04	-3.6916	1.551490D-04	-3.8093	7.627620D-01	-.1176
21	MG 2+	2.0	6.693780D-04	-3.1743	2.952990D-04	-3.5297	4.411550D-01	-.3554
22	MN 2+	2.0	1.565130D-06	-5.8055	5.998960D-07	-6.2219	3.832890D-01	-.4165
24	NA+	1.0	1.003760D-01	-.9984	7.912590D-02	-1.1017	7.882980D-01	-.1033
27	PB 2+	2.0	6.169940D-18	-17.2097	2.364870D-18	-17.6262	3.832890D-01	-.4165
29	SO4 2-	-2.0	2.576620D-22	-21.5889	9.232560D-23	-22.0347	3.583200D-01	-.4457
30	H4SIO4	.0	1.234060D-04	-3.9087	1.261510D-04	-3.8991	1.022250D+00	.0096
31	SR 2+	2.0	5.170590D-05	-4.2865	1.981830D-05	-4.7029	3.832890D-01	-.4165
32	UO2 2+	2.0	3.167070D-24	-23.4993	1.213900D-24	-23.9158	3.832890D-01	-.4165
34	ZN 2+	2.0	2.885610D-17	-16.5398	1.106020D-17	-16.9562	3.832890D-01	-.4165
35	MOO4 2-	-2.0	6.720920D-11	-10.1726	2.576060D-11	-10.5890	3.832890D-01	-.4165
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.17176[illegible]	[illegible]	[illegible]	-.5371

9/19/90

9/20/90

61	UO2 +	1.0	1.980630-15	-14.7032	1.555260-15	-14.8074	[illegible]	[illegible]
65	OH-	-1.0	9.999740-08	-7.0000	7.868110-08	-7.1041	7.868310-01	-.1041
66	H3SIO4 -	-1.0	1.942940-07	-6.7115	1.528760-07	-6.8157	7.868310-01	-.1041
67	H2SIO4--	-2.0	3.789910-12	-11.4214	1.452630-12	-11.8378	3.832890-01	-.4165
76	MGOH +	1.0	4.242610-09	-8.3724	3.338220-09	-8.4765	7.868310-01	-.1041
78	MGCO3 AQ	.0	1.580000-06	-5.8013	1.615150-06	-5.7918	1.022250+00	.0096
79	MGHCO3 +	1.0	4.129900-05	-4.3841	3.249540-05	-4.4882	7.868310-01	-.1041
80	MGSO4 AQ	.0	4.332600-24	-23.3633	4.428980-24	-23.3537	1.022250+00	.0096
84	CAOH +	1.0	4.651190-10	-9.3324	3.659700-10	-9.4366	7.868310-01	-.1041
85	CAHCO3 +	1.0	1.890960-05	-4.7233	1.487870-05	-4.8274	7.868310-01	-.1041
86	CACO3 AQ	.0	1.535710-06	-5.8137	1.569870-06	-5.8041	1.022250+00	.0096
87	CASO4 AQ	.0	3.345630-24	-23.4755	3.420060-24	-23.4660	1.022250+00	.0096
92	NACO3 -	-1.0	7.109300-06	-5.1482	5.593820-06	-5.2523	7.868310-01	-.1041
93	NAHCO3 A	.0	3.391210-04	-3.4696	3.466650-04	-3.4601	1.022250+00	.0096
94	NASO4 -	-1.0	4.328250-23	-22.3637	3.405600-23	-22.4678	7.868310-01	-.1041
97	KSO4 -	-1.0	1.048230-25	-24.9795	8.247840-26	-25.0837	7.868310-01	-.1041
109	FEOH +	1.0	9.021770-14	-13.0447	7.098610-14	-13.1488	7.868310-01	-.1041
110	FEOH3 -1	-1.0	3.252910-21	-20.4877	2.559490-21	-20.5918	7.868310-01	-.1041
113	FEOH2 AQ	.0	4.062040-18	-17.3913	4.152410-18	-17.3817	1.022250+00	.0096
115	FE(HS)2	.0	7.340590-07	-6.1343	7.503900-07	-6.1247	1.022250+00	.0096
116	FE(HS)3	-1.0	5.277800-07	-6.2775	4.152740-07	-6.3817	7.868310-01	-.1041
117	FEOH 2+	2.0	1.296240-25	-24.8873	4.968350-26	-25.3038	3.832890-01	-.4165
120	FECL 2+	2.0	2.238800-30	-29.6500	8.581090-31	-30.0665	3.832890-01	-.4165
123	FEOH2 +	1.0	2.548990-22	-21.5936	2.005620-22	-21.6978	7.868310-01	-.1041
124	FEOH3 AQ	.0	2.226780-23	-22.6523	2.276320-23	-22.6428	1.022250+00	.0096
125	FEOH4 -	-1.0	3.762640-24	-23.4245	2.960560-24	-23.5286	7.868310-01	-.1041
134	SROH +	1.0	1.215530-11	-10.9152	9.564180-12	-11.0194	7.868310-01	-.1041
136	MNCL +	1.0	1.550060-07	-6.8097	1.219640-07	-6.9138	7.868310-01	-.1041
137	MNCL2 AQ	.0	1.628650-09	-8.7882	1.664890-09	-8.7786	1.022250+00	.0096
138	MNCL3 -	-1.0	4.793550-11	-10.3193	3.771720-11	-10.4235	7.868310-01	-.1041
139	MNO- +	1.0	1.433740-10	-9.8435	1.128110-10	-9.9476	7.868310-01	-.1041
140	MN(OH)3	-1.0	7.725130-20	-19.1121	6.078360-20	-19.2162	7.868310-01	-.1041
142	MNSO4 AQ	.0	8.568670-27	-26.0671	8.759300-27	-26.0575	1.022250+00	.0096
144	MNHCO3 +	1.0	1.106050-07	-6.9562	8.702990-08	-7.0603	7.868310-01	-.1041
162	ZNCL +	1.0	1.148970-18	-17.9397	9.040490-19	-18.0438	7.868310-01	-.1041
163	ZNCL2 AQ	.0	4.444830-20	-19.3521	4.543710-20	-19.3426	1.022250+00	.0096
164	ZNCL3 -	-1.0	3.040330-21	-20.5171	2.392230-21	-20.6212	7.868310-01	-.1041
165	ZNCL4 2-	-2.0	1.432590-22	-21.8439	5.490960-23	-22.2604	3.832890-01	-.4165
167	ZNOH +	1.0	1.148760-19	-18.9398	9.038970-20	-19.0439	7.868310-01	-.1041
168	ZN(OH)2	.0	1.225540-20	-19.9117	1.252810-20	-19.9021	1.022250+00	.0096
169	ZN(OH)3	-1.0	5.394010-25	-24.2681	4.244180-25	-24.3722	7.868310-01	-.1041
170	ZN(OH)4	-2.0	1.283840-30	-29.8915	4.920840-31	-30.3080	3.832890-01	-.4165
171	ZNOHCL A	.0	3.341440-19	-18.4761	3.415770-19	-18.4665	1.022250+00	.0096
172	ZN(HS)2	.0	2.794460-07	-6.5537	2.856630-07	-6.5441	1.022250+00	.0096
173	ZN(HS)3	-1.0	2.857720-08	-7.5440	2.248540-08	-7.6481	7.868310-01	-.1041
176	ZNBR +	1.0	1.356220-22	-21.8677	1.067110-22	-21.9718	7.868310-01	-.1041
177	ZNBR2 AQ	.0	1.524410-27	-26.8169	1.558320-27	-26.8073	1.022250+00	.0096
180	ZNHCO3 +	1.0	6.448730-28	-27.1905	5.074060-28	-27.2946	7.868310-01	-.1041
181	ZNCO3 AQ	.0	1.464570-17	-16.8342	1.497140-17	-16.8246	1.022250+00	.0096
182	ZN(CO3)2	-2.0	5.667890-18	-17.2466	2.172440-18	-17.6631	3.832890-01	-.4165
183	CDCL +	1.0	5.452170-20	-19.2634	4.289940-20	-19.3675	7.868310-01	-.1041
184	CDCL2 AQ	.0	8.429450-21	-20.0742	8.616970-21	-20.0646	1.022250+00	.0096
185	CDCL3 -	-1.0	2.917030-22	-21.5351	2.295210-22	-21.6392	7.868310-01	-.1041
188	CD(CO3)3	-4.0	2.231170-28	-27.6515	4.815460-30	-29.3174	2.158270-02	-1.6659
189	CDOH +	1.0	7.811450-24	-23.1073	6.146290-24	-23.2114	7.868310-01	-.1041
190	CD(OH)2	.0	1.397810-26	-25.8546	1.428900-26	-25.8450	1.022250+00	.0096
194	CDOHCL A	.0	2.522040-22	-21.5982	2.578150-22	-21.5887	1.022250+00	.0096
197	CDHS +	1.0	9.506630-13	-12.0220	7.480110-13	-12.1261	7.868310-01	-.1041
198	CD(HS)2	.0	9.126360-09	-8.0396	9.331440-09	-8.0301	1.022250+00	.0096
199	CD(HS)3	-1.0	9.775030-09	-8.0099	7.691300-09	-8.1140	7.868310-01	-.1041
200	CD(HS)4	-2.0	1.692400-08	-7.7715	6.486800-09	-8.1880	3.832890-01	-.4165
201	CDBR +	1.0	6.747930-23	-22.1708	5.309460-23	-22.2749	7.868310-01	-.1041
202	CDBR2 AQ	.0	9.687220-27	-26.0136	9.902730-27	-26.0042	1.022250+00	.0096

9/14/97

9/20/98

15

[illegible]	[illegible]	[illegible]	[illegible]
ARSENOLI	-109.1150	-85.0707	-24.0442
CLAUDETI	-109.1150	-85.2960	-23.8190
ORIPMENT	-210.2905	-211.6446	[illegible]
REALGAR	-83.1153	-76.8833	-6.2320
AS2O5	-38.8552	6.8808	-45.7360
SULFUR	-44.0599	-37.6393	-6.4206
CA3(ASO4	-.4122	22.3000	-22.7122
FEASO4.2	-4.4971	13.7642	-18.2613
MN3ASO42	-8.1964	12.5000	-20.6964
PB3(ASO4	-16.9627	5.8000	-22.7627
ZN3ASO42	-11.6022	13.6500	-25.2522
LIME	12.8155	34.3458	-21.5303
PORTLAND	12.8146	23.6955	-10.8809
WUSTITE	10.8394	12.5204	-1.6810
PERICLAS	13.0918	22.7173	-9.6255
MAG-FERR	42,9562	45.7251	-2.7689
WOLLASTO	9.0799	13.6516	-4.5717
P-WOLLST	9.0799	14.5541	-5.4741
CA-OLIVI	21.8954	39.4775	-17.5821
LARNITE	21.8954	41.0527	-19.1573
CA3SIO5	34.7109	77.4231	-42.7127
MONTICEL	22.1717	31.9214	-9.7497
AKERMINI	31.2516	50.0243	-18.7727
MERWINIT	44.0671	72.1192	-28.0520
LEPIDOCR	14.9318	14.7342	.1976
FE(OH)3S	14.9309	16.0342	-1.1032
NA2SO3	-14.1216	5.0489	-19.1705
K2SO3	-19.3116	8.2828	-27.5945
CASO3.2H	-15.5439	-3.5819	-11.9619
CASO3.5H	-15.5426	-3.1266	-12.4159
MGSO3	-15.2658	7.1152	-22.3810
CH4(GAS)	-53.0047	-43.1184	-9.8864
CO2(GAS)	-21.5984	-18.1777	-3.4207
O2(GAS)	15.7023	87.6856	-71.9833
CAMOO4	-9.9598	-7.7434	-2.2164
NAT. SE	62.5884	-63.7019	126.2903
FERROSEL	-122.0110	-130.7170	8.7060

see Attachment D

9/14/90

9/20/90

Attachment D: PHREEQE model predicted dissolved species and minerals-saturation indices on various constituents present in the Mancos groundwater, Well 982.

```
gr JD3 cheney mancos water speciation, well 982
0000012000 0 0          .00000
ELEMENTS
C         10         50.
           0          0.
SOLUTION 2
gr JD3 Mancos Shale, well #982 at Cheney
16 10 2    7.27    -6.23    14.0     1.00
   9  3.7000+00  10  1.0020+03  11  1.9500+01  12  4.0000-03  13  2.3200+03
  17  7.0000-02  19  7.9000+00  21  1.7200+01  22  1.0000-01  24  2.3000+03
  27  3.0000-02  29  1.0400+03  30  1.1800+01  31  4.5000+00  32  4.3000-03
  34  2.0000-02  35  3.3400-02  37  2.3000-02
SOLUTION NUMBER 2          gr JD3 Mancos Shale, well #982 at Cheney
```

pH pe temperature, °C density of solution, g/cc.

TOTAL MOLALITIES OF ELEMENTS

continue

9/14/90
9/20/90

SCHOEPIT	-4.3952	5.8027	-10.1978
RUTHERFO	-25.9919	-14.4461	-11.5458
URANOPHA	-3.4434	17.4900	-20.9334
ANHYDRIT	-7.6910	-4.5140	-3.1770
ARAGONIT	-6.7830	-6.2261	-.5569
ARTINITE	4.5817	10.5604	-5.9787
BRUCITE	13.0909	17.6535	-4.5625
CALCITE	-6.7830	-6.4123	-.3707
CELESTIT	-8.7933	-6.4543	-2.3390
CHALCEDO	-3.7355	-3.6740	-.0615
CHRYSOTI	31.8025	33.9440	-2.1414
CLINOENS	9.3562	12.0086	-2.6524
CRISTOBA	-3.7355	-3.7738	.0382
DIOPSIDE	18.4362	20.9687	-2.5325
DOLOMITE	-17.2896	-16.7230	-.5667
EPSOMITE	-7.4207	-2.2342	-5.1865
SEPIOLIT	14.9739	18.7800	-3.8061
FERRIHYD	14.9309	18.2542	-3.3232
FE3(OH)8	40.8576	46.9553	-6.0977
FE(OH)2.7	11.9854	10.3242	1.6612
FES PPT	-40.9044	-39.5896	-1.3147
FE2(SO4)	-31.6549	32.2838	-63.9388
FLUORITE	-12.3402	-11.1174	-1.2228
FORSTERI	22.4480	29.9210	-7.4730
GOETHITE	14.9318	14.3480	.5838
GREENALI	25.5471	20.8100	4.7371
GREIGITE	-166.7729	-160.9802	-5.7928
GYPSUM	-7.6927	-4.8587	-2.8340
HALITE	-2.7008	1.5493	-4.2501
HEMATITE	29.8644	23.7592	6.1053
HUNTITE	-34.3030	-29.1092	-5.1938
HYDRMAGN	-20.9392	-7.0254	-13.9138
JAROSITE	3.7799	29.8453	-26.0655
MACKINAW	-40.9044	-40.3196	-.5847
MAGADIIT	-19.0347	-14.3000	-4.7347
MAGHEMIT	29.8644	33.1183	-3.2539
MAGNESIT	-8.5067	-7.8238	-.6828
MAGNETIT	40.8711	32.1545	8.7166
MELANTER	-9.5058	-2.5656	-6.9403
MIRABILI	-6.2791	-1.7446	-4.5345
NATRON	-7.3711	-1.8360	-5.5351
NESQUEHO	-8.5093	-5.4265	-3.0827
PYRITE	-84.9642	-90.1968	5.2326
QUARTZ	-3.7355	-4.2178	.4823
SIDERITE	-10.5918	-10.3719	-.2199
SIO2(A,G	-3.7355	-2.8330	-.9025
SIO2(A,P	-3.7355	-2.8330	-.9025
SRF2	-13.4425	-8.5818	-4.8607
STRONTIA	-9.8853	-9.2269	-.6584
TALC	24.3323	24.2299	.1024
THENARDI	-6.2704	-.1610	-6.1095
THERMONA	-7.3633	.2236	-7.5869
TREMOLIT	61.2047	59.7783	1.4264
PYROLUSI	18.0724	43.2059	-25.1335
BIRNESSI	18.0724	44.4608	-26.3884
NSUTITE	18.0724	43.8708	-25.7984
BIXBYITE	28.2936	52.6308	-24.3372
HAUSMANN	38.5148	64.2179	-25.7031
PYROCROI	10.2204	15.8449	-5.6245
MANGANIT	14.1464	26.1308	-11.9844
RHODOCHR	-11.3772	-10.3405	-1.0367
MNCL2, 4	-9.4199	2.1292	-11.5492
MNS GREE	-41.6898	-31.6761	-10.0136
MNSO4	-10.2852	3.1873	-13.4725

9/14/90

9/20/90

ZNCO3, 1	-12.5143	-10.2600	-2.2543
ZNF2	-16.0706	-1.0829	-14.9877
ZN(OH)2	9.0842	11.5000	-2.4158
ZN2(OH)3	8.3499	15.2000	-6.8501
ZN5(OH)8	25.7841	38.5000	-12.7159
ZN2(OH)2	-2.3372	7.5000	-9.8372
ZN4(OH)6	15.8311	28.4000	-12.5689
ZNNO3)2,	-169.6812	3.2559	-172.9371
ZNO(ACTI	9.0850	11.3100	-2.2250
ZINCITE	9.0850	11.8705	-2.7854
ZN3O(SO4	-13.7578	21.0918	-34.8495
ZNS (A)	-42.8260	-44.8423	2.0163
SPHALERI	-42.8260	-47.5653	4.7393
WURTZITE	-42.8260	-45.5187	2.6927
ZNSIO3	5.3495	3.5405	1.8090
WILLEMIT	14.4346	16.4451	-2.0105
ZINCOSIT	-11.4214	3.6516	-15.0730
ZNSO4, 1	-11.4223	-.2145	-11.2078
BIANCHIT	-11.4266	-1.7547	-9.6719
GOSLARIT	-11.4275	-2.0703	-9.3572
CD METAL	-1.0903	14.0915	-15.1818
GAMMA CD	-1.0903	14.1962	-15.2865
OTAVITE	-14.8376	-13.7206	-1.1170
CDCL2	-12.8769	-.5306	-12.3463
CDCL2, 1	-12.8778	-1.6492	-11.2286
CDCL2,2.	-12.8790	-1.9971	-10.8819
CDF2	-18.3945	-2.6552	-15.7396
CD(OH)2	6.7600	13.6500	-6.8900
CDOHCL	-3.0585	3.7676	-6.8261
CD3(OH)4	-.2257	22.5600	-22.7857
CD3OH2(S	-20.7313	6.7100	-27.4413
CD4(OH)6	6.5347	28.4000	-21.8655
MONTEPON	6.7608	15.9474	-9.1865
CDSIO3	3.0253	9.6157	-6.5904
CDSO4	-13.7456	.3925	-14.1382
CDSO4, 1	-13.7465	-1.4087	-12.3378
CDSO4,2.	-13.7479	-1.7263	-12.0216
GREENOCK	-45.1502	-52.1463	6.9961
PB METAL	-.5537	4.2566	-4.8103
COTUNNIT	-12.3402	-4.9571	-7.3831
MATLOCKI	-15.0992	-9.6957	-5.4035
PHOSGENI	-26.6412	-19.8100	-6.8312
CERRUSIT	-14.3010	-13.2924	-1.0086
PBF2	-17.8582	-7.4166	-10.4415
MASSICOT	7.2975	13.4707	-6.1732
LITHARGE	7.2975	13.2673	-5.9699
PBO, .3H	7.2972	12.9800	-5.6828
PB2OCO3	-7.0035	-.3171	-6.6864
LARNAKIT	-5.9115	-.0645	-5.8467
PB3O2SO4	1.3860	11.0934	-9.7074
PB4O3SO4	8.6835	23.2719	-14.5884
PB3O2CO3	.2940	11.9032	-11.6092
PBSIO3	3.5619	7.6294	-4.0675
PB2SIO4	10.8594	20.6288	-9.7694
ANGLESIT	-13.2090	-7.8618	-5.3471
GALENA	-44.6135	-51.4479	6.8344
PLATTNER	15.1456	51.6635	-36.5179
PB2O3	22.4461	61.0400	-38.5939
MINIUM	29.7436	77.1238	-47.3802
PB(OH)2	7.2966	8.6175	-1.3209
LAURIONI	-2.5218	.6200	-3.1418
PB2(OH)3	4.7748	8.7900	-4.0152
HYDCERRU	-21.3053	-17.4600	-3.8453

see Attachment D

see " "

9/14/90

9/20/90

11

125	FEOH4 -	-1.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
127	FEF 2+	2.0	4.96191D-22	-21.3044	2.17731D-22	-21.6621	4.36604D-01	-.3577
128	FEF2 +	1.0	5.75299D-22	-21.2401	4.68232D-22	-21.3295	8.13894D-01	-.0894
129	FEF3 AQ	.0	4.42757D-23	-22.3538	4.48946D-23	-22.3478	1.01391D+00	.0060
130	FE(SO4)2	-1.0	1.94281D-26	-25.7116	1.58124D-26	-25.8010	8.13894D-01	-.0894
	SROH +	1.0	5.75697D-11	-10.2398	4.68556D-11	-10.3292	8.13894D-01	-.0894
	MNCL +	1.0	5.23891D-08	-7.2808	4.26391D-08	-7.3702	8.13894D-01	-.0894
	MNCL2 AQ	.0	4.15451D-10	-9.3815	4.21230D-10	-9.3755	1.01391D+00	.0060
138	MNCL3 -	-1.0	8.48522D-12	-11.0713	6.90608D-12	-11.1608	8.13894D-01	-.0894
139	MNOH +	1.0	7.23626D-10	-9.1405	5.88955D-10	-9.2299	8.13894D-01	-.0894
140	MN(OH)3	-1.0	7.74358D-17	-16.1111	6.30245D-17	-16.2005	8.13894D-01	-.0894
141	MNF +	1.0	1.59690D-10	-9.7967	1.29971D-10	-9.8862	8.13894D-01	-.0894
142	MNSO4 AQ	.0	7.87520D-09	-8.1037	7.98475D-09	-8.0977	1.01391D+00	.0060
144	MNHCO3 +	1.0	8.55497D-09	-8.0678	6.96284D-09	-8.1572	8.13894D-01	-.0894
162	ZNCL +	1.0	1.39877D-09	-8.8543	1.13845D-09	-8.9437	8.13894D-01	-.0894
163	ZNCL2 AQ	.0	4.04857D-11	-10.3927	4.10488D-11	-10.3867	1.01391D+00	.0060
164	ZNCL3 -	-1.0	1.89681D-12	-11.7220	1.54380D-12	-11.8114	8.13894D-01	-.0894
165	ZNCL4 2-	-2.0	5.74447D-14	-13.2407	2.52070D-14	-13.5985	4.36604D-01	-.3577
166	ZNF +	1.0	1.96296D-11	-10.7071	1.59764D-11	-10.7965	8.13894D-01	-.0894
167	ZNOH +	1.0	2.32673D-09	-8.6333	1.89371D-09	-8.7227	8.13894D-01	-.0894
168	ZN(OH)2	.0	3.04889D-09	-8.5159	3.09130D-09	-8.5099	1.01391D+00	.0060
169	ZN(OH)3	-1.0	1.49512D-12	-11.8253	1.21687D-12	-11.9148	8.13894D-01	-.0894
170	ZN(OH)4	-2.0	3.47474D-17	-16.4591	1.52473D-17	-16.8168	4.36604D-01	-.3577
171	ZNOHCL A	.0	6.02228D-09	-8.2202	6.10605D-09	-8.2142	1.01391D+00	.0060
172	ZN(HS)2	.0	3.43092D-09	-8.4646	3.47865D-09	-8.4586	1.01391D+00	.0060
173	ZN(HS)3	-1.0	8.48365D-16	-15.0714	6.90476D-16	-15.1608	8.13894D-01	-.0894
174	ZNSO4 AQ	.0	7.89120D-10	-9.1029	8.00097D-10	-9.0969	1.01391D+00	.0060
175	ZN(SO4)2	-2.0	2.94437D-12	-11.5310	1.29200D-12	-11.8887	4.36604D-01	-.3577
180	ZNHCO3 +	1.0	1.97712D-19	-18.7040	1.60916D-19	-18.7934	8.13894D-01	-.0894
181	ZNCO3 AQ	.0	6.03394D-08	-7.2194	6.11788D-08	-7.2134	1.01391D+00	.0060
	ZN(CO3)2	-2.0	4.31538D-08	-7.3650	1.89360D-08	-7.7227	4.36604D-01	-.3577
	CDCL +	1.0	4.19369D-10	-9.3779	3.33183D-10	-9.4773	8.13894D-01	-.0894
	CDCL2 AQ	.0	4.73886D-11	-10.3243	4.80478D-11	-10.3183	1.01391D+00	.0060
	CDCL3 -	-1.0	1.10136D-12	-11.9581	8.96393D-13	-12.0475	8.13894D-01	-.0894
186	CDF +	1.0	9.83711D-14	-13.0071	8.00636D-14	-13.0966	8.13894D-01	-.0894
187	CDF2 AQ	.0	1.25656D-17	-16.9008	1.27404D-17	-16.8945	1.01391D+00	.0060
188	CD(CO3)3	-4.0	1.36355D-17	-16.8653	5.05536D-19	-18.2962	3.70781D-02	-1.4309
189	CDOH +	1.0	8.96419D-13	-12.0475	7.29590D-13	-12.1369	8.13894D-01	-.0894
190	CD(OH)2	.0	2.53490D-14	-13.5960	2.57016D-14	-13.5900	1.01391D+00	.0060
191	CD(OH)3	-1.0	8.48264D-19	-18.0715	6.90397D-19	-18.1609	8.13894D-01	-.0894
192	CD(OH)4	-2.0	3.35711D-24	-23.4740	1.47311D-24	-23.8318	4.36604D-01	-.3577
193	CD2OH +3	3.0	2.71146D-21	-20.5668	4.24925D-22	-21.3717	1.56714D-01	-.8049
194	CDOHCL A	.0	2.43226D-11	-10.6140	2.46609D-11	-10.6080	1.01391D+00	.0060
196	CDSO4 AQ	.0	4.70191D-12	-11.3277	4.76731D-12	-11.3217	1.01391D+00	.0060
197	CDHS +	1.0	2.50535D-08	-7.6011	2.03909D-08	-7.6906	8.13894D-01	-.0894
198	CD(HS)2	.0	6.32676D-10	-9.1988	6.41477D-10	-9.1928	1.01391D+00	.0060
199	CD(HS)3	-1.0	1.63816D-15	-14.7856	1.33329D-15	-14.8751	8.13894D-01	-.0894
200	CD(HS)4	-2.0	6.46251D-21	-20.1896	2.83577D-21	-20.5473	4.36604D-01	-.3577
205	CDHCO3 +	1.0	1.86985D-11	-10.7282	1.52186D-11	-10.8176	8.13894D-01	-.0894
206	CDCO3 AQ	.0	3.59233D-10	-9.4446	3.64230D-10	-9.4386	1.01391D+00	.0060
207	CD(SO4)2	-2.0	2.31615D-14	-13.6352	1.01634D-14	-13.9930	4.36604D-01	-.3577
208	PBCL +	1.0	4.38664D-10	-9.3579	3.57026D-10	-9.4473	8.13894D-01	-.0894
209	PBCL2 AQ	.0	2.61627D-11	-10.5823	2.65266D-11	-10.5763	1.01391D+00	.0060
210	PBCL3 -	-1.0	8.63779D-13	-12.0636	7.03024D-13	-12.1530	8.13894D-01	-.0894
211	PBCL4 2-	-2.0	2.51748D-14	-13.5990	1.10468D-14	-13.9568	4.36604D-01	-.3577
212	PB(CO3)2	-2.0	7.20204D-09	-8.1425	3.16028D-09	-8.5003	4.36604D-01	-.3577
213	PBF +	1.0	4.78112D-13	-12.3205	3.89133D-13	-12.4099	8.13894D-01	-.0894
	PBF2 AQ	.0	4.96417D-16	-15.3042	5.03323D-16	-15.2982	1.01391D+00	.0060
	PBF3 -	-1.0	2.83610D-19	-18.5470	2.30991D-19	-18.6364	8.13894D-01	-.0894
216	PBF4 2-	-2.0	1.59615D-23	-22.7969	7.00396D-24	-23.1547	4.36604D-01	-.3577
217	PBOH +	1.0	1.98115D-09	-8.7031	1.61245D-09	-8.7925	8.13894D-01	-.0894
218	PB(OH)2	.0	1.48123D-10	-9.8294	1.50184D-10	-9.8234	1.01391D+00	.0060
219	PB(OH)3	-1.0	5.07216D-13	-12.2948	4.12820D-13	-12.3842	8.13894D-01	-.0894
220	PB2OH +3	3.0	7.95658D-17	-16.0993	1.24691D-17	-16.9042	1.56714D-01	-.8049

9/14/90

9/20/90

225	PB3(OH)4	2.0	5.29432D-20	-19.2762	2.32317D-20	-19.6339	4.38804D-01	-.3577
230	PBCO3 AQ	.0	8.57112D-08	-7.0670	8.69035D-08	-7.0610	1.01391D+00	.0060
231	PB(OH)4	-2.0	5.17161D-16	-15.2864	2.26932D-16	-15.6441	4.38804D-01	-.3577
232	PB(SO4)2	-2.0	7.43755D-14	-13.1286	3.26363D-14	-13.4863	4.38804D-01	-.3577
233	PBHCO3 +	1.0	4.05947D-10	-9.3915	3.30395D-10	-9.4810	8.13894D-01	-.0894
265	H2ASO3 -	-1.0	1.54563D-08	-7.8108	1.25814D-08	-7.9003	8.13894D-01	-.0894
266	HASO3 2-	-2.0	3.02132D-12	-11.5198	1.32577D-12	-11.8775	4.38804D-01	-.3577
267	ASO3 -3	-3.0	4.91089D-17	-16.3088	7.69607D-18	-17.1137	1.56714D-01	-.8049
268	H4ASO3 +	1.0	3.72708D-16	-15.4286	3.03345D-16	-15.5181	8.13894D-01	-.0894
269	H2ASO4 -	-1.0	7.14508D-14	-13.1460	5.81533D-14	-13.2354	8.13894D-01	-.0894
270	HASO4 2-	-2.0	5.23087D-12	-11.2814	2.29533D-12	-11.6392	4.38804D-01	-.3577
271	ASO4 -3	-3.0	6.37348D-15	-14.1956	9.98816D-16	-15.0005	1.56714D-01	-.8049
272	HCO3 -	-1.0	2.15868D-03	-2.6658	1.75693D-03	-2.7552	8.13894D-01	-.0894
273	H2CO3 AQ	.0	2.00655D-05	-4.6976	2.03446D-05	-4.6916	1.01391D+00	.0060
274	HSO4 -	-1.0	6.25082D-11	-10.2041	5.08750D-11	-10.2935	8.13894D-01	-.0894
275	HF AQ	.0	2.94531D-10	-9.5309	2.98628D-10	-9.5249	1.01391D+00	.0060
276	HF2 -	-1.0	8.12622D-14	-13.0901	6.61388D-14	-13.1795	8.13894D-01	-.0894
277	H2F2 AQ	.0	4.03179D-19	-18.3945	4.08788D-19	-18.3885	1.01391D+00	.0060
281	H2S AQ	.0	8.37238D-10	-9.0772	8.48854D-10	-9.0712	1.01391D+00	.0060
282	S 2-	-2.0	3.57394D-13	-12.4469	1.56826D-13	-12.8046	4.38804D-01	-.3577
283	UOH +3	3.0	5.49819D-28	-27.2598	8.61645D-29	-28.0647	1.56714D-01	-.8049
284	U(OH)2 +	2.0	7.19780D-22	-21.1428	3.15542D-22	-21.5005	4.38804D-01	-.3577
285	U(OH)3 +	1.0	1.37658D-16	-15.8612	1.12039D-16	-15.9506	8.13894D-01	-.0894
286	U(OH)4 A	.0	6.14940D-12	-11.2112	6.23494D-12	-11.2052	1.01391D+00	.0060
287	U(OH)5 -	-1.0	3.52644D-08	-7.4527	2.87015D-08	-7.5421	8.13894D-01	-.0894
289	UF2 2+	2.0	6.04352D-30	-29.2187	2.65192D-30	-29.5764	4.38804D-01	-.3577
290	UF3 +1	1.0	9.42782D-30	-29.0256	7.67324D-30	-29.1150	8.13894D-01	-.0894
291	UF4 AQ	.0	1.95435D-29	-28.7091	1.98124D-29	-28.7031	1.01391D+00	.0060
301	UO2OH +1	1.0	7.66696D-19	-18.1154	6.24009D-19	-18.2048	8.13894D-01	-.0894
304	UO2CO3 A	.0	1.21653D-16	-15.9149	1.23345D-16	-15.9089	1.01391D+00	.0060
305	UO2(CO3)2	-2.0	2.53555D-14	-13.5959	1.11261D-14	-13.9537	4.38804D-01	-.3577
306	UO2(CO3)3	-4.0	2.74033D-13	-12.5622	1.01598D-14	-13.9931	3.70751D-02	-1.4309
307	UO2F +1	1.0	7.22182D-21	-20.1414	5.87779D-21	-20.2308	8.13894D-01	-.0894
308	UO2F2 AQ	.0	2.48314D-21	-20.6050	2.51765D-21	-20.5990	1.01391D+00	.0060
309	UO2F3 -1	-1.0	5.42638D-23	-22.2655	4.41650D-23	-22.3549	8.13894D-01	-.0894
310	UO2F4 2-	-2.0	1.13739D-25	-24.9441	4.99093D-26	-25.3018	4.38804D-01	-.3577
311	UO2CL +1	1.0	4.74646D-23	-22.3236	3.86312D-23	-22.4131	8.13894D-01	-.0894
312	UO2SO4 A	.0	4.70716D-23	-22.3272	4.77264D-23	-22.3212	1.01391D+00	.0060
313	UO2(SO4)2	-2.0	5.47519D-25	-24.2614	2.40385D-25	-24.6191	4.38804D-01	-.3577
319	UO2H3SIO	1.0	1.51213D-19	-18.8204	1.23072D-19	-18.9098	8.13894D-01	-.0894
353	HSO3-	-1.0	5.43381D-17	-16.2649	4.42254D-17	-16.3543	8.13894D-01	-.0894
354	H2SO3 AQ	.0	6.95362D-24	-23.1578	7.05034D-24	-23.1518	1.01391D+00	.0060
367	SE2-2	-2.0	5.71[illegible]D-08	-7.2429	2.50824D-08	-7.6006	4.38804D-01	-.3577
368	SE-2	-2.0	7.24943D-22	-21.1397	3.18108D-22	-21.4974	4.38804D-01	-.3577
369	HSE-	-1.0	3.59987D-15	-14.4437	2.92991D-15	-14.5331	8.13894D-01	-.0894
370	H2SE	.0	7.31346D-20	-19.1359	7.41519D-20	-19.1299	1.01391D+00	.0060
371	SE03-2	-2.0	2.58553D-30	-29.5875	1:13454D-30	-29.9452	4.38804D-01	-.3577
372	MOO2+	1.0	4.14321D-09	-8.3827	3.37213D-09	-8.4721	8.13894D-01	-.0894
373	HMOO4-	-1.0	9.40451D-29	-28.0267	7.65427D-29	-28.1161	8.13894D-01	-.0894

---- LOOK MIN IAP ----

SATURATION INDICES

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-12.2446	-14.4480	2.2034
UO2 (AM	-12.2446	-8.5540	-3.6906
U4O9 (C)	-41.1271	-41.4693	.3422
U3O8 (C)	-21.0314	-6.1146	-14.9168
USIO4 (C	-15.9801	-17.5043	1.5242
UF4 (C)	-62.5559	-28.3389	-34.2169
UF4.2.5H	-62.5550	-37.9208	-24.6372
UO3 (C)	-4.3934	8.3656	-12.7590

→ see Attachment D

9/14/90

9/20/90

7

Attachment C: PHREEQE (model) predicted dissolved species and minerals-saturation indices of various constituents present in the Mancos groundwater, Well 981.

ENTS
IES

ed and minerals saturation indices in mancos groundwater, Cheney si
.0000 0 0 .00000
ENTS
10 50.
0 0.
JTION 1
cos Shale, GRJ Cheney Site, well #981
10 2 [8.36] [-4.45] [12.0] [1.00]

pH — Pe = 16.92 Eh — Temperature, °C — Density of solution (water), g/cc.

1	2.2680-02	11	9.8200+00	12	3.0000-03	13	1.6100+03	16	1.5000+00
7	2.3000-01	19	6.8000+00	21	1.1000+01	22	4.0000-02	35	3.5070-01
4	1.5400+03	23	1.1030+01	27	2.0000-02	29	4.6800+01	37	1.4580-02
0	1.7600+01	31	1.7900+00	32	9.4920-03	34	1.1000-02	10	1.1480+02

UTION NUMBER 1 Mancos Shale, GRJ Cheney Site, well #981

Pe to Eh Conversion

$$Pe = \frac{F}{2.3RT} Eh$$

F = Faraday Const = 23.06 kcal/volt-gm
R = "Gas Constant" = 0.001987 kcal/deg
T = 298.15°K

INPUT PARAMETERS FOR GROUNDWATER FROM WELL #981

Input values are in correspondence. [signature] 9/20/90

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	1.6032290-07	-6.7950
TOT ALK	2.3017150-03	-2.6379
CA	2.4563890-04	-3.6093
CD	2.6780630-08	-7.5722
CL	4.5565880-02	-1.3414
F	7.9221130-05	-4.1012
FE	4.1323280-06	-5.3838
K	1.7449250-04	-3.7582
MG	4.5396220-04	-3.3430
MN	7.3055680-07	-6.1363
N	1.7849100-04	-3.7484
NA	6.7212860-02	-1.1725
PB	9.6856350-08	-7.0139
S	4.8863560-04	-3.3108
SI	1.8373250-04	-3.7358
SR	2.0496240-05	-4.6883
U	3.5270860-08	-7.4526
ZN	1.6884250-07	-6.7725
MO	2.2001490-06	-5.6575
SE	1.1432190-07	-6.9419

----DESCRIPTION OF SOLUTION----

PH = 8.3830
PE = -4.4540
ACTIVITY H2O = .9982
IONIC STRENGTH = .0600
TEMPERATURE = 12.0000
ELECTRICAL BALANCE = 2.00870-02
THOR = -2.84450+04
TOTAL ALKALINITY = 2.30170-03
ITERATIONS = 22

9/14/90
[signature] 9/20/90

DISTRIBUTION OF SPECIES

DISSOLVED SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	5.12192D-09	-8.2906	4.16569D-09	-8.3800	8.13894D-01	-.0894
2	E-	-1.0	2.84446D+04	4.4540	2.84446D+04	4.4540	1.00000D+00	.0000
3	H2O	.0	9.98015D-01	-.0009	9.98015D-01	-.0009	1.00000D+00	.0000
6	H3ASO4	.0	3.67369D-20	-19.4349	3.72479D-20	-19.4289	1.01391D+00	.0060
10	CO3 2-	-2.0	3.29927D-05	-4.4816	1.44773D-05	-4.8393	4.38804D-01	-.3577
11	CA 2+	2.0	2.38563D-04	-3.6224	1.13850D-04	-3.9437	4.77194D-01	-.3213
12	CD 2+	2.0	2.26779D-10	-9.6446	1.00359D-10	-9.9983	4.38804D-01	-.3577
13	CL-	-1.0	4.55658D-02	-1.3414	3.63673D-02	-1.4393	7.98127D-01	-.0979
16	F-	-1.0	7.78361D-05	-4.1088	6.33503D-05	-4.1983	8.13894D-01	-.0894
17	FE 2+	2.0	4.02945D-06	-5.3948	1.76814D-06	-5.7525	4.38804D-01	-.3577
19	K+	1.0	1.74323D-04	-3.7586	1.39132D-04	-3.8566	7.98127D-01	-.0979
21	MG 2+	2.0	4.39683D-04	-3.3569	2.15105D-04	-3.6674	4.89227D-01	-.3105
22	MN 2+	2.0	6.60430D-07	-6.1802	2.89799D-07	-6.5379	4.38804D-01	-.3577
23	NO3 -	-1.0	0.00000D+00	-80.9115	0.00000D+00	-81.0010	8.13894D-01	-.0894
24	NA+	1.0	6.71087D-02	-1.1732	5.47571D-02	-1.2616	8.15946D-01	-.0883
27	PB 2+	2.0	7.87188D-10	-9.1039	3.45421D-10	-9.4617	4.38804D-01	-.3577
29	SO4 2-	-2.0	4.23085D-04	-3.3736	1.78927D-04	-3.7473	4.22910D-01	-.3738
30	H4SIO4	.0	1.80605D-04	-3.7433	1.83117D-04	-3.7373	1.01391D+00	.0060
31	SR 2+	2.0	2.04982D-05	-4.6883	8.99465D-06	-5.0460	4.38804D-01	-.3577
32	UO2 2+	2.0	1.60383D-21	-20.7948	7.03766D-22	-21.1526	4.38804D-01	-.3577
34	ZN 2+	2.0	4.82668D-08	-7.3164	2.11793D-08	-7.6741	4.38804D-01	-.3577
35	MOO4 2-	-2.0	2.19631D-06	-5.6584	9.63816D-07	-6.0161	4.38804D-01	-.3577
51	H3ASO3	.0	1.44556D-07	-6.8391	1.46571D-07	-6.8331	1.01391D+00	.0060
53	FE 3+	3.0	1.70707D-23	-22.7677	2.67522D-24	-23.5726	1.56714D-01	-.8049
55	NH4 +	1.0	1.78081D-04	-3.7494	1.44939D-04	-3.8388	8.13894D-01	-.0894
57	HS-	-1.0	1.68725D-08	-7.7728	1.37324D-08	-7.8623	8.13894D-01	-.0894
58	SO3 2-	-2.0	1.60788D-15	-14.7938	7.05414D-16	-15.1516	4.38804D-01	-.3577
61	UO2 +	1.0	1.93256D-14	-13.7139	1.57290D-14	-13.8033	8.13894D-01	-.0894
65	OH-	-1.0	1.05837D-06	-5.9754	8.61399D-07	-6.0648	8.13894D-01	-.0894
66	H3SIO4 -	-1.0	3.12691D-06	-5.5049	2.54497D-06	-5.5943	8.13894D-01	-.0894
67	H2SIO4--	-2.0	5.39279D-10	-9.2682	2.36635D-10	-9.6259	4.38804D-01	-.3577
75	NH4SO4 -	-1.0	4.10474D-07	-6.3867	3.34082D-07	-6.4761	8.13894D-01	-.0894
76	MGOH +	1.0	3.19444D-08	-7.4956	2.59993D-08	-7.5850	8.13894D-01	-.0894
77	MGF +	1.0	7.77352D-07	-6.1124	6.28368D-07	-6.2018	8.13894D-01	-.0894
78	MGCO3 AQ	.0	2.40080D-06	-5.6196	2.43420D-06	-5.6136	1.01391D+00	.0060
79	MGHCO3 +	1.0	5.03330D-06	-5.2981	4.09657D-06	-5.3876	8.13894D-01	-.0894
80	MGSO4 AQ	.0	6.06147D-06	-5.2174	6.14578D-06	-5.2114	1.01391D+00	.0060
84	CAOH +	1.0	2.76169D-09	-8.5588	2.24769D-09	-8.6482	8.13894D-01	-.0894
85	CAHCO3 +	1.0	1.71061D-06	-5.7669	1.39225D-06	-5.8563	8.13894D-01	-.0894
86	CACO3 AQ	.0	1.82999D-06	-5.7376	1.85545D-06	-5.7316	1.01391D+00	.0060
87	CASO4 AQ	.0	3.65501D-06	-5.4371	3.70586D-06	-5.4311	1.01391D+00	.0060
91	CAF +	1.0	5.76239D-08	-7.2394	4.68997D-08	-7.3288	8.13894D-01	-.0894
92	NACO3 -	-1.0	9.09481D-06	-5.0412	7.40221D-06	-5.1306	8.13894D-01	-.0894
93	NAHCO3 A	.0	3.91858D-05	-4.4069	3.97309D-05	-4.4009	1.01391D+00	.0060
94	NASO4 -	-1.0	5.53506D-05	-4.2569	4.50495D-05	-4.3463	8.13894D-01	-.0894
96	NAF AQ	.0	5.54868D-07	-6.2558	5.62586D-07	-6.2498	1.01391D+00	.0060
97	KSO4 -	-1.0	1.69571D-07	-6.7706	1.38013D-07	-6.8601	8.13894D-01	-.0894
109	FEOH +	1.0	5.95706D-08	-7.2250	4.84842D-08	-7.3144	8.13894D-01	-.0894
110	FEOH3 -1	-1.0	2.89645D-13	-12.5381	2.35741D-13	-12.6276	8.13894D-01	-.0894
111	FESO4 AQ	.0	4.32773D-08	-7.3637	4.38793D-08	-7.3577	1.01391D+00	.0060
113	FEOH2 AQ	.0	2.98725D-11	-10.5247	3.02881D-11	-10.5187	1.01391D+00	.0060
115	FE(HS)2	.0	2.93096D-13	-12.5330	2.97173D-13	-12.5270	1.01391D+00	.0060
116	FE(HS)3	-1.0	5.09544D-19	-18.2928	4.14714D-19	-18.3823	8.13894D-01	-.0894
117	FEOH 2+	2.0	4.23386D-18	-17.3733	1.85783D-18	-17.7310	4.38804D-01	-.3577
119	FESO4 +	1.0	3.62086D-24	-23.4412	2.94699D-24	-23.5306	8.13894D-01	-.0894
120	FECL 2+	2.0	4.35183D-24	-23.3613	1.90960D-24	-23.7191	4.38804D-01	-.3577
121	FECL2 +	1.0	5.86426D-25	-24.2318	4.77285D-25	-24.3212	8.13894D-01	-.0894
122	FECL3 AQ	.0	1.71196D-27	-26.7665	1.73577D-27	-26.7605	1.01391D+00	.0060
123	FEOH2 +	1.0	1.05734D-13	[illegible]	[illegible]	[illegible]	8.13894D-01	-.0894

9/14/90

[signature] 9/20/[illegible]

WATER QUALITY ANALYTICAL RESULTS

SITE ID: BRJ03 LOCATION ID: 981 SAMPLE ID: 0

SAMPLE DATE: 11/18/89 ANALYTICAL LAB CODE: BAR

LAB SAMPLE CONTROL ID: 1556-14 DATE RECEIVED: 11-20-89

ANALYSIS CHECKED BY: [illegible] DATE CHECKED: 12-22-89

COMMENTS: Total Report DO #035, Lot 2

RSD-34-6724-[illegible]5-88-[illegible]

PARAMETER	V I	PARAMETER VALUE	VALUE UNCERTAINTY	DETECTION LIMIT	UNITS OF MEASURE	COMMENTS
AG	(	.01		0.01	MG/L	
AL	(	.1		0.1	MG/L	
AS		.012		0.01	MG/L	
BA	(	.1		0.1	MG/L	
BE	(	.01		0.01	MG/L	
BR		6.9		0.1	MG/L	
CA		9.82		0.01	MG/L	
CD		.003		0.001	MG/L	
CL		1610.		1.0	MG/L	
CN	(	.01		0.01	MG/L	
CO	(	.05		0.05	MG/L	
CR	(	.01		0.01	MG/L	
CU	(	.02		0.02	MG/L	
F		1.5		0.1	MG/L	
FE		.23		0.03	MG/L	
GA		140.	50.	1.0	PCI/L	
GB		55.	22.	0.5	PCI/L	
	(	.0002		0.0002	MG/L	
		6.8		0.01	MG/L	
MG		11.0		0.001	MG/L	
MN		.04		0.01	MG/L	
MO		.21		0.01	MG/L	
NA		1540.		0.002	MG/L	
NH4		3.2		0.1	MG/L	
NI	(	.04		0.04	MG/L	
NO3	(	.1		1.0	MG/L	
PB		.02		0.01	MG/L	
REL		0.0	0.1	1.0	PCI/L	
RAB		0.1	1.6	1.0	PCI/L	
S		14.		0.1	MG/L	
SB		.011		0.003	MG/L	
SE		.009		0.005	MG/L	
SIO		11.		2.0	MG/L	
SN		.101		0.005	MG/L	
SO4		426.		0.1	MG/L	
SR		1.79		0.1	MG/L	
TDS		4170.		10.0	MG/L	
TL	(	.01		0.01	MG/L	
TOC		69.		1.0	MG/L	
U		0.0084		0.003	MG/L	
V	(	.01		0.01	MG/L	
ZN		.011		0.005	MG/L	

9/14/90

9/20/90

WATER QUALITY ANALYTICAL RESULTS

SITE ID: GRJ03 LOCATION ID: 982 SAMPLE ID: 0:
SAMPLE DATE: 11/18/89 ANALYTICAL LAB CODE: BAR

LAB SAMPLE CONTROL ID: 1556-15 DATE RECEIVED: 11-20
ANALYSIS CHECKED BY: [illegible] DATE CHECKED: 12-22

COMMENTS: Total Report DO#035, lot 2 ASD-34-6704-5-88

PARAMETER	V I	PARAMETER VALUE	VALUE UNCERTAINTY	DETECTION LIMIT	UNITS OF MEASURE	COMMENTS
AG	<	.01		0.01	MG/L	
AL	<	.1		0.1	MG/L	
AS	<	.01		0.01	MG/L	
BA	<	.1		0.1	MG/L	
BE	<	.01		0.01	MG/L	
BR		3.7		0.1	MG/L	
CA		19.5		0.01	MG/L	
CD		.004		0.001	MG/L	
CL		2320.		1.0	MG/L	
CN	<	.01		0.01	MG/L	
CO	<	.05		0.05	MG/L	
CR	<	.01		0.01	MG/L	
CU	<	.02		0.02	MG/L	
F		1.4		0.1	MG/L	
FE		.07		0.03	MG/L	
GA		38.	49.	1.0	PCI/L	
GB		36.	24.	0.5	PCI/L	
HG		.0002		0.0002	MG/L	
K		7.9		0.01	MG/L	
MG		17.2		0.001	MG/L	
MN		.10		0.01	MG/L	
MO		.02		0.01	MG/L	
NA		2300.		0.002	MG/L	
NH4		5.0		0.1	MG/L	
NI	<	.04		0.04	MG/L	
NO3	<	.1		1.0	MG/L	
PB		.03		0.01	MG/L	
R6L		0.5	0.2	1.0	PCI/L	
RAB		1.9	1.1	1.0	PCI/L	
S	<	4.		0.1	MG/L	
SB		.041		0.003	MG/L	
SE		.014		0.005	MG/L	
SIO		8.		2.0	MG/L	
SN		.153		0.005	MG/L	
SO4		1040.		0.1	MG/L	
SR		4.50		0.1	MG/L	
TOL		0.0	0.3	1.0	PCI/L	
TDS		6440.		10.0	MG/L	
TL		.041		0.01	MG/L	
TOC		23.		1.0	MG/L	
U		0.0038		0.003	MG/L	
	<	.01		0.01	MG/L	
ZN		.020		0.005	MG/L	

9/14/90
[illegible] 9/20/90

Attachment A: On-site measured parameters of groundwater condition in the Mancos Shale at the Cheney site.

FOUNDATION	WELL NUMBER	Eh(mV)	pH	TDS* (mg/l)	ALKALINITY (mg/l as CaCO3)	TEMP (C)
ALLUVIUM	808	206	7.48	1170	327	14
ALLUVIUM	811S	227	7.36	664	286	12
ALLUVIUM	820	24	7.49	1630		14
ALLUVIUM	828	-20	7.51	620	474	14
ALLUVIUM	8292	208	7.23	680	401	13
ALLUVIUM	904	111	7.31	966	422	13
ALLUVIUM	965	221	7.09	798	290	15
ALLUVIUM	966	247	7.31	812	349	13
ALLUVIUM	967	255	7.40	760	259	12
MANCOS SHALE	811D	57	7.14	4320	457	10
MANCOS SHALE	981	-252	8.38	4220	1148	12
MANCOS SHALE	982	-355	7.22	6210	1002	14
DAKOTA SANDSTO	977	-12.5	7.21	12100	6630	19
DAKOTA SANDSTO	978		7.43	15410	7861	19
DAKOTA SANDSTO	971		7.80	15300	7899	17

*= LABORATORY MEASUREMENTS MADE ON SAMPLE COLLECTED
ALL OTHER MEASUREMENTS MADE IN FIELD FROM 11/89-2/90

Attachment B: Chemical analysis of groundwater in Wells 981 and 982 in the Mancos Shale at the Cheney site.

9/14/90

9/20/90

respectively.

The values of the saturation indices and the dissolved species of the hazardous constituents are read off directly from the computer print outs presented in Attachments C and D.

C. Assumptions

1. The calculation represents thermodynamic equilibrium reactions with no consideration for time dependence of these reactions (kinetic effects). This is a reasonable assumption as the reactions involving the constituents of interest are probably instantaneous.

2. The thermodynamic data base adequately represents the minerals and the dissolved species that are present in the Mancos groundwater. The data base is not adequate in that a) the number of minerals and dissolved species for the elements for which data is present are limited, and b) for a number of elements (for example, bismuth, copper, cobalt and chromium) no data is in the data base.

D. Material properties

Not applicable.

E. Data Sources

Thermodynamic data, chemical equations, procedures for calculation of the dissolved species and saturation indices for minerals containing hazardous constituents are in PHREEQE data base of the UMTRA Project file maintained at the DOE's Albuquerque office. The groundwater data used in the calculation are in Attachments A and B of this calculation.

F. Solution

The details of calculations performed is voluminous and are not attached. However, they can be exactly reproduced using PHREEQE and the chemical input parameters shown in Attachments C and D, with the input oxidation-reduction potential held constant and the density of the solution being 1 gram per milliliter.

The dissolved species and the saturation indices of minerals for the groundwater in wells 981 and 982 are shown in Attachments C and D respectively. The dominant dissolved species and the minerals containing selected chemical elements including the hazardous constituents of interest are highlighted in these Attachments.

G. Conclusions and Recommendations

1. The data presented in Attachments C and D strongly support the field observations (Attachment A) that the groundwater in the

9/17/90
9/17/90

Mancos Shale underneath the proposed disposal cell is in a highly reducing geochemical condition. Methane gas was produced during drilling of wells into the Mancos Shale; the modeling data show that the groundwater is supersaturated with respect to methane (well 982) and pyrite, and the chemically reduced ~~dissolved~~ species of various elements including those of sulfur, iron, arsenic, ~~cadmium,~~ molybdenum, selenium and uranium are predicted to be dominant in the Mancos groundwater. This highly reducing geochemical condition coupled with the alkaline pH condition will insolubilize the hazardous constituents present in the Grand Junction tailings pore leachate.

2. The saturation indices of the hazardous constituents presented in Attachments C and D show that the Mancos groundwater is supersaturated with respect to coffinite ($USiO_4$), sphalerite (ZnS), greenockite (CdS), galena (PbS), ferroselite ($FeSe_2$), native selenium (Se) and molybdenite (MoS). Therefore, these hazardous constituents are predicted to precipitate in these mineral forms as the tailings leachate mixes with the Mancos groundwater. The concentration of other hazardous constituents in the Mancos groundwater was below their detection limits.

H. Results

The dissolved species and minerals-saturation indices of the various constituents of interest, including the hazardous constituents, are highlighted in Attachments C and D. Also see the conclusions above.

I. References

See the cover sheet of this calculation.

J. Attachments

Attachment A: On-site measured parameters of groundwater condition in the Mancos Shale at the Cheney site.

Attachment B: Chemical analysis of groundwater in Wells 981 and 982 in the Mancos Shale at the Cheney site.

Attachment C: PHREEQE (model) predicted dissolved species and minerals-saturation indices of various constituents present in the Mancos groundwater, Well 981.

Attachment D: PHREEQE model predicted dissolved species and minerals-saturation indices on various constituents present in the Mancos groundwater, Well 982.

JE JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. GRJ03-07-90-1?-0?(0?)-00 But reported as GRJ03-07-90-13-06(?)-00 in the RAP. DISCIPLINE Hydrology NO. OF SHEETS 22

PROJECT:

UMTRA

SITE: GRJ03: Cheney disposal site for the GRJ tailings, Grand Junction, Colorado

FEATURE: Aquifer Hydraulic and Geochemical Properties: Geochemical Modeling: Speciation and Saturation Indices of Groundwater in the Mancos Shale

SOURCES OF DATA:

1. Groundwater Quality data from ~~the~~ selected Mancos shale groundwater wells – presented in this calculation
2. Geochemical computer code – PHREEQE (referenced below) was used

SOURCES OF FORMULAE & REFERENCES:

Parkhurst, D.L., Thorstenson, D.C., and Plummer, L.N., 1980. "PHREEQE – A Computer Program for Geochemical Calculations," U.S.G.S. Water Resources Investigations, 80-96, Washington D.C., 210 p.

PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. ______

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		[signature]	9/13/90	[signature]	9/20/90	KB	9/21/90

DETERMINATION OF DISSOLVED SPECIES AND MINERALS SATURATION INDICES OF THE HAZARDOUS CONSTITUENTS IN GROUNDWATER OF THE MANCOS SHALE UNDERLYING THE PROPOSED DISPOSAL CELL AT THE CHENEY SITE, GRAND JUNCTION, COLORADO

CALCULATION NUMBER: GRJ03-07-90-14-14(01)-00 (WAS REPORTED AS GRJ03-07-90-13-06(02)-00 IN THE LATEST GRAND JUNCTION RAP).

A. Purpose

The batch and column test data presented in Calculation GRJ03-07-90-31-06(01))-00 demonstrate that the hazardous constiutents present in the Grand Junction tailings pore water will be attenuated by the Quaternary alluvium and Mancos Shale underlying the disposal cell at the proposed Cheney site. The purpose of this calculation is to determine if the geochemical condition of the groundwater where it is present in the Mancos Shale underneath the Cheney site, is also conducive to attenuation of the hazardous constituents by chemical precipitation.

B. Overview of Method

The numerical computer code PHREEQE was used to determine a) the dissolved species of the hazardous constiutents in the groundwater of the Mancos Shale and, b) the saturation indices of several minerals that contain these hazardous constituents. The dissolved species indicate which species of a chemical element is stable in the solution. Saturation index on the other hand, is a measure of solubility of a mineral, that is, whether a mineral precipitates or dissolves in a solution of known chemical composition and condition. The computational details used by PHREEQE are provided in Parkhurst and others(1980).

The input parameters for this computation consisted of the following types:

a) On-site measured parameters of the Mancos Shale groundwater geochemical condition. These parameters are: oxidation-reduction potential, pH, alkalinity, electrical conductance and temperature. The measurements were made following the procedures described in the UMTRA Project Standard Operating Procedure No. 16.1.13. The data are provided in Attachment A.

b) Concentrations of several dissolved constituents including the hazardous constituents that are present in the groundwater. The chemical analysis of groundwater in wells 981 and 982 are provided in Attachment B.

The input parameters used in the computation for the groundwater from wells 981 and 982 are summarized in Attachments C and D

9/17/90
9/20/90

Table 3.39 Dakota Sandstone water quality statistics at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	MEDIAN (UNITS)	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TOTAL DISSOLVED SOLIDS			MG/L								
6	10500.0000	18300.0000	15355.0000	14518.3333	2780.8662	0.1915	0.0	10698.1033	18338.5634	NORMAL	
TOTAL KJELDAHL NITROGEN			MG/L								
3	0.5000	5.0000	0.5000	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
URANIUM			MG/L								
6	0.0004	0.0032	0.0015	NA	NA	NA	50.0	0.0004	0.0032	NONPARAMETRIC	2,6
VANADIUM			MG/L								
6	0.0050	0.0300	0.0050	NA	NA	NA	83.3	0.0050	0.0300	NONPARAMETRIC	2,6
ZINC			MG/L								
6	0.0025	4.0600	0.6995	NA	NA	NA	33.3	0.0025	4.0600	NONPARAMETRIC	2,6

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

INPUT DATA FILENAME: J:\DART\GRJ03\GW010020.DAT

77

Table 3.39 Dakota Sandstone water quality statistics at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM			MG/L								
6	13.7000	42.0000	22.5000	26.7167	10.7682	0.4031	0.0	11.9238	41.5095	NORMAL	
MANGANESE			MG/L								
6	0.0200	0.3900	0.1100	0.0809	3.5524	NA	0.0	0.0142	0.4615	LOGNORMAL	7,8
MERCURY			MG/L								
6	0.0001	0.0910	0.0001	NA	NA	NA	83.3	0.0001	0.0910	NONPARAMETRIC	2,6
MOLYBDENUM			MG/L								
6	0.0050	0.2100	0.0500	NA	NA	NA	33.3	0.0050	0.2100	NONPARAMETRIC	2,6
NICKEL			MG/L								
6	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,6
NITRATE			MG/L								
6	0.5000	10.0000	1.7500	NA	NA	NA	50.0	0.5000	10.0000	NONPARAMETRIC	2,6
PHOSPHATE			MG/L								
6	0.1200	11.4000	2.4000	1.4390	5.4103	NA	0.0	0.1415	14.6326	LOGNORMAL	7,8
POTASSIUM			MG/L								
6	14.0000	111.0000	71.6500	67.2167	39.0866	0.5815	0.0	13.5212	120.9121	NORMAL	
RADIUM-226			PCI/L								
6	1.5000	32.0000	2.8500	4.7334	3.6747	NA	0.0	0.7920	28.2906	LOGNORMAL	7,8
RADIUM-228			PCI/L								
6	3.4000	48.0000	23.5000	25.0667	15.7915	0.6300	0.0	3.3730	46.7603	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

L.M. CONS PL.
SEP 90
75

Table 3.39 Dakota [illegible]stone water quality statistics at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 95% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SELENIUM			MG/L								
6	0.0025	0.0050	0.0025	NA	NA	NA	83.3	0.0025	0.0050	NONPARAMETRIC	2,6
SILICA - SIO2			MG/L								
6	8.0000	46.0000	18.3500	21.2333	13.1767	0.6206	0.0	3.1317	39.3350	NORMAL	
SILVER			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
SODIUM			MG/L								
6	4210.0000	7020.0000	5930.0000	5756.6667	1012.9692	0.1760	0.0	4365.0947	7148.2387	NORMAL	
SPECIFIC CONDUCTANCE			UMHO/CM								
2	15.5900	21000.0000	10507.7950	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
STRONTIUM			MG/L								
6	3.5900	9.0500	7.7200	7.1850	2.0867	0.2904	0.0	4.3184	10.0516	NORMAL	
SULFATE			MG/L								
6	6.2000	175.0000	54.3000	67.0167	61.8021	0.9222	0.0	-17.8843	151.9176	NORMAL	
SULFIDE			MG/L								
6	0.0500	10.0000	0.1700	NA	NA	NA	50.0	0.0500	10.0000	NONPARAMETRIC	2,6
TEMPERATURE			C - DEGREE								
5	16.9000	22.1000	19.0000	19.4200	1.8939	0.0975	0.0	16.2443	22.5957	NORMAL	
THALLIUM			MG/L								
3	0.0500	0.1000	0.0500	NA	NA	NA	66.7	NA	NA	UNKNOWN	1

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.3% one sided confidence int.

Table Dakota Sandstone water quality statistics at the Cheney disposal site, Grand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	5	5667.0000	9139.0000	7861.0000	7439.2000	1329.8636	0.1788	0.0	5210.7352	9667.6648	NORMAL	
ALUMINUM	MG/L	6	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,6
AMMONIUM	MG/L	6	5.2000	8.0000	6.0500	6.2667	1.0690	0.1706	0.0	4.7982	7.7352	NORMAL	
ANTIMONY	MG/L	3	0.0015	0.0015	0.0015	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ARSENIC	MG/L	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
BARIUM	MG/L	6	4.4400	38.0000	33.3000	27.2567	13.1413	0.4821	0.0	9.2037	45.3096	NORMAL	
BERYLLIUM	MG/L	3	0.0025	0.0025	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BORON	MG/L	6	1.5000	3.1300	2.0450	2.2633	0.6217	0.2747	0.0	1.4093	3.1174	NORMAL	
CADMIUM	MG/L	6	0.0005	0.0005	0.0005	NA	NA	NA	100.0	0.0005	0.0005	NONPARAMETRIC	2,6
CALCIUM	MG/L	6	14.5000	42.0000	33.8000	31.6833	9.7016	0.3062	0.0	18.3557	45.0110	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, a = 0.01
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

Z3
L.M. COONS PE PHG
Gro. ol
9/19/90

Table 3.39 Dakota San[...]ater quality statistics at the
Cheney disposal si[...]rand Junction, Colorado
SITE: GRJ03 CHENEY RESERVOIR
02/02/90 TO 06/29/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHLORIDE			MG/L								
6	3040.0000	4850.0000	4310.0000	4085.0000	731.7035	0.1791	0.0	3079.8183	5090.1817	NORMAL	
CHROMIUM			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
COBALT			MG/L								
6	0.0250	0.0250	0.0250	NA	NA	NA	100.0	0.0250	0.0250	NONPARAMETRIC	2,6
COPPER			MG/L								
6	0.0100	0.0200	0.0100	NA	NA	NA	66.7	0.0100	0.0200	NONPARAMETRIC	2,6
CYANIDE			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
FLUORIDE			MG/L								
6	1.2000	2.2000	1.6000	1.6667	0.3724	0.2234	0.0	1.1551	2.1782	NORMAL	
GROSS ALPHA			PCI/L								
6	0.0000	98.0000	37.5000	NA	NA	NA	33.3	0.0000	98.0000	NONPARAMETRIC	2,6
GROSS BETA			PCI/L								
6	0.0000	160.0000	102.5000	NA	NA	NA	16.7	0.0000	160.0000	NONPARAMETRIC	2,6
IRON			MG/L								
6	0.2500	0.8900	0.4850	0.5067	0.2106	0.4156	0.0	0.2174	0.7960	NORMAL	
LEAD			MG/L								
6	0.0050	0.0100	0.0050	NA	NA	NA	83.3	0.0050	0.0100	NONPARAMETRIC	2,6

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

Table 3.36 Background water quality in the Mancos Shale at the Cheney disposal site, Colorado
SITE: GRJ03 CHENEY RESERVOIR
07/27/86 TO 06/27/90
REPORT DATE: 08/23/90

Parameter Name	Units	# of Samp	Minimum	Maximum	Median	Mean	Standard Deviation	Coeff. of Variation	% of Non Detects	Statistical Range 95% Confidence Interval Minimum	Statistical Range 95% Confidence Interval Maximum *	Distribution Type	Foot Note
STRONTIUM	MG/L	7	1.2650	9.0000	2.6700	3.3706	2.0819	NA	0.0	1.4105	8.0543	LOGNORMAL	7,8
SULFATE	MG/L	7	344.6000	3690.0000	875.2000	920.8585	2.1770	NA	0.0	365.4535	2320.3509	LOGNORMAL	7,8
SULFIDE	MG/L	5	0.0500	16.5000	1.0250	NA	NA	NA	33.3	0.0500	16.5000	NONPARAMETRIC	2,5
TEMPERATURE	C - DEGREE	7	12.6500	39.7600	14.0000	16.2430	1.4897	NA	0.0	10.1166	26.0795	LOGNORMAL	7,8
THALLIUM	MG/L	6	0.0050	0.0525	0.0275	NA	NA	NA	72.7	0.0050	0.0525	NONPARAMETRIC	2,6
THORIUM-230	PCI/L	6	0.0000	0.6000	0.0750	NA	NA	NA	44.4	0.0000	0.6000	NONPARAMETRIC	2,6
TIN	MG/L	6	0.0025	0.1530	0.0265	NA	NA	NA	42.9	0.0025	0.1530	NONPARAMETRIC	2,6
TOTAL DISSOLVED SOLIDS	MG/L	7	873.4000	7010.0000	4195.0000	2909.9871	2.2242	NA	0.0	1125.8183	7521.4620	LOGNORMAL	7,8
TOTAL KJELDAHL NITROGEN	MG/L	2	3.0000	4.0000	3.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) Data from a minimum of 4 locations must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Table 3.36 Background water quality in the Mancos Shale at the Cheney disposal site, Colorado
SITE: GRJ03 CHENEY RESERVOIR
07/27/86 TO 06/27/90
REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	MEDIAN (UNITS)	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TOTAL ORGANIC CARBON			MG/L								
7	20.0000	184.0000	63.0000	54.9848	2.0427	NA	0.0	23.5362	128.4546	LOGNORMAL	7,8
URANIUM			MG/L								
7	0.0027	0.0110	0.0096	0.0065	1.8671	NA	10.0	0.0031	0.0136	LOGNORMAL	7,8
VANADIUM			MG/L								
7	0.0050	0.1300	0.0930	NA	NA	NA	35.0	0.0050	0.1300	NONPARAMETRIC	2
ZINC			MG/L								
7	0.0067	0.0250	0.0112	NA	NA	NA	30.0	0.0067	0.0250	NONPARAMETRIC	2

' Note the data at each location was averaged before the statistical calculations were performed
* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

INPUT DATA FILENAME: J:\DART\GRJ03\GW010019.DAT

Table 3.39 Dak[illegible]dstone water quality statistics at the Cheney disposal site, Grand Junction, Colorado

SITE: GRJ03 CHENEY RESERVOIR

02/02/90 TO 06/29/90

REPORT DATE: 08/23/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	MEDIAN (UNITS)	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TOTAL DISSOLVED SOLIDS			MG/L								
6	10500.0000	18300.0000	15355.0000	14518.3333	2780.8662	0.1915	0.0	10698.1033	18338.5634	NORMAL	
TOTAL KJELDAHL NITROGEN			MG/L								
3	0.5000	5.0000	0.5000	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
URANIUM			MG/L								
6	0.0004	0.0032	0.0015	NA	NA	NA	50.0	0.0004	0.0032	NONPARAMETRIC	2,6
VANADIUM			MG/L								
6	0.0050	0.0300	0.0050	NA	NA	NA	83.3	0.0050	0.0300	NONPARAMETRIC	2,6
ZINC			MG/L								
6	0.0025	4.0600	0.6995	NA	NA	NA	33.3	0.0025	4.0600	NONPARAMETRIC	2,6

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01

1) A minimum of 4 samples must be available for the statistical analysis.

2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

INPUT DATA FILENAME: J:\DART\GRJ03\GWQ10020.DAT

posed Conc. Limit obtained from Statistics maximum of background 0.03 mg/l