Project No. RM78-682
June 79

D'APPOLONIA
CONSULTING ENGINEERS, INC.

Engineers Report

Tailings Management System

White Mesa Uranium Project
Blanding, Utah

Energy Fuels Nuclear, Inc.
Denver, Colorado

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Engineers Report

Tailings Management System

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1.0 INTRODUCTION

1.1 INTRODUCTION

The White Mesa Uranium Project, Energy Fuels Nuclear, Inc., (Energy Fuels), is a proposed uranium ore mill facility located in southeastern Utah about six miles south of the town of Blanding (as shown on Figure 1). The mill is designed to process uranium ore by an acid leaching operation into a yellow-cake uranium concentrate. The planned mill capacity is 2,000 tons/day of ore for a 15 year project life.

By-products of the milling operation include the crushed sandy ore waste, commonly called tailings and waste water. The amount of tailings equals the amount of ore processed due to the low percentage of uranium in the ore. Approximately an equal amount (by weight) of tailings and tailings water are created. The tailings management system presented herein is designed to dispose of these by-products in an economical and environmentally sound manner.

1.2 BACKGROUND

The White Mesa Uranium Project is fully described in the Environmental Report (ER) (Dames and Moore, 1978); the Source Material License Application (SMLA) (Energy Fuels, 1978); and supplemental reports on air and water quality, meteorology and radiological aspects. These reports were prepared and submitted in accordance with the requirements of U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 3.5 (USNRC, 1977a). They were reviewed by the NRC staff and the Draft Environmental Statement (DES) (USNRC, 1978) issued.

The tailings management system reviewed in the DES essentially was the system presented in the SMLA, Appendix AA, with the following two major changes:

- The lining for the cells was changed from on-site clayey-silt to a synthetic material.
- The reclamation cover was modified from 9 feet of silt-sand and 9 inches of topsoil to 2 feet of clay, 10 feet of clayey-silt and 9 inches of topsoil.

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The tailings management system described in this report is based on the system reviewed in the DES and is similar to it. Modifications have been made to the cell layouts and the operational procedures, however, due to detailed design for construction and questions and statements made in the DES.

1.3 SUMMARY

The tailings management system described herein consists of the following major parts:

- Tailings Disposal System - Five cells or storage reservoirs to hold the tailings water and solid wastes. The cells are located in a shallow valley or swale area to minimize exposure of the tailings and to provide storage below the existing grade of the swales or ridges. The multiple-cell system will be sequentially constructed, operated and reclaimed to minimize disturbance of the area, construction costs, and tailings exposure. Each cell is formed by excavation of soil and rock and by construction of a dike across the open end of the swale. The dikes will be constructed of on-site soils and are designed in accordance with Regulatory Guide 3.11 (USNRC, 1977b). The cells will be lined to prevent seepage into the in situ materials or groundwater. All water will be disposed of by evaporation and no discharge out of the system will occur. Reclamation of the tailings cells will be achieved by covering with layers of clay, soil, and rock.

- Operational Procedures Plan - The plan for operation of the tailings management system includes beaching the tailings solids in a dense, stable deposit, decanting most of the water, and pumping the water to separate cells for evaporation. This plan will produce deposited tailings which may be readily reclaimed and will control the water separately from the solids.

- Surface Water Control System - Several ditches and small berms are proposed to divert precipitation runoff away from the tailings disposal system. Ditches and a diversion fill are also proposed to prevent precipitation runoff from flooding the facilities area. A sedimentation pond is proposed to collect and control runoff and sediment from the facilities area.

- Groundwater Monitoring System - This system consists of groundwater wells installed to provide preoperational and operational monitoring of the groundwater quality, in accordance with NRC requirements. The system also includes several wells to detect cell leakage in strata above the groundwater table.

The tailings management system will be constructed in phases. The Initial Phase consists of a tailings disposal cell (Cell 2) and an evaporation cell (Cell 1-Initial). This phase will provide for tailings water and solids disposal for approximately 2-3 years of mill operations. Appendix A contains the drawings showing the detailed designs for construction of this phase. These drawings are referred to as "Sheets" throughout this report. Appendix B contains the Guideline Specifications for construction of the Initial Phase. Expansion phases will consist of the construction of an additional evaporation cell (Cell 1-Enlargement) and three tailings disposal cells (Cells 3, 4 and 5) constructed sequentially, as required. The expansion phases are conceptually shown on the drawings in Appendix A. The complete system will provide storage for tailings from 15 years of mill operation.

1.4 CONCLUSIONS

The complete tailings management system is designed to meet the requirements of the U.S. Nuclear Regulatory Commission, applicable state regulations and prudent engineering practices. The Draft Generic Environmental Impact Statement on Uranium Milling (DGEIS) (USNRC, 1979) was also reviewed and proposed requirements implemented to the extent possible. However, DGEIS was issued after the ER and DES were published and consequently may not apply in its entirety.

The Construction Documents presented herein concentrate on the details of the Initial Phase since it will be constructed in the near future. Sufficient details for the remainder of the system are presented to show feasibility. Preparation of additional construction details may be necessary prior to construction of the Expansion Phases.

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The system as designed is considered to be within the regulatory requirements, economical, environmentally sound and complies with the needs of operating the White Mesa Uranium Mill.

Respectfully submitted,

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2.0 SYSTEM REQUIREMENTS

2.1 GENERAL

The tailings management system is designed with regard to specific requirements related to the physical aspects of the site, the design capacity of the project, the operation of the system, and the constraints imposed by previous permitting actions. This chapter discusses those requirements. In general, the requirements are as follows:

- The system will be similar in layout and concept to that presented in the Source Material License Application, Appendix AA.
- The system will be adequate for storage of the volume for the 15 year project life.
- The system will show an adequate water balance by evaporation and/or storage. No recycling of the water is proposed and seepage is minimized to the maximum extent practical.
- The tailings will be stored below the existing surface of the mesa.
- Environmental aspects will be considered including minimizing the disturbance of archaeological sites, groundwater protection and rapid reclamation to minimize fugitive dust.
- The system will be constructed utilizing a minimum of borrow outside of the cell construction area; and the system will be relatively easily constructed with available construction equipment.
- The system will incorporate safety and spill prevention features in case of unanticipated accidents during operations.
- Surface water will be prevented from entering the cells or flooding the facilities area.
- The groundwater will be monitored to detect any unanticipated seepage.

The layout for the system is contained in the Source Material License Application. The remaining requirements are discussed in detail below.

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2.2 TAILINGS SOLIDS VOLUME

The project is designed to produce 2,000 tons of uranium tailings solids per day for 340 days per year for 15 years. This will require storage of approximately 680,000 tons per year and 10.2 million tons total. The required storage volume of the cells is dependent on the density of the tailings solids as they are deposited into the cells. For this project the dry unit weight of the deposited tailings is estimated to be approximately 92 pounds per cubic foot. This unit weight is based on previous studies (D'Appolonia, 1977) and a review of available literature. It is slightly higher than some reported values, but is considered appropriate due to the planned beaching method of disposal. Therefore, the volume of tailings, as deposited, is estimated to be approximately 1 acre-foot per day, 340 acre-feet per year and 5100 acre-feet total.

2.3 TAILINGS WATER VOLUME

The amount of water entering the cell is designed to be equivalent in tonnage to the amount of tailings entering the cell or 2,000 tons per day. This is approximately 1.47 acre-feet of water per day or 500 acre-feet of water per year.

Since seepage is not considered, this water must be handled by evaporation or storage to achieve a water balance. A certain amount of storage will occur in the voids of the tailings as they are deposited in the cells. To determine this storage volume the following characteristics of the tailings are used:

- Void ratio e = 0.8
- Porosity, n = 0.44
- Specific gravity G = 2.65.

Selection of these values is based on the same reasoning as noted above for selection of the unit weight value.

Utilizing this information and considering that only a portion of the tailings will be saturated, i.e., because of the sloping beach deposit and cell bottoms, the volume of water stored in the voids is

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estimated to be approximately 0.40 acre-feet per day. Therefore, there is a total of 1.07 acre-feet per day or 364 acre-feet per year of water which must be removed by evaporation to achieve a water balance.

2.4 BELOW GRADE STORAGE OF TAILINGS

Due to previous permitting actions the tailings must be disposed of below grade. Nuclear Regulatory Commission position papers, as well as the Draft Generic Environmental Impact Statement (DGEIS), indicate that below grade storage of tailings is preferrable. The position is based on not allowing the tailings to become exposed to the environment at some time in the future due to erosion of the surface.

The topography of this site permits storage below the grade of the idges which form the shallow valleys or swa where the tailings cells are located.

2.5 ENVIRONMENTAL CONSIDERATIONS

The primary environmental considerations include (a) minimizing areal disturbance due to the archaeological sites and requirements for reclamation, (b) eliminating or minimizing seepage from the cells to prevent groundwater contamination, and (c) minimizing blowing tailings or fugitive dust. The layout of the cells will be such as to disturb the fewest possible sites. Further discussion of these criteria is given below under Construction Considerations. Minimizing seepage will be handled by lining of the cells. The type and integrity of the lining is a design consideration. A consideration in the design of the liner is the pH of the tailings water which is approximately 1.8 to 2.0 and has a chemical analysis as shown on Table 2-1. Minimizing fugitive dust is usually handled by either keeping tailings wet and/or rapidly covering the tailings after final deposition.

2.6 CONSTRUCTION CONSIDERATIONS

Since reclamation of the area is relatively difficult due to the arid conditions at the site, and since a significant number of archaeological sites have been located in the area, all unnecessary disturbance due to construction is to be avoided. Since the tailings storage cells will result in the major disturbance, a criterion for construction is to minimize the plan area of the cells. Excavation of materials within the cell area to increase volume for tailings storage is necessary to reduce the total cell area and maintain the required storage volume.

Blasting is to be avoided, if possible, to prevent possible fracturing of the underlying rock and increasing the potential for seepage excursions.

2.7 SAFETY AND SPILL PREVENTION FEATURES

The safety of the system is primarily related to the integrity of the dikes. Stability of the dikes is imperative and an important design consideration.

Spill prevention is achieved by (a) preventing surface runoff inflow to the cells from upstream drainage areas thereby preventing overtopping of the dikes and (b) providing catchment areas downstream from each cell to prevent downstream discharge of accidental discharges.

2.8 SURFACE WATER CONTROL

Surface water control is required to prevent precipitation runoff from entering the cells or flooding the facilities area, and to collect runoff water from the facilities area. Design of the system for the probable maximum precipitation (PMP) event is prudent since it is economical to provide the added protection versus designing for a lesser storm. The diversion of flow from the PMP event also lessens the problem of cell overtopping due to unusually large storms. Sedimentation ponds are commonly designed to retain at least the 10-year 24-hour storm event. Retention of a larger storm may be prudent if economically achievable. The mill and facilities area sedimentation pond will hold runoff from the 100-year 24-hour storm.

2.9 GROUNDWATER MONITO

Even though a cell lining is required, a monitoring system is required to detect the unlikely leakage event and the effects on underlying

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aquifers. The type and extent of the monitoring system depends on the site characteristics and the potential paths of unanticipated leakage emanating from the pond.

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3.0 SITE DESCRIPTION

3.1 GENERAL

To meet the design requirements discussed in Chapter 2.0, the site conditions were considered. The site geology governed the depth of cell excavation and the potential paths of seepage excursion. The hydrology defines the groundwater system for assessment of potential detrimental affects, if any, and provides the data necessary for design of surface water control systems. Climatology is important to determine the potential for evaporation, and provide data for design storm events. This chapter discusses the pertinent aspects of these factors as they relate to the tailings system design.

3.2 GEOLOGY

The surface soils are mostly silty sands of aeolian origin. They are approximately 5 to 20 feet thick in the project area, will form the upper part of the tailing cells, and will supply material for dike construction and reclamation.

The rock stratigraphy in the project area consists of sedimentary rock units of Cretaceous and Jurassic age. The Cretaceous age Dakota Sandstone underlies the site and is the unit that will be excavated for construction of the tailings cells. It is a yellowish-brown to light gray, massive, cross-bedded, and fine- to coarse-grained quartzose sandstone unit, 30 to 75 feet thick. It outcrops along the east and west sides of the mesa, but not in the project area as it is covered by a layer of soil.

The early Cretaceous age Burro Canyon Formation underlies the Dakota Sandstone, but at a sufficient depth so as not to be disturbed by tailings cell construction. It is a sandstone unit 50 to 150 feet thick and is very similar to the Dakota. Together they form the flat top mesas and steep sided canyons that are characteristic of the region.

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The Brushy Basin Member of the Jurassic age Morrison Formation, underlies the Burro Canyon Formation. This unit consists of gray and reddish-brown to pink mudstone and claystone layers containing a high percentage of montmorillonite. It does not outcrop in the project area, but off-site exposures are being investigated and tested for possible use as a source of clay for linings of expansion cells.

The structure in the project area consists of rock units which are nearly flat-lying with reported dips of less than 1 degree to the south. There are no reported faults and the area is characterized by low seismic activity. The major joint sets measured in the Dakota Sandstone and Burro Canyon Formation are reported (Dames and Moore, 1978) as N10-18°E and N50-85°E with both sets being nearly vertical. The lack of faulting and the low dip will mitigate downward movement of any seepage, although the major joint sets may increase the potential for downward movement of seepage.

Subsurface conditions at the project site have been investigated by several phases of borings and the results reported elsewhere (Appendix H, Dames and Moore, 1978; Chen, 1978; and Chen, 1979). The locations of these borings are shown on Sheet 3. The borings by Chen were soil borings for investigation of the on-site soils for use as earth lining in the cells. These borings were made with an auger and extended only a few feet into rock in most cases. Soil classification tests and compaction tests were run on many samples. The borings by Dames and Moore consisted of shallow borings (10 to 15 feet into rock) and several deep borings into the bedrock. Portions of the deeper borings were cored and in-situ permeability tests were also conducted in some intervals. Classification tests on the soils were made on numerous samples and strength tests were run on two samples.

To layout the tailings cells and compute excavation quantities, a contour map on the top of rock was developed and is shown on Sheet 3.

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These contours are based on interpretations of the boring logs from the investigations mentioned above. Due to the approximate location and spacing of borings, the actual top of rock may vary from that shown.

The excavation characteristics of the bedrock were estimated based on seismic refraction survey work performed at the site (Nielsons, 1978). Thirteen survey locations, shown on Sheet 3, were tested and velocity measurements made. Table 3-1 gives the seismic velocity values and interpreted material excavation characteristics for each location. Nielsons classified the bedrock as rippable if the seismic velocity was less than 5,000 feet per second and non-rippable if greater than 6,500 feet per second. The rippability of sandstone, siltstone and claystone according to the Caterpillar Tractor Company (Caterpillar, 1975), based on seismic velocity values, is as follows:

- Rippable 0-8,500 feet per second
- Marginally rippable 8,500-10,500 feet per second
- Non-rippable greater than 10,500 feet per second

Based on this information, approximately 5 to 8 feet of bedrock in the area of the tailings cells may be excavated by ripping.

3.3 HYDROLOGY

3.3.1 Surface Water

As shown on Sheet 2, the tailings cells are located in the upper reaches of the major drainage basin on the site. The mill and facilities are located in a smaller drainage basin east of the cells. These drainages are ephemeral, flowing only during periods of heavy precipitation. No intermittent or perennial drainages exist on the flat mesa in the project area.

Runoff from the drainage areas upstream of the cells and facilities will be diverted into Corral Creek and Westwater drainages located to the east and west of White Mesa respectively, as shown on Sheet 1. These are intermittent drainages, but have been perennial during wet years. They are 200 to 300 feet below the elevation of the mesa and do not have a direct bearing on the tailings cell design other than to stress the need for prevention of tailings water seepage.

3.3.2 Groundwater

Even though the tailings cells are designed to prevent seepage into the groundwater, an understanding of the quantity and direction of groundwater flow beneath the site is required to assess the consequences of any accidental seepage and to develop a monitoring program to detect such excursions.

The site groundwater model, Figure 2, is from information presented in the ER (Dames and Moore, 1978). It consists of an unconfined aquifer in the Dakota Sandstone with the groundwater table varying about 50 to 100 feet below the ground surface. This model is based only on water level measurements in the deep borings at the site and it is not definitely known whether these levels are a single water table or separate perched water tables. The additional groundwater wells installed as part of the monitoring program (discussed in Chapter 7.0) will provide additional data to further assess this model.

Previous site investigations yielded the following pertinent information:

- The reported groundwater gradient varies from 0.01 to 0.03 feet per foot.
- The calculated rate of movement through the formation varies from 0.0025 to 0.02 feet per year.
- The direction of movement is to the south-southwest.
- Recharge of the aquifer is by infiltration of precipitation falling on the surface of White Mesa.

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These data indicate that the movement will be from the upper tailings cells toward the lower cells as shown on Figure 2. The monitoring system has been developed to detect the effect of the accidental seepage which may enter the aquifer and move in this direction.

Water quality testing has indicated that the groundwater is slightly saline and is high in total dissolved solids. The only present usage in the site area is for livestock watering.

3.4 PRECIPITATION AND EVAPORATION

3.4.1 Evaporation and Precipitation For Water Balance

The water balance is dependent on the site evaporation and precipitation rates. A significant net evaporation rate is necessary to permit the operation of an evaporative water elimination system.

The site receives an average of 11.8 inches of precipitation annually according to the National Weather Service Station located in Blanding. About 30 percent of this occurs as snowfall and much of the remaining 70 percent occurs as rainfall from thunderstorms. The mean monthly precipitation values for the Blanding area are listed in Table 3-2.

Since no evaporation data are available in the Blanding area, evaporation data for the site was obtained from the National Oceanic and Atmospheric Administration (NOAA) (U.S. Dept. of Commerce, 1977). Using NOAA data the following values were determined for the site area:

- Mean annual Class A pan evaporation 68 inches.
- Mean annual lake evaporation 46 inches.
- Mean annual Class A pan coefficient 68 percent.
- Mean May-October evaporation 75 percent of annual.

The gross evaporation rate measured by a standard Class A evaporation pan installation is not directly applicable to larger bodies of water for several reasons including:

- Size and depth difference between the pan and lake.
- Air temperature and relative humidity.
- Prevailing winds.
- Lake orientation with respect to incident solar radiation.

The adjustment from pan rate to lake rate is made by applying the pan coefficient. This coefficient has been determined by comparison of many evaporation readings by NOAA and values range from 81 to 60 percent throughout the United States with the lower values occurring in the western U.S. The gross lake evaporation rate may be obtained by multiplying the pan rate by the pan coefficient or by using the NOAA value as reported above.

Due to the extreme seasonal variation in evaporation rates at the site, the annual rate was not considered adequate to determine the requirements for surcharge storage of tailings water during winter months. Table 3-2 gives monthly Class A pan rates from Haliburton (1978) and corresponding lake rates, using a pan coefficient of 68 percent. Although the annual evaporation rate and May-October percentage as given in Table 3-2 are slightly different than the NOAA data given above, the values are comparable. Therefore, the monthly gross lake evaporation rates listed in Table 3-2 and an annual rate of 47.4 inches were used for design and analysis of the tailings system water balance requirements.

The net evaporation rate is equal to the gross evaporation rate less the precipitation rate and for the site is 35.6 inches per year. Net evaporation is the appropriate value to use for determining water balance requirements since precipitation occurring on the tailings cells will also need to be evaporated.

The evaporation rate reported in the ER (Dames and Moore, 1978) of 61.5 inches per year from Green River, Utah, is a gross Class A pan rate and

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is not appropriate for determining water balance requirements as discussed above. The rate is comparable, however, to the values from NOAA and Haliburton (1978).

3.4.2 Storm Precipitation Events

For design of the surface water control system and to design the cells for handling runoff from flood events, several 24-hour duration storm events and the probable maximum precipitation (PMP) storm event were determined. Rainfall amounts for the 10-, 25- and 100-year recurrence interval, 24-hour duration events at the site are (U.S. Dept. of Commerce, 1973):

- 10-year storm - 2.0 inches rainfall
- 25-year storm - 2.5 inches rainfall
- 100-year storm - 3.0 inches rainfall

PMP values in the western United States are based on either a general-type storm or more frequently a thunderstorm. In the site area, the PMP values for the following design storms are (U.S. Dept. of Interior, 1977):

- General-type storm, 6-hour duration--4.0 inches rainfall
- General-type storm, 24-hour duration--8.4 inches rainfall
- Thunderstorm, 1-hour duration--7.0 inches rainfall

To ensure the stability and integrity of the tailings cells under flood conditions the design flood required by Regulatory Guide 3.11 (USNRC, 1977b) is the probable maximum flood series (PMFS). This is defined as the flood equivalent to approximately 40 percent of the probable maximum flood (PMF) followed in three to five days by the PMF, all of which may be preceded or followed by the 100-year storm. The PMF is defined as the flood resulting from the PMP which in this case is the 24-hour general-type storm. Therefore, the required design flood is equivalent to about 15 inches of rainfall.

The amount of runoff into the cells and precipitation which falls directly on the cells during the PMFS, must be stored in the tailings cells or safely routed through a spillway. Due to the toxic nature of the tailings water, storage of the runoff and precipitation is desirable if it is economical to do so. Storage of the PMFS is designed into this system.

The surface water diversion ditches are designed to carry the maximum peak discharge from the PMP thunderstorm since this event produces higher peak discharges due to its short duration than the more lengt higher volume discharges of the PMP general-type storm.

The facilities area sedimentation pond is designed to store runoff from the 100-year recurrence interval storm. This capacity is greater than required by regulations, but it will allow for sediment build-up and eliminate regular maintenance requirements.

4.0 TAILINGS DISPOSAL SYSTEM DESCRIPTION AND DESIGN

4.1 GENERAL DESCRIPTION

The complete tailings disposal system consists of (a) four cells for solids tailings disposal and storage (b) one cell for tailings water evaporation, (c) dikes as part of cell construction, (d) cell linings and (e) appurtenant systems including a tailings slurry transport and dispersal system, tailings water pumping system and slimes pool drain system.

The system will be built in phases. The Initial Phase will consist of tailings disposal Cell 2 and Evaporation Cell 1-Initial. Future expansion will include three more tailings disposal cells and enlargement of evaporation Cell 1 to allow for 15 years of disposal operations. The construction drawings in Appendix A present the detailed design of the Initial Phase and conceptual design of the expansion phases of the system. Guideline Specifications in Appendix B cover the Initial Phase construction procedures.

4.2 CELL DESIGN

4.2.1 Tailings Storage Capacity

The available storage volume within the cell construction area is restricted by (a) the depth of rippable rock, and (b) the elevation of the ridges forming the valley. The depth of rippable rock is the extent of nonblasting excavation. The ridges set the maximum height of storage by the criterion for final below grade storage of tailings. Furthermore, the size of any one cell is limited to allow sequential reclamation.

With these constraints four cells (Cells 2, 3, 4, and 5) for tailings disposal were laid out with cell bottoms limited by the depth of rippable rock and maximum tailings storage elevations limited by the topographic ridges as shown on Sheets 4, 5 and 6. The size of each cell is somewhat arbitrary and a result of the dike location.

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Sheet 15 shows the area-capacity curves for the tailings storage cells. Two curves for each cell are shown including (a) a curve for available volume subsequent to dike construction but prior to cell excavation and (b) a curve for the cell as excavated. For storage of tailings, the curve for complete excavation is applicable. This curve assumes level storage, which does not represent the actual case since beaching will deposit tailings as a slope. Using this curve and the anticipated volume of 340 acre-feet of tailings per year, the minimum time for filling any given cell can be determined. The actual design capacity is determined by adding the volume of storage available above the level storage capacity, due to the final sloping surface, to the volume from the area-capacity curve. The final sloping surface was determined by establishing the outer edge of the beach at an elevation five feet below grade and the edge of the beach along the dike at five feet below the crest. The curve for storage with no cell excavation is used for analysis of the dike as a safety dike. The storage capacity and other data on each cell is given in Table 4.1.

4.2.2 Water Balance

4.2.2.1 Evaporation Cell Sizing and Performance

A water balance for this system is designed by sizing the evaporation cells to remove water at a rate equal to the rate of water inflow less the water stored in the tailings. As discussed in Section 2.3 this amounts to evaporation requirements of approximately [illegible] acre-feet of water per year. Since the net annual evaporation is 35.[illegible] inches per year or 2.97 acre-feet per acre of water surface, an evaporation area of 123 acres is required for a yearly water balance.

Cell 1 consists of two parts to allow increased storage and evaporative capacity. The two parts are laid out with flatter bottoms than the tailings storage cells to increase the surface area versus water depth relation. This will maximize the amount of evaporation. Both parts are also laid out with regard to the depth of rippable rock, as discussed above, and previous permitting action requirements.

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Cell 1 is designed with a total surface area of 95 acres. This area is less than the total required area since additional evaporation is anticipated from (a) the slimes pool in the tailings storage cell, (b) the beach area of the tailings storage cell, and (c) the discharge of pumped water as a spray into the evaporation cells.

The surface area design value is based on "average" annual conditions and can vary with either a wet or dry year. Also, the effect of the varying precipitation and evaporation values during the seasons of the year is not accounted for using annual values. The lack of evaporation during the winter months will result in a build-up of tailings water requiring seasonal storage. Surcharge capacity in the evaporation cells is required.

To assess the performance of the evaporation cell and determine the required surcharge capacity, the system was modeled under mean monthly conditions. Sheet 16 shows the results of this modeling as a plot of pool elevation versus time. The model assumes a June start-up date, a minimum slimes pool area, and no additional evaporation from beach areas or spray discharge.

The model shows that Cell 1-Initial will reach its capacity at Elevation 5615 during the winter of the 2nd year of operation due mainly to the lack of evaporation during the winter months. At this time tailings water inflow is switched to Cell 1-Enlargement. The model indicates it will fill up to its capacity at Elevation 5637 during the winter of the 4th year of operation and begin discharging into Cell 1-Initial. By this time evaporation will have dropped the level in Cell 1-Initial to approximately Elevation 5608 which is well below its maximum operating level. With Cell 1-Enlargement at capacity and discharging into Cell 1-Initial the model indicates that Cell 1-Initial, will reach capacity during the winter of the 5th year of operation.

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Although the model shows the system capacity is exceeded during the 5th year of operation, system observations with appropriate operational modifications, if required, will prevent this occurrence. Such observations will allow correction of any inaccurate assumptions made in the model. Average conditions and maximum production rates were assumed in the analysis. This may be too conservative because the parameters could vary considerably. Particularly during the start-up period, the mill will not be operating at capacity so it is likely that Cell 1-Initial will function through the winter of the 2nd year and probably not reach capacity until the winter of the 3rd year.

One possible operational modification, if observations indicate the system will exceed its capacity, is the installation of sprayers or aerators to increase the evaporation volumes. As shown Sheet 16, for the option of installing sprayers in Cell 1-Initial only with an assumed doubling of the average evaporation rates, Cell 1-Initial capacity will not be exceeded and a water balance would be achieved. Another possible modification is the recycling of water from the evaporation cells back to the mill. As shown on Sheet 16, if 12 acre-feet per month or approximately 90 gallons per minute of water was recycled, the system capacity will not be exceeded.

Considerable surcharge volume is required to store water build-up during the winter months. This surcharge requirement can be minimized by the recycling option because it operates all year whereas sprayers are not functional during the winter.

These options or modifications are only illustrations of possible measures to reduce or handle the excess water built-up in the evaporation ponds should it become necessary. Observations during the first few years of operation will determine the need for such systems.

4.2.2.2 Monitoring Program For Water Balance

A monitoring program is proposed to measure site specific evaporation and precipitation rates, and mill production data so an accurate determination of water balance requirements can be made. This information will permit a better basis for designing system expansions or other options to handle the tailings water.

The program consists of the following components:

- Class A evaporation pan installation
- Precipitation gauge installation
- As-built area-capacity curves for evaporation cells
- Staff gauges
- Flow meters

The Class A pan and precipitation gauge will be used to provide an accurate data base of site specific evaporation and precipitation rates. The flow meters will measure the volume of water pumped into the cells. The staff gauges will determine the pool level. As-built area-capacity curves will be determined by on-site survey of the constructed cells. With these items an accurate measure of actual cell evaporation volumes can be made. Records of the actual slurry ratio and tailings inflow volumes should be kept as standard operating procedure so that determination of additional evaporation from the slimes pool or other areas can also be made.

With this program, an accurate determination of the water balance requirements for the system can be made. From measurements made during the initial phase it may be possible to reduce the size of Cell 1-Enlargement or determine that another option such as sprayers in Cell 1-Initial are feasible. Frequent reading and maintenance of the equipment should be conducted.

4.2.3 Environmental Considerations

4.2.3.1 General

Environmental considerations for cell designs are as follows:

- Prevent seepage to the underlying aquifers.
- Minimize disturbance to archaeological sites in the area.
- Provide interim stabilization to avoid blowing tailings.
- Provide a final reclamation cover to prevent radon emanation and/or future exposure of the tailings.

The prevention of seepage will be accomplished by liner installation as discussed in Section 4.4. The other environmental considerations are discussed below.

4.2.3.2 Archaeological Disturbance

The archaeological sites, shown on Sheet 2, have been identified by state archaeological surveys conducted in the project area. Most of these sites have been avoided by adjusting cell limits, but some as noted on Sheet 2 are being excavated and investigated prior to project construction. Also, as noted on Sheet 2, some of the future tailings cells may be modified due to locations of some archaeological sites.

4.2.3.3 Interim Stabilization

An interim stabilization program is required to prevent or minimize disturbance of the deposited tailings prior to reclamation. The main concern is blowing of the tailings by winds.

Since the tailings will be deposited in a natural swale or valley and they will be a minimum of 5 feet below the surrounding ground surface, they will be relatively isolated from the winds. Also, the beaching method of disposal will concentrate the coarser size particles on the exposed areas and these sized particles will not be as susceptible to erosion by winds.

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The slimes pool area will be covered with water until each cell is abandoned and allowed to dry. During this drying phase, finer grain particles will be subject to possible erosion or dusting by winds.

Interim stabilization of beach and slimes pool areas will be implemented as required depending on operating conditions. Alternate methods proposed include:

- Sprinklers to maintain a moist surface
- Chemical soil binders
- Covering with coarse material

The method to be used will be determined later depending on actual conditions.

4.2.3.4 Final Reclamation

Each cell containing tailings is required to be covered to reduce emanation of radon gas and to prohibit erosion of the tailings. These requirements are met by a reclamation cover of the following materials, listed in order from the top down:

- Topsoil - 1 foot thick
- Rock - 6 feet thick (with rolled or choked surface)
- Soil - 4 feet thick
- Clay - 2 feet thick

The clay portion of this cover alone will reduce radon gas emanation to below twice the background level (Ford, Bacon and Davis, 1979). The remaining 11 feet of cover will essentially eliminate the potential for exposing the deposited tailings by surface erosion. The surface erosion rate is minimal because of (a) the low precipitation values, (b) the location of the cells out of any large up-gradient drainage area, and (c) the erosion resistance of the rock cover.

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The thickness of the rock and soil cover material is based on the availability of material from the excavation and the minimum requirement of 10 feet (3 meters) of cover over the tailings (USNRC, 1979). The reclamation cover volumes for each cell are shown on the table on Sheet 16 and the totals for each material summarized below:

- Topsoil 0.6 x 10^6 cubic yards
- Rock 2.9 x 10^6 cubic yards
- Soil 2.3 x 10^6 cubic yards
- Clay 1.0 x 10^6 cubic yards

The clay will be obtained from an off-site borrow area. The other materials will be obtained from the cell excavations with the exception of 343 x 10^3 cubic yards of soil that will be obtained from on-site borrow areas shown on Sheet 2.

During placement of the rock, additional effort may be required to breakdown rock on the top surface to obtain a suitable surface for placing topsoil to support revegetation. It may be necessary to adjust the cover sequence if suitable breakdown of the rock cannot be achieved. This adjustment would involve placing 2 feet of soil above the clay followed by 6 feet of rock, 2 feet of soil, and then the topsoil. The necessary adjustments will be made in the field depending on actual conditions.

4.2.4 Construction Considerations

4.2.4.1 Earthwork

To minimize the area disturbed by cell construction, the required storage volume was obtained by proposing excavation into rippable rock and building small dikes. Excavation cell bottom contours conform in general to the top of rock contours, shown on Sheet 3, thereby maintaining a constant thickness of excavated rock and avoiding blasting. Excavation slopes ithin the cells are established on 3H:1V (horizontal:vertical) to maintain ease of construction and provide an acceptable slope for lining installation. Topsoil from disturbed areas will be removed and stockpiled for use during reclamation.

The excavation quantities (soil and rock) for each cell were determined by calculation of the volume behind the cell dike between the existing ground surface contours, the top of rock contours, and the excavation cell bottom contours. The excavation volumes for topsoil were based on a thickness of one foot over the disturbed areas. The in situ volumes from each cell are shown on Sheet 16 and the total for each material summarized below:

- Topsoil - 0.6×10^6 cubic yards
- Soil - 3.0×10^6 cubic yards
- Rock - 2.7×10^6 cubic yards

The topsoil volume is adequate to meet cover requirements set forth in Section 4.2.3.4. The excavated soils volume (3.0×10^6 cubic yards) will be utilized as cover (2.3×10^6 cubic yards) and other earthwork construction (700,000 cubic yards). Since approximately 950,000 cubic yards are required for dike construction and additional fill is required for liner cover, borrowing from other areas will be required as discussed in Sections 4.2.3.4. and 4.2.4.4. Rock will swell approximately 15 percent from in situ values to placement as cover. Approximately 3.1×10^6 cubic yards will therefore, be available for cover, leaving an excess of 0.2×10^6 cubic yards for disposal.

4.2.4.2 Schedule and Materials Handling

Sheet 16 shows the construction, operation, and reclamation schedule for the tailings disposal system. It is based on the tailings capacity of the cells, estimated construction lead times, and reclamation requirements. The schedule shows the reclamation of each cell is planned to coincide with construction of the next cell. This sequencing will reduce rehandling of the excavated materials.

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The rapid reclamation of the beached tailings and the slimes pool area will be enhanced by the continuous removal of tailings water during the cell operation and by pumping from the drain system in the slimes pool area as discussed in Section 4.5.4. The slimes pool area is estimated to require at least 1 year (one summer evaporation season) for drying prior to placement of the reclamation cover. Material from the excavations designated for reclaiming the slimes pool area may be piled on the rest of the cell and pushed out over the slimes pool as it dries. This will eliminate stockpiling of this cover material and subsequent rehandling.

Clay will be brought from the off-site borrow areas and placed on the cell prior to the construction of the next cell so materials excavated from that cell may be placed directly as reclamation cover.

The materials handling table, shown on Sheet 16, shows in detail the earthwork operations for the six planned construction phases and the final reclamation phase. For each phase, the volumes are shown for each material type that is excavated, required for construction, and required for reclamation. Also shown, is the sequence or handling schedule illustrating the amount of each material going to (a) construction or reclamation from excavation, (b) the stockpiles from excavation, (c) reclamation from the stockpiles, (d) reclamation from the borrow areas, and (e) cumulative stockpile and borrow volumes. The handling schedule is based on the systems schedule and cell quantities table, both shown on Sheet 16 and the cell layouts shown on Sheets 4, 5 and 6. Adjustments or changes in the future system layouts or schedule will alter this sequence.

4.2.4.3 Stockpiles

Excess excavated materials mostly from the Initial Construction Phase will be stockpiled in the areas shown on Sheet 2. The stockpiles are designed with a uniform height of 25 feet and 3H:1V side slopes. Although the piles could be constructed considerably higher to reduce surface area disturbance they would not blend easily with the surrounding topography. The side slopes were also selected to blend in with the surrounding topography and to provide stable slopes.

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The stockpiles for various materials are sized and located based on the schedule and materials handling sequence discussed above, to minimize haul distances during the Initial Construction Phase, to optimize later rehandling for use as reclamation cover, and to avoid archaeological sites. In addition, the topsoil stockpiles have been sized to hold topsoil which is stripped from the areas of the rock and soil stockpiles. Table 4-2 gives details for each stockpile including its design capacity, size, surface area, material source, and material destination.

Calcareous soils or other special soils as described in the Guideline Specification, Appendix B, will be selectively stockpiled within the soil stockpile areas shown on Sheet 2. The stockpiles will be treated by mulching, seeding or other means as appropriate, depending on conditions, to reduce wind erosion.

A typical stockpile section is shown on Sheet 11 illustrating the construction of a small berm around each stockpile to control the runoff and erosion of material by rainfall.

4.2.4.4 Borrow Areas

Two on-site soil borrow areas are shown on Sheet 2. Material from these areas is required for soil reclamation cover. The southern area will provide soil for reclamation cover on Cell 5 and the northern area for Cell 1-Enlargement. The areas are selected to minimize haul distances, and sized based on an assumed available soil thickness of 5 feet. Available subsurface information indicates the soils may be thicker. Therefore, the actual borrow areas may be smaller.

Topsoil, approximately 1 foot deep, will be stripped from each borrow area and stockpiled for replacement when the borrow operation is completed. This will provide a base for seeding and revegetation of the area. Depending on the actual excavation and reclamation volumes, excess rock that may be available could be used to refill some of the borrow areas.

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4.2.5 Safety Features of Cells

4.2.5.1 General

The safety features of the cells and cell system include: (a) the ability of the cells to store the required design storm without overtopping the dikes and (b) the ability of the system to retain (behind the safety dike) the outflow from a breached cell without causing downstream discharge. Prevention of discharge during these conditions can also be viewed as an environmental consideration.

4.2.5.2 Design Flood Retention

The design flood is the probable maximum flood series as discussed in Section 3.4.2 and is equivalent to approximately 15 inches of rainfall. Since the cells are located and designed to eliminate practically all surface runoff into the cells, the only flood storage volume required is from direct precipitation on the cells. Assuming this amount of rainfall occurs and the cell pools are at their maximum operating levels, the cells will store the total runoff amount and still leave a minimum 3 feet freeboard on all dikes as shown by the area-capacity curves on Sheet 15. This minimum freeboard meets the design recommendations of the Bureau of Reclamation (U.S. Dept. of Interior, 1977).

4.2.5.3 Safety Dike Analysis

For any given phase of development, the system is designed to store the volume of water from the active cell behind the safety dike. Each safety dike is actually just the dike for the next cell.

The safety dike analysis is based on the assumption that the active tailings cell is at its maximum tailings storage capacity shown on Table 4-1. From the area-capacity curves with no excavation on Sheet 15, there is enough storage capacity behind the safety dike for each cell to retain a minimum of 39 percent of the upstream active tailings cell maximum capacity. Since the actual volume of tailings that will be unstable and likely to flow is small, due to the beaching method of disposal, this available storage percentage is considered adequate.

Also, under actual operations the next cell will be excavated behind its associated safety dike when the active upstream cell is at capacity. This will provide storage for all of the upstream cell volume. Since no tailings will flow downstream, the system is considered more than adequate for spill prevention.

Analysis of successive cell (or dike) failure was also made. The potential for successive dike failure realistically only exists during the initial phase prior to reclamation of Cell 2. Once Cell 2 is reclaimed the system consists of two areas separated by a very wide fill. Analysis prior to Cell 2 reclamation indicates that under maximum flood storage conditions and successive dike failure of Cell 1-Enlargement, Cell 1-Initial, and Cell 2, the safety dike (Cell 3 dike, with no excavation) will not be overtopped. This analysis assumes that only material stored in the other cells above the crest elevation of the safety dike (El. 5610) is additional material requiring storage behind the safety dike. Due to the sloping cell bottoms and the location and height of the dikes, the safety dike will retain material in all of Cell 2 and part of Cell 1-Initial below Elevation 5610. This is illustrated by Section E-E on Sheet 8. From the area-capacity curves on Sheet 15 the storage volume above Elevation 5610 in Cell 1-Enlargement, Cell 1-Initial, and Cell 2 is approximately 630 acre-feet which is less than the maximum 800 acre-feet of storage available behind the safety dike.

Analysis of successive cell (or dike) failure after Cell 2 is reclaimed involves only the two parts of Cell 1. If Cell 1-Enlargement dike fails there is not adequate storage volume in Cell 1-Initial to retain the material from Cell 1-Enlargement, with the dike crest at Elevation 5620. The main dike dividing Cell 1-Initial and Cell 2 would not be overtopped because the 13 feet of reclamation cover would increase the dike height effectively to Elevation 5633. Therefore, the water from Cell 1-Enlargement would overtop the small dike on the east side of Cell 1-Initial, flooding the facilities area, and possibly spill over the edge of the cell on the

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west side and flow into Westwater Creek. To prevent this occurrence the dike around the east and west sides of Cell 1-Initial will be increased when Cell 2 reclamation cover is placed. The exact elevation of the increased dike will be based on the determination of the as-built cell storage volumes. The design of the increase in Cell 1-Initial Dike is not considered a part of this phase of the project.

4.3 DIKE DESIGN

4.3.1 General

There are seven dikes ranging in height from 20 to 35 feet maximum and totaling about 950,000 cubic yards of fill for the complete tailings disposal system. Data concerning the tailings cell dikes is given on Table 4-1. Three of the dikes (Cell 2, 3 and 4) are only divider dikes through the tailings disposal area so staged, sequential construction, operation and reclamation can be achieved. The design life for these divider dikes is quite short (4-5 yr.). When tailings are disposed on the downstream side of the dike, in the next cell, the dike is completely surrounded by tailings and ceases to function as a dike. Dikes for Cell 1-Initial and Cell 1-Enlargement will retain tailings water throughout the total project life and slightly beyond until evaporation is complete. Cell 5 Dike is the final cell dike and its downstream slope will form the final reclaimed surface. Therefore, it will theoretically function as a dike forever. For this reason, it is designed with an erosion resistant rockfill downstream section at a lower angle, 6H:1V, slope. The one remaining dike is the Cell 5 Safety Dike. It is only a safety dike and should not retain any water. It will be functional only during Cell 5 operation and reclamation, and will be completely removed when no longer required.

4.3.2 Geotechnical Analysis and Design

Geotechnical considerations for all the dikes include settlement assessment, seepage evaluation and slope stability assessments. Settlement of the dike fill or the foundation soil is not considered to be a proble . in general, due to the low height of the dikes, the thin layer of in situ 273 317 soil and the freeboard available under normal and minimum conditions. Also, seepage in general, is not considered to be a problem due to the inclusion of a lining inside the cells and the low permeability of the fill materials. The lining, either synthetic or clay, will allow little if any water to ever come in contact with the dike fill. Also, the life of any of the cells is short enough so only partial saturation, assuring lining failure, could occur prior to cell filling and abandonment. Therefore, settlement and seepage are not considered major design factors for this system and are not discussed further.

Stability of the dike fills is determined, in general, by using experience and engineering judgment to select a stable design section. All the dikes are therefore designed for:

- 20 foot wide crests
- 3H:1V upstream and downstream slopes
- Homogeneous fill sections
- Controlled, compacted fill material

Using these constraints, the dikes are conceptually laid out and are considered stable. Formal stability analyses are, however, made for the dikes to be constructed in the Initial Phase, as discussed below. Formal stability analyses of the other dikes will be made during detailed design of each expansion phase.

Initial Phase dike stability analyses is based on geotechnical data on the soil materials, in the area of the Initial Phase construction, as shown on Sheet 12. This includes grain size curves, compaction test curves, plasticity indices, and strength test results. The dike fill and in situ soil material properties used in the design are based on the test data shown on Sheet 12 and the in situ claystone and sandstone material properties are estimated and based on previous design analyses (Appendix H, Dames and Moore, 1978).

Stability analysis of the dikes was made with a Quality Assurance verified computer program. It utilizes the Modified Bishop method of slices stability analysis and a pseudostatic earthquake analysis. Three design sections are shown on Sheet 12, two for Cell 1-Initial Dike, one with sandstone bedrock and one with a claystone layer overlying the sandstone; and one section with sandstone bedrock was analyzed for Cell 2 Dike. Determination of the design sections were based on a review of the boring logs. No stability analysis was made for the safety dike (Cell 3 Dike) since Cell 3 excavation and tailings impoundment will not occur until the next phase.

Dike stability was analyzed for two cases on each design section. Case 1 corresponds to the maximum pool under flood conditions with steady seepage as required in NRC Regulatory Guide 3.11. For this project, this case includes the additional assumptions that the cell lining is completely failed and that sufficient time is available for complete fill saturation. These assumptions are very conservative and almost unrealistic. The minimum factor of safety for this case, shown on Sheet 12, is 1.65 which is greater than the 1.5 value required by Guide 3.11. Under a 0.10g earthquake loading (a conservative value) the minimum factor of safety is 1.07, again greater than the minimum required. Case 2 assumes end of construction conditions with no water in the cells or piezometric surface in the fill. Minimum factor of safety for this case is 1.71 and 1.08 for no earthquake and with earthquake loading, respectively. Again these values are greater than minimum requirements by Guide 3.11. Therefore, these dikes are shown to be stable even under very conservative assumptions.

4.3.3 Freeboard Analysis

For the tailings storage cells a minimum operating freeboard of 5 feet is necessary since the tailings are required to be stored at least 5 feet lower than the existing grade along the cell edges. Therefore, the maximum operational pool level is 5 feet below the dike crest in Cells 2-5. This is considered adequate based on the actual cell operation method and exceeds the design recommendations of the Bureau of Reclamation (U.S. Dept. of Interior, 1977).

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The minimum freeboard available under design flood conditions, assuming the cell is at its maximum operating level, is at least 3 feet as shown on the area-capacity curves on Sheet 15 and previously discussed in Section 4.2.5.2.

For Cell 1-Enlargement the maximum operating and minimum freeboard is 3 feet. Since this level is controlled by an ungated overflow spillway it is acceptable although it is less than the USBR recommended maximum operating value.

The minimum flood condition freeboard on Cell 1-Initial Dike is 3 feet. The maximum operating level is Elevation 5615 with Cell 1-Enlargement below its overflow level or Elevation 5614 with Cell 1-Enlargement at its overflow capacity. This dual requirement is necessary because of the uncontrolled overflow spillway in Cell 1-Enlargement and the result that all the flood volume from both cells must be stored safely behind Cell 1-Initial Dike.

In addition to the freeboard allowances discussed above, an emergency spillway is provided on each dike (except Cell 1-Enlargement) to prevent overtopping of the dike from accidental over-filling. A typical section through a spillway is shown on Sheet 11. It is simply a low section, 1.5 feet below the dike crest and 100 feet long located in natural material to allow flow out of the cell without breaching the dike.

4.3.4 Construction Considerations

Design details for Cell 1-Initial, Cell 2, and Cell 3 Dikes are shown on Sheets 10 and 11. Materials for construction will be obtained from the cell excavations. The dikes will be constructed by placing approved materials in layers of specified thickness and compacting them to a minimum specified density. The details of the fill specifications and other earthwork specifications are contained in the Guideline Specification for Initial Phase Construction in Appendix B.

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4.4 LINING DESIGN

4.4.1 General

Seepage from the tailings cells is required to be very low, essentially zero, to prohibit contamination of the surrounding environment. To achieve this zero seepage requirement tailings cells are commonly lined with either a compacted earth (clay) lining or a synthetic membrane lining. Both types have advantages and disadvantages. Clay is usually less expensive if a suitable material supply is available. The synthetic lining has one major disadvantage; if it gets punctured or tears the lining can allow a significant amount of leakage with minimal chance of repair. A clay lining, on the other hand, may allow some seepage by flow through it, but it is very unlikely that a properly designed and constructed clay lining would ever completely deteriorate. Furthermore, clay can self heal even if a crack does occur.

Due to previous permitting actions, the Initial Phase of the tailings system will be constructed with a synthetic lining. A borrow area for suitable clay lining material is currently being investigated however, and the conceptual expansion of the tailings system is planned with a clay lining. The detailed design of the clay lining is, therefore, not discussed herein.

4.4.2 Synthetic Linings

There are several types of synthetic linings. Three of the more common types are Hypalon, Polyvinyl Chloride (PVC), and Chlorinated Polyethylene (CPE). These three types have different properties and different, but overlapping applications. Major features of these three types are:

- Hypalon - resistant to direct sun exposure; may be reinforced with fabric material; resistant to most chemicals; expensive.
- PVC - non-resistant to direct sunlight, must be covered; excellent chemical resistance, better than Hypalon with regard to kerosene and fuel oil; long history of success; less expensive.

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- CPE - resistant to direct sunlight; excellent chemical resistance; may be reinforced with fabric material; slightly less expensive than Hypalon.

For any synthetic lining the main causes of failure are (a) improper installation, (b) improper maintenance, (c) attack by non-design chemicals, and (d) vandalism. The lining must be installed with strict adherence to quality installation procedures and preferrably under the guidance of a technical representative. Many linings fail due to attack by a chemical that either was not supposed to be discharged into the pond or was overlooked in the design process. Maintenance of the cover or other lining features must be conducted to ensure satisfactory lining performance. Vandalism is an item that is difficult to predict and defend against; however, it is often the cause of lining fail .

Based on the above discussions a PVC synthetic lining was selected as providing the best overall cell lining system. The main reasons for this selection are:

- PVC has the longest history of successful installations. It is relatively easier to handle and install correctly.

- PVC is less expensive than the other linings.

- A covered lining is considered the best installation with regard to protection during the cell operations from the equipment and also from vandalism.

- PVC is more resistant to kerosene which is present in minor concentrations in the tailings water. Also, the covered lining will partially protect against direct contact with the tailings water.

- The relatively small pond depths and the 3H:1V design slopes do not require the use of a reinforced lining.

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4.4.3 Initial Phase Lining Design

A 30 mil (0.030 in), nominal thickness PVC synthetic lining is specified for use in the Initial P Construction. Installation details are shown on c 10. Detailed specifications covering preparation, installation, maintenance, and quality assurance of the lining are included in the Guideline Specifications in Appendix B. Major points of the lining system are:

- A prepared bedding layer, 6 inches thick, for lining subgrade in all areas where lining is placed on an excavation surface. For fill surface installations, the surface will be inspected to ensure that it is acceptable.

- The lining is covered by 12 inches of soil on the bottom of the cells and 18 inches of soil on all slopes.

- Bedding and cover materials are soil materials from the excavations. They contain no sharp or oversized material.

- The lining is anchored in a trench which is backfilled with compacted soil. It is located above the design flood storage level.

- Installation will be overseen by a lining representative.

- Control of cover erosion, as required, by adding soil binder or other suitable means.

4.5 APPURTENANT SYSTEM FEATURES

4.5.1 Tailings Slurry System

The tailings slurry system consists of a transport pipeline, distribution piping around the cell, valves, down lines to the tailings beach surface, and flexible moveable discharge pipes within the cell. Typical details of these features are shown on Sheets 13 and 14. This system will discharge tailings slurry at approximately 500 gallons per minute. 273 323

The pipeline is designed as a double pipe system to contain and control flow from possible pipe breaks. The inside pipe will normally handle the tailings slurry and will operate under slight pressure to convey the slurry at relatively high velocities so the larger particles in the slurry will not settle out. The outer pipe will collect any leakage from the inner pipe and convey it to the tailings cell. The outer pipe is fitted with T-sections and down pipes to convey all flow down and out of the piping system without causing erosion of the cell lining cover. The pipes will be acid and corrosion resistant to provide safe operation and maximum system life. Since they will be placed on the surface, allowance will be necessary for movement due to thermal expansion of the pipes. The supports for the pipes will not be rigidly attached to allow for this movement; nor will the supports penetrate the surface to avoid damage to the synthetic lining.

The valves will be used to shut off flow while changes are made in the disposal piping inside the cell. The valves are not enclosed in the safety pipes so that they can be repaired and maintained as necessary. The valves will be made of acid and corrosion resistant materials.

The down lines located around the cell perimeter extend from the valves down the slope to the cell bottoms. These lines allow the discharge lines within the cell to be moved around the disposal of tailings in all parts of the cell.

4.5.2 Tailings Water System

Tailings water that forms the slimes pool will be pumped to the evaporation cell for storage and evaporation. The transport system involves a floating barge with a sump pump and a pipeline. Details of these features are shown on Sheets 9 and 14.

The floating barge is shown schematically on Sheet 9. It consists of the barge, pump, and skimming pump. The barge and walkway will be constructed out of acid resistant materials. The pump will also be acid resistant and will be capable of pumping about 200-300 gallons/minute. The skimming bucket, located beneath the barge, is designed so only water flowing over the top edge or lip of the bucket may be pumped. This will reduce the amount of suspended solids pumped to the evaporation cell.

The pipeline system is similar to that described in Section 4.5.1 for the tailings slurry pipeline. The pipeline is a double pipe system to contain and control spills due to pipe failure. Down pipes will be installed at regular intervals to control water escaping from a broken pipe. The pipes will be acid and corrosion resistant to prevent damage from the water and suspended solids. The inside pipe will also be high pressure pipe to permit spray discharge into the evaporation cell.

4.5.3 Pipeline Trenches

Trenches to carry the pipelines across dikes will be constructed as shown on Sheet 14. A typical trench will be about 2 feet wide and 1.5 feet deep. The depth dimension is required to avoid complications with the synthetic lining which is typically located 1.5 feet below the dike crest. With this design the trench will be constructed on top of the synthetic lining and will not affect the lining installation. Trenches will be covered with a grating designed to support heavy truck loadings.

4.5.4 Slimes Pool Drain System

A slimes pool drain system will provide bottom drainage for water [illegible] in the slimes. This system consists of slotted, plastic PVC pipes installed on a grid pattern over the lowest part of the cell, as shown on Sheet 4. Typical details of the system are shown on Sheet 9. This drain system will reduce the time required for drying and stabilization of the slimes area by providing drainage at the bottom of the deposit. The reduced time will permit reclamation sooner due to more rapid densification of the slimes.

The drainage will be collected in a sump installed in the rockfill access ramp. A float-switch pump will remove the water from the sump area. The water may be discharged back into the slimes pool where it will be pumped to the evaporation cell or it may be discharged to the next active tailings cell if that cell is in operation.

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As a contingency safety measure, the sump is also fitted with a high level overflow pipe. This will allow flow from the slimes pool to enter the sump uncontrolled and actuate the pump if the pool rises to the pipe invert level. Under normal operating conditions the pool will not reach the overflow level.

5.0 OPERATIONAL PROCEDURES

5.1 GENERAL PROCEDURES

Tailings will be deposited in the tailings cells by the method known as beaching. In this method the tailings are discharged onto already deposited tailings and not into standing water. The coarser tailings particles will form the beached deposits and the finer tailings particles and the water from the slurry will form a pool, commonly called a slimes pool. The level and area of the slimes pool will be controlled so beaching of the coarser particles is always possible. This method produces a compact, dense coarse tailings deposit that is stable and can be readily reclaimed.

The actual disposal operation may be achieved by several methods. The coarser tailings particles can be dropped from a pipeline as the slurry flows through the pipe. The majority of the water in the slurry and the finer sized particles will be carried to the end of the pipe and discharged adjacent to or into the slimes pool. Another possible method is to discharge the slurry onto the previously beached tailings. As the flow hits and spreads out, the coarser particles will be deposited and the finer particles carried on with the water into the slimes pool.

The slimes pool will be formed against the dike in the central part of the cell due to the sloping cell bottoms. The finer tailings particles carried into the slimes pool will settle out and form a soft deposit on the bottom of the cell. This deposit will build up as tailings disposal continues in the cell. During operations, the water level in the slimes pool will be maintained above the deposited slimes particles, to prevent them from drying out and blowing. When tailings disposal is switched to the next cell, the slimes will be dried out and reclaimed.

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5.2 INITIAL PHASE

Disposal operations for the initial phase of the system are shown on Sheet 13. Tailings disposal will begin in Cell 2 and evaporation of water in Cell 1-Initial. The system will operate in general as described in the previous section.

Tailings discharge will be initiated on the rockfill pad as shown on Sheet 13. The pad is necessary to prevent the initial slurry discharge from acting directly on the cell lining cover and causing severe erosion and possible damage to the lining. The rockfill pad will absorb the impact of the slurry discharge and allow a build-up of coarse particles in and around the pad. These coarser particles will drop out of the slurry as it is discharged onto the pad and the water containing finer sized particles, or slimes, will flow on through the rockfill and down the sloping cell bottom to form the slimes pool.

As the coarser particles drop out and cover the rockfill, a beach deposit will be formed. As described in the previous section, the discharge will be maintained on the beached tailings, however it will be shifted around to expand the beach deposit and produce uniform tailings disposal. Initially the beach will be developed around the slimes pool area, shown on Sheet 13, to aid in controlling its extent and location. Thereafter, the discharge will be moved around the cell and tailings deposited and built-up approximately uniformly throughout the cell. It is important that the discharge and beaching be controlled and operated such that the slimes can flow unrestricted to the slimes pool so secondary slime deposits are not scattered throughout the cell. This would produce soft spots that could cause difficulty during reclamation.

Tailings water will be drawn out of the slimes pool, as necessary or desired, and pumped to Cell 1-Initial for holding and evaporation. The initial discharge into this cell must be carefully controlled to prevent lining damage or cover erosion. The initial discharge, shown on Sheet 13, is located in the lowest area of the cell so water build-up will rapidly cover the area and minimize any cover erosion. Discharge will be by spray directed initially onto the toe of the rockfill ramp so erosion of the cover will be avoided. As the pool builds up the spray will be directed up and out into the pool. The spray discharge location on the rockfill ramp will be moveable so direct discharge into the pool and not onto the cell side slopes can be maintained regardless of the pool elevation.

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The discharge point may be shifted to the west, shown on Sheet 13, after the pool builds up to cover that area. This may be necessary if prevailing winds at the site carry any of the spray over to the mill area.

5.3 SYSTEM EXPANSION

As tailings continue to be discharged into Cell 2, the water pumped to Cell 1-Initial will fill that cell to its capacity of 325 acre-feet. This will occur because the surface area required for a water balance of 123 acres, as discussed in Section 4.2.2, is much greater than the 53 acres of Cell 1-Initial. Therefore, the evaporation volume of Cell 1-Initial is much less than the inflow volume from Cell 2.

For continued operations, Cell 1-Enlargement will be constructed and be operational when Cell 1-Initial reaches its capacity. The discharge of tailings water pumped from Cell 2 will then be switched to Cell 1-Enlargement where the water will be stored for evaporation. The initial discharge operation will be the same as that described for Cell 1-Initial. As Cell 1-Enlargement fills up with water, the level in Cell 1-Initial will be dropping due to evaporation since there will be no inflow from the tailings disposal operation. Cell 1-Enlargement will fill up as did Cell 1-Initial since its surface area of 42 acres is also much less than the necessary water balance area. As Cell 1-Enlargement reaches its capacity of 445 acre-feet at Elevation 5637, flow through the overflow spillway will commence and tailings water will spill into Cell 1-Initial. As part of the detailed design of Cell 1-Enlargement the invert elevation of the spillway and its width will be determined so under maximum overflow conditions the pool level will be at least 3 feet below the dike crest. This is the minimum acceptable freeboard allowance for the dike.

With overflow into Cell 1-Initial, its pool level will begin to rise. Since the overflow is designed as an uncontrolled spillway, the runoff volume from the design flood on both cells must be stored in Cell 1-Initial. Therefore, the maximum operating pool level in Cell 1-Initial,

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with Cell 1-Enlargement at its capacity, is Elevation 5614 as shown on the Cell 1-Initial area-capacity curve on Sheet 15.

The system will operate in this manner for several years. Depending on the actual net evaporation volumes and other mill process conditions it may function for the life of the project although the total surface area of both cells is only 95 acres and the required area for a water balance is 123 acres. Several options, as discussed in Section 4.2.2, are available to modify the operation of this system and reduce the water balance area requirement.

Tailings disposal will be switched to successive cells as they are needed and the slurry and water pipelines will be extended to the active tailings cell. Reclamation of the completed cells will be performed as described in previous sections with the exception of a zone where the pipelines will pass over the completed cells to the active one. This zone will not be fully reclaimed so that a trench will be formed by the higher reclamation surface on the rest of the cell. This trench will contain and control any spill from possible pipeline breaks. The location of the pipeline trench will most likely extend to the south from the eastern edge of Cell 1-Initial where the pipe is located on the edge of the dike. Partial reclamation cover will be placed beneath the pipes to reduce the tailings exposure and to build up the elevation of the bottom of the trench. The trench bottom must be above the elevation of the maximum pool level in Cell 1-Initial under successive dike failure conditions as discussed in Section 4.2.5.3. This is necessary so it does not act as a spillway carrying flow into the active tailings cell.

6.0 SURFACE WATER CONTROL SYSTEM

6.1 GENERAL

Surface water control is required to avoid possible disturbance to the tailings cells or disruption to the system operations by flooding or surface water runoff. In the project area, natural surface water drainage is poorly developed as discussed in Section 3.3.1. Therefore, surface water control at this site involves only the control of runoff from precipitation.

The major drainage divides in the project area are shown on Sheet 2. The tailings cells are located in the upper reaches of the main site drainage basin and they extend to the eastern and western edges of the basin so there are only small areas that drain towards the cells. The only other drainage area that affects the project is a small basin located north of the mill and facilities area.

Due to the small drainage areas involved, the particular site layout, and the relatively small runoff volumes, the method selected to handle the runoff is to divert it around and away from the areas of concern by construction of ditches. These surface water diversion ditches are shown on Sheets 2 and 4. They are designed to carry the maximum runoff discharge from the PMP event with non-erosive velocities. This maximum discharge is produced by the probable maximum thunderstorm as discussed in Section 3.4.2. Typical ditch sections and design data are given on Sheet 11.

A sedimentation pond is also required to collect and settle particles from water runoff from the facilities area. This prevents downstream discharge of the casual radioactive materials that may be inherent in the facility runoff water.

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6.2 TAILINGS CELL AREA DIVERSIONS

Diversion of runoff from around the area of the initial phase tailings cells is accomplished by Diversion Ditch No. 1 shown on Sheet 4. This ditch will intercept runoff from the area north of Cell 1-Initial and discharge it to the west where it will drain away from the cells and into Westwater Creek. The ditch is designed to be constructed at a constant depth and bed slope. It will be located in the field and, based on available subsurface information, should not require any rock excavation. With the expansion of the system and construction of Cell 1-Enlargement, Diversion Ditch No. 1 will be removed.

Diversion of runoff from other small areas adjacent to the cells will be accomplished by construction of a small berm, typically shown on Sheet 10. This berm will be constructed along the top of all excavation slopes (as shown on Sheet 4) and will redirect or hold for evaporation any runoff from the small contributing areas.

6.3 MILL AND FACILITIES AREA DIVERSIONS

Diversion of runoff from the area north of the mill and facilities area is accomplished by Diversion Ditch No. 2 and No. 3 located as shown on Sheets 2 and 4. These ditches will intercept runoff and discharge it to the east where it will drain away from the project area. Both ditches are designed at a constant bed slope and will be located approximately as shown. Several small fill sections will be required on the downhill side of the ditches to maintain the required design depth. A typical ditch fill section is shown on Sheet 11. Based on available subsurface information the ditches should not require any rock excavation.

A random fill will be placed as shown on Sheet 4 to fill in a low area and redirect the drainage in the area along the toe of the fill and into Ditch No. 2. This fill will be a maximum of about 15 feet high and cover approximately 7 acres. It will be a permanent fill and will be topsoiled and revegetated. Spoil, waste material, or rock from the cell excavations may be incorporated in the fill.

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6.4 MILL AND FACILITIES AREA SEDIMENTATION POND

The mill and facilities area sedimentation pond is located in the southwest corner of the area as shown on Sheet 4. It is designed to hold runoff from the entire facilities area including the ore storage piles associated with the buying station. It will be constructed as shown with 3H:1V side slopes and an approximate level bottom at Elevation 5605. This design is based on the facilities area site grading plan (Western Knapp Engineering, 1979) so the drainage culvert will flow into the pond. The storage volume available in the pond below the culvert invert Elevation 5611 is about 11 acre-feet or enough to hold runoff from the 100 year storm.

The pond is designed with no outlet or overflow structure. It may be emptied by pumping into Cell 1-Initial if necessary, but evaporation should keep the water level quite low.

The pond will be unlined. Bottom and side slopes will be seeded and mulched as necessary to minimize erosion.

7.0 GROUNDWATER MONITORING PROGRAM

7.1 GENERAL

Regular monitoring of the groundwater in the immediate area of the tailings cells is required by NRC regulations. This is necessary to detect contamination of the groundwater from the tailings disposal operations. Pertinent site groundwater hydrology features have been presented in Section 3.3.2. The program discussed herein is essentially the same as the program previously presented (D'Appolonia, 1979) and is included in this report in its final form for completeness.

The groundwater monitoring program is designed to (a) allow groundwater sample procurement from the aquifer underlying the site for preoperational baseline water quality testing, (b) allow similar data retrieval for operational groundwater quality monitoring and (c) allow detection of possible tailings cell leakage in near surface and intermediate depth non-aquifer strata. The program consists of five deep wells completed into the existing groundwater aquifer and five shallow, twin wells with monitoring zones in (a) the surface soils and top of the weathered and fractured rock and (b) the zone of unweathered rock below the top of rock and above the water table. The locations of these wells are shown on Sheet 2 and Figure 2. Figures B1, B2 and B3, Appendix B, illustrates typical installation details for these wells.

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7.2 PREOPERATIONAL PROGRAM

The preoperational program consists of the installation of 4 deep wells, Wells 1-4 shown on Sheet 2. These wells are located to (a) provide up-gradient baseline sampling (Well 1), (b) provide down-gradient sampling (Well 3), and (c) provide cross-gradient sampling (Wells 2 and 4). These 4 wells will be installed and sampled prior to construction to provide preoperational baseline data. They are located outside the area to be disturbed by the completed tailings cell system, so they can be sampled to provide data throughout the total life of the project. Figure B1, Appendix B, shows typical installation details. The exact screen depth, length, etc. will be based on boring data from each well.

Well 2 has been located and will be operated to provide an additional monitoring and excursion prevention function discussed in the next section. Well 3, the single down-gradient preoperational well, is considered adequate to provide down-gradient baseline data due to the small length of the tailings cells parallel to the direction of groundwater movement and the installation of Well 5 prior to operations.

Sampling of Wells 1-4 will be done quarterly and the samples tested for the parameters listed in Table 7-1 as follows:

- Quarterly Testing - Parameter Lists A and B
- Semi-Annual Testing - Parameter List C

Existing wells within a 2 kilometer radius of the site are also required to be sampled and tested as part of the preoperational program. Based on information presented in the Environmental Report (Dames and Moore, 1978) this requirement includes the wells listed in Table 7-2. Some of the wells may be listed more than once with different designations from different sources in the Environmental Report, but it was not possible due mainly to the scale of some plates to determine the exact location of all wells. It is recommended that all these designated locations be checked to confirm any dual markings. Due to the location of the tailings cells, it is recommended that the following wells be grouted:

- SW; SE; no mark; 35; 36; G6R; G7R

Grouting should be done with cement placed by tremie methods in the bottom of the well and completely grouting the well full to the ground surface.

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This leaves only Well 37 within 2 kilometers (1.24 miles) radius of the tailings facility to be included in the preoperational testing program.

7.3 OPERATIONAL PROGRAM - INITIAL PHASE

The initial phase operational monitoring program will include monitoring the wells installed in the preoperational program plus Wells 5-10 installed as shown on Sheet 2 and Figure 2. Well 5 is a deep well installed into the existing groundwater aquifer. It is located on Cell 3 Dike crest and will be installed after completion of the dike. It will provide additional down gradient monitoring capability near the active tailings cell.

Wells 5 and 2 are located to detect possible tailings cell leakage that may move along preferred flow paths corresponding to the major joint set directions shown on Figure 2. These two wells will also be installed and operated as pumping wells, for several reasons. First, the flow along any existing preferred flow paths on the edges of the cells can be drawn to the wells. This will allow detection of leakage from the entire cell area. If these two wells were located closer to Cell 2, their radius of influence may not be sufficient to detect possible leakage along preferred flow paths that could exist along the cell edges. Second, the gradient toward the wells will increase allowing decreased flow and leakage detection times. Third, if any leakage is detected the contaminated groundwater may be removed by these wells and the impact of the leakage on the regional groundwater quality mitigated. The discharge from these two wells can be returned to the tailings cells or discharged to stock ponds depending on conditions.

The pumps installed in these wells should be submersible well type pumps of small capacity. They will be corrosion and acid resistant. Water level controls will be installed to operate the pumps and flow volumes should be measured and recorded. It is not anticipated that much volume will be pumped.

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Wells 6-10 are each a double level installation; one well to be installed in the near surface strata and the other in an intermediate depth strata above the existing groundwater table. They are located in areas where possible leakage on, near, or within the upper part of the bedrock will be concentrated. Well 7 is located at the low point of the bedrock surface (see Figure 2) immediately down slope of Cell 2. Wells 6 and 8 are located in minor bedrock troughs on either side of the low point for detection of leakage moving along these areas of the bedrock surface. Wells 9 and 10 are located to the west of Cell 1-Initial to detect leakage moving along either near the bedrock surface or at depth within the bedrock along preferred joint planes. These wells will be installed typically as shown on Figures B2 and B3, Appendix B.

Operational sampling of the deep wells and testing will be performed as shown on Table 7-3. Groundwater quality parameters in List E, on Table 7-1, are critical indicator parameters that will indicate tailings cell leakage. List D parameters are indicators of groundwater quality that are also likely to be affected by tailings cell leakage. Testing of parameters on these lists will be done with the greatest frequency to monitor the groundwater quality and avoid producing an excess amount of data. The baseline parameters in Lists A, B and C will be done to maintain comparison data and if the indicator tests show anomolous results. Since Wells 6-10 are located above the water table no water is expected, but they will be monitored regularly (monthly for the 1st year and quarterly thereafter) and any water detected will be sampled and tested to determine if it is from the tailings operation. Depending on the location and magnitude of any leaks detected by these wells the contamination may be controlled by well pumping, installation of additional shallow wells, temporary abandonment of the leaking cell while it is fixed, or other options.

The groundwater monitoring program will be expanded with the construction of additional tailings cells. Wells 6, 7 and 8 will be fully grouted immediately prior to cell excavation and similar wells will be installed in the area of Cell 4 to detect possible leakage from Cell 3. Wells 9 and 10 will remain operational throughout the life of the project. Also, additional deep wells located along preferred flow paths may be installed. Data from the installation and monitoring of the wells described previously will assist in determining the requirements, including number of wells and locations, of the expanded groundwater monitoring program.

7.4 WELL INSTALLATION

The deep wells will be drilled prefe rably with air or possibly foam or special muds, if necessary. The holes should be inspected by a geologist to determine the screen location and to oversee the well installation. Details of the well installation is shown on Figure B1, Appendix B. The well should be cleaned upon completion by air lifting or bailing.

The intermediate depth wells will be drilled in the same manner as the deep wells and installed as shown on Figure B2, Appendix B. They will be completed to approximately 20 feet above the existing water table based on the latest data available from the preoperational program. Observations during the drilling of these holes may alter the above requirement.

The shallow wells will be drilled by an auger if possible. They will be installed as shown on Figure B3, Appendix B.

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TABLES

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TABLE 2-1

TAILINGS WATER ANALYSIS[1]
WHITE MESA URANIUM PROJECT

ION	GRAMS/LITER
V	0.24
U	0.0025
Na	4.90
NH_3	0.065
Cl	3.05
SO_4	82.2
Cu	1.62
Ca	0.48
Mg	4.06
Al	4.26
Mn	4.58
Zn	0.09
Mo	0.007
pH	1.5 - 2.0

[1] From page 3-12, Environmental Report (Dames and Moore, 1978)

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TABLE 3-1

SEISMIC VELOCITY DATA[1]
WHITE MESA URANIUM PROJECT

SEISMIC SURVEY TEST NUMBER[2]	MEASURED VELOCITY (FEET/SECOND)	DEPTH INTERVAL (FEET)	PROBABLE MATERIAL	EXCAVATION CHARACTER
1	1500	0-11	Sandy-Clay Soil	Unconsolidated Soil
	7400	11-33	Dakota Sandstone	Drill & Shoot Rock
2	900	0-6	Sandy-Clay Soil	Unconsolidated Soil
	7000	6-33	Dakota Sandstone	Drill & Shoot Rock
3	1300	0-3	Sandy-Clay Soil	Unconsolidated Soil
	2000	3-9	Sandy-Clay Soil	Compact Soil
	3100	9-33	Dakota Sandstone	Soft Rippable Rock
4	900	0-4	Sandy-Clay Soil	Unconsolidated Soil
	4000	4-33	Dakota Sandstone	Soft Rippable Rock
5	900	0-3	Sandy-Clay Soil	Unconsolidated Soil
	1700	3-15	Sandy-Clay Soil	Compact Soil
	6500	15-33	Dakota Sandstone	Drill & Shoot Rock
6	1300	0-5	Sandy-Clay Soil	Unconsolidated Soil
	4200	5-13	Dakota Sandstone	Medium Soft Rippable Rock
	6800	13-33	Dakota Sandstone	Drill & Shoot Rock

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TABLE 3-1
(CONTINUED)

SEISMIC SURVEY TEST NUMBER(2)	MEASURED VELOCITY (FEET/SECOND)	DEPTH INTERVAL (FEET)	PROBABLE MATERIAL	EXCAVATION CHARACTER
7	1250	0-3	Sandy-Clay Soil	Unconsolidated Soil
	2200	3-18	Sandy-Clay Soil	Compact Soil
	6500	18-33	Dakota Sandstone	Drill & Shoot Rock
8	1400	0-6	Sandy-Silty Soil	Unconsolidated Soil
	4400	6-33	Dakota Sandstone	Medium Soft Rippable Rock
9	1300	0-6	Sandy-Silty Soil	Unconsolidated Soil
	5000	6-33	Dakota Sandstone	Medium Hard Rippable Rock
10	1500	0-5	Sandy-Silty Soil	Unconsolidated Soil
	2450	5-17	Sandy-Silty Soil	Compact, Cemented Soil
	7000	17-33	Dakota Sandstone	Drill & Shoot Rock
11	800	0-5	Sandy-Silty Soil	Unconsolidated Soil
	3500	5-13	Dakota Sandstone	Medium Soft Rippable Rock
	8400	13-33	Dakota Sandstone	Drill & Shoot Rock
12	1400	0-7	Sandy-Silty Soil	Unconsolidated Soil
	4500	7-33	Dakota Sandstone	Medium Soft Rippable Rock

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TABLE 3-1
(CONTINUED)

SEISMIC SURVEY TEST NUMBER(2)	MEASURED VELOCITY (FEET/SECOND)	DEPTH INTERVAL (FEET)	PROBABLE MATERIAL	EXCAVATION CHARACTER
13	1750	0-6	Sandy-Silty Soil	Unconsolidated Soil
	3700	6-33	Dakota Sandstone	Medium Soft Rippable Rock

(1) Data From Nielsons, 1978

(2) For Location of Tests See Sheet 3 of 16

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TABLE 3-2

MONTHLY PRECIPITATION AND EVAPORATION VALUES
WHITE MESA URANIUM PROJECT

MONTH	PRECIPITATION(1) (INCHES)	GROSS PAN(2) EVAPORATION (INCHES)	GROSS LAKE(3) EVAPORATION (INCHES)	NET LAKE(4) EVAPORATION (INCHES)
JANUARY	1.1	0.0	0.0	- 1.1
FEBRUARY	0.8	0.0	0.0	- 0.8
MARCH	0.7	0.0	0.0	- 0.7
APRIL	0.7	6.9	4.7	4.0
MAY	0.6	9.5	6.5	5.9
JUNE	0.4	12.2	8.3	7.9
JULY	1.1	13.8	9.4	8.3
AUGUST	1.7	9.1	6.2	4.5
SEPTEMBER	0.9	10.6	7.2	6.3
OCTOBER	1.6	4.7	3.2	1.6
NOVEMBER	0.9	2.8	1.9	1.0
DECEMBER	1.3	0.0	0.0	- 1.3
TOTALS	11.8	69.6	47.4	35.6

(1) Mean monthly precipitation values from Plate 2.7-3, Environmental Report (Dames and Moore, 1978)

(2) Standard Class A Pan evaporation values (Haliburton, 1978)

(3) Gross Pan Rate multiplied by a pan coefficient of 68%

(4) Gross lake evaporation less precipitation. Minus indicates net precipitation.

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TABLE 4-1

TAILINGS CELL DATA
WHITE MESA URANIUM PROJECT

CELL	SURFACE AREA (ACRES)	TAILINGS STORAGE CAPACITY[1]		MAXIMUM TAILINGS STORAGE ELEVATION	MAXIMUM TAILINGS DEPTH (FEET)	TOTAL EXCAVATION ($x10^3$ yd.^{3})	CREST ELEVATION	DIKE LENGTH (FEET)	MAXIMUM HEIGHT (FEET)
		ACRE-FEET	YEARS						
1-Initial	53	--	--	--	--	744	5620	3030	20
1-Enlargement	42	--	--	--	--	708	5640	3080	25
2	63	1180	3.5	5610-5615	30	1302	5615	3130	25
3	69	1420	4.2	5605-5610	35	1390	5610	3390	30
4	61	1430	4.2	5595-5605	35	1160	5595	2740	25
5	56	1110	3.2	5580-5590	35	1013	5585	2720	30
TOTALS	344	5140	15.1			6317			

(1) Storage capacity in years assumes 340 acre-feet tailings production per year.

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TABLE 4-2

STOCKPILE DATA
WHITE MESA URANIUM PROJECT

STOCKPILE		CAPACITY ($x10^3$ yd.^{3})		PLAN AREA (FEET x FEET)	MATERIAL FROM	MATERIAL TO
MATERIAL	LOCATION	INITIAL PHASE	MAXIMUM			
Soil	West	229	229	500 x 650	Cell 1-Initial Cell 2	Cell 1-Initial Cell 1-Enlargement
	East	65	123	300 x 700	Cell 1-Initial Cell 2	Cell 3 Cell 4
	Northwest	0	308	450 x 1000	Cell 1-Enlargement	Cell 1-Enlargement
Rock	West	489	563	600 x 1250	Cell 1-Initial Cell 2 Cell 3	Cell 1-Initial Cell 3 Cell 4 Cell 5
	East	489	563	600 x 1250	Cell 1-Initial Cell 2 Cell 3	Cell 1-Initial Cell 3 Cell 4 Cell 5
	Northwest	0	144	400 x 550	Cell 1-Enlargement	Cell 1-Initial
Topsoil	Northwest	186	229	500 x 700	Cell 1-Initial Cell 1-Enlargement Stockpiles	Cell 1-Initial Cell 1-Enlargement
	East	100	186	500 x 550	Cell 1-Initial Cell 2 Cell 3 Cell 4 Stockpiles	Cell 4 Cell 5

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TABLE 7-1

GROUNDWATER QUALITY PARAMETERS
WHITE MESA URANIUM PROJECT

List A

Aluminum
Ammonia (N)
Arsenic
Barium
Boron
Cadmium
Calcium
Carbonate (CO_3)
Chloride
Chromium
Copper
Fluoride
Iron
Lead
Magnesium
Manganese
Mercury
Molybdenum
Nitrate (N)
Phosphorus (P)
Potassium
Selenium
Silica (SiO_2)
Silver
Sodium
Strontium
Sulfate (SO_4)
Vandium
Zinc
Total Dissolved Solids
Total Suspended Solids
Total Organic Carbon
Alkalinity ($CaCO_3$)
Hardness, Total ($CaCO_3$)
Chemical Oxygen Demand
Redox Potential
pH
Field pH
Field Specific Conductance
Temperature

List B

Natural Uranium (U)
Ra-226
Th-230

List C

Pb-210
Po-210

List D

Calcium
Carbonate
Bicarbonate
Chloride
Magnesium
Potassium
Sodium

List E

Specific Conductance
Alkalinity
Sulfate
pH
Total Dissolved Solids
Gross Alpha Emissions
Gross Beta Emissions

NOTE: All tests are for dissolved concentrations, except Iron and Manganese which are for both dissolved and total concentrations.

273 3489

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TABLE 7-2

EXISTING WELL DATA
WHITE MESA URANIUM PROJECT

WELL DESIGNATION	REFERENCE[1]	DESCRIPTION
SW	Plate 2.6-2, p. 2-1[illegible]	Stock well
SE	Same	Stock well
No Mark (Northwest of the mill site)	Same	--
35	Plate 2.6-3, p. 2-128 Table 2.6-1, p. 2-129	6 inch ϕ, 250 feet deep; domestic, stockwatering.
36	Same	5 inch ϕ, 800 feet deep; irrigation, domestic
37	Same	4.5 inch ϕ, 200 feet deep; stockwatering
G6R	Plate 2.6-10, p. 2-151 Table 2.6-6, p. 2-152	Abandoned stock well
G7R	Same	Abandoned stock well

[1] All references from the Environmental Report (Dames and Moore, 1978)

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TABLE 7-3

OPERATIONAL GROUNDWATER PROGRAM
WHITE MESA URANIUM PROJECT

MONITORING WELLS[1]	SAMPLING FREQUENCY	TESTING PROGRAM FREQUENCY	TESTING PROGRAM PARAMETERS[3]
1; Existing[2]	Quarterly; Semi-annually after 1st year	Quarterly; Semi-annually after 1st year	Lists A and B
		Semi-annually	List C
2; 5	Monthly; Quarterly after 1st year	Monthly; Quarterly after 1st year	Lists B, C, & E
		Annual	List D
		Bi-annually	List A
3; 4	Quarterly	Quarterly	Lists B, C & E
		Annually	List D
		Bi-annually	List A

(1) For location of wells see Sheet 2 Figure 1

(2) For discussion of applicable existing wells see Section 6.2

(3) Parameter lists given on Table 6-1

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D'APPOLONIA

FIGURES

273 352

DRAWN BY D.J.R. 6-6-79 | CHECKED BY CEO 6/6/79 | APPROVED BY MST 6/6/79 | DRAWING NUMBER RM78-682-A4

SCALE

50 0 50 100 MI.

FIGURE 1

273 353

SITE LOCATION MAP

PREPARED FOR

ENERGY FUELS NUCLEAR, INC.
DENVER, COLORADO

REFERENCE: ROAD MAP OF
WESTERN UNITED STATES
SCALE: 1:4,000,000.

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APPENDIX A
CONSTRUCTION DRAWINGS
TAILINGS MANAGEMENT SYSTEM
WHITE MESA URANIUM PROJECT
BLANDING, UTAH

273 355

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GUIDELINE SPECIFICATIONS

INITIAL PHASE CONSTRUCTION
TAILINGS MANAGEMENT SYSTEM
WHITE MESA URANIUM PROJECT
BLANDING, UTAH

273 3517

D'APPOLONIA

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FIGURES

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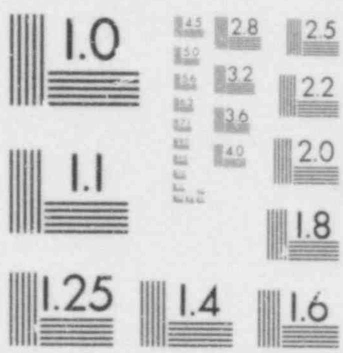
IMAGE EVALUATION
TEST TARGET (MT-3)

6"

IMAGE EVALUATION TEST TARGET (MT-3)



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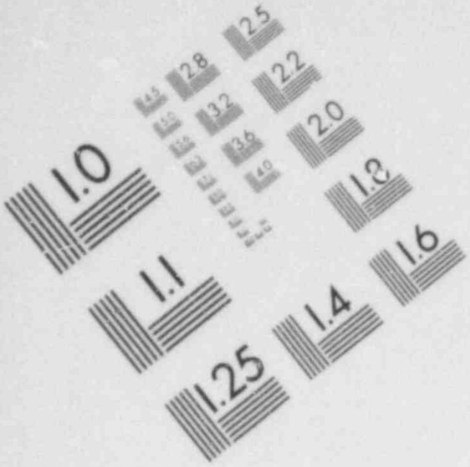

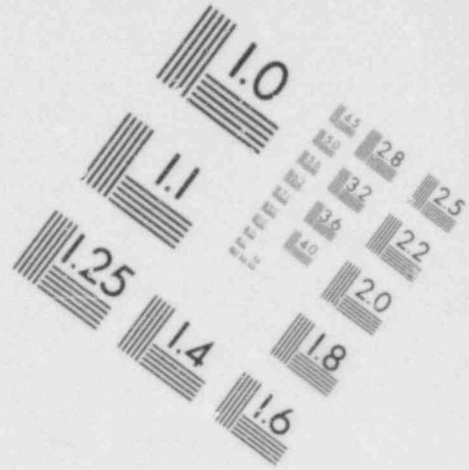

IMAGE EVALUATION
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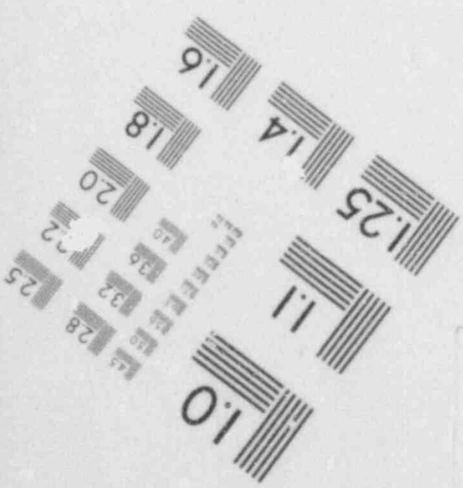
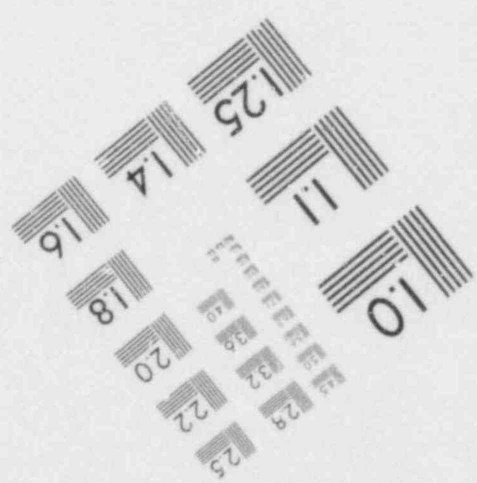
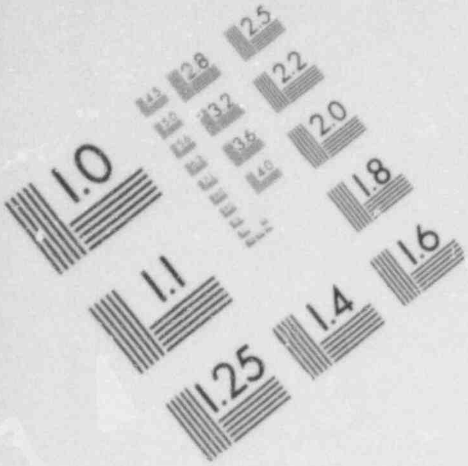






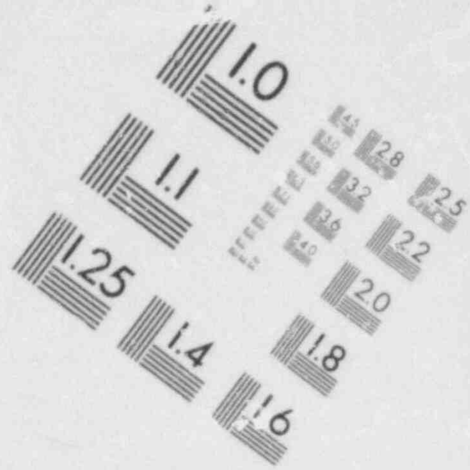
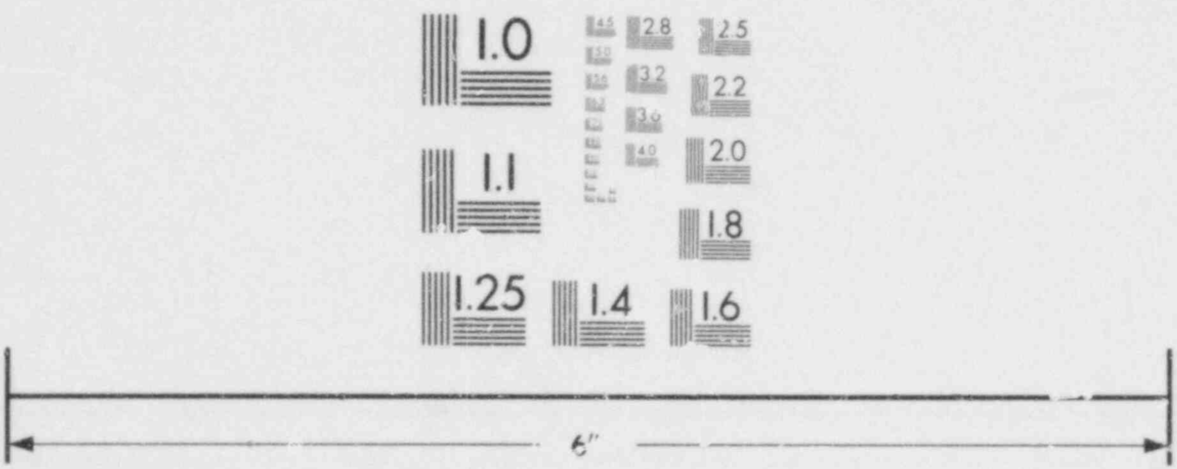
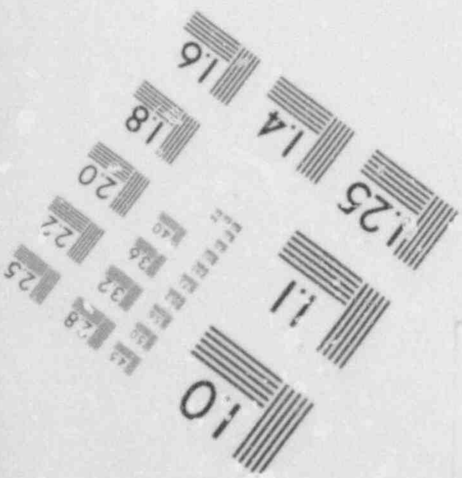
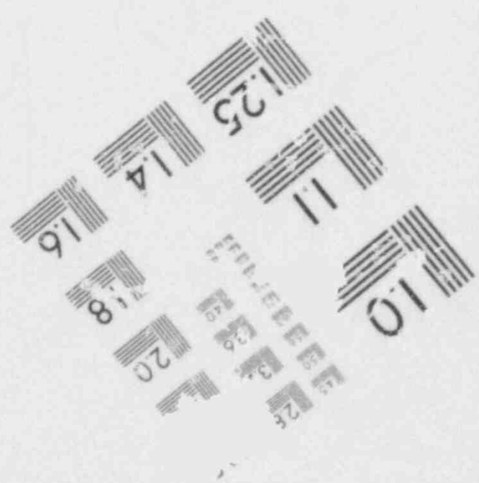


IMAGE EVALUATION
TEST TARGET (MT-3)







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274 002

INTRODUCTION

WORK DESCRIPTION

These Guideline Specifications were prepared for use during the Initial Phase Construction of the Tailings Management System, White Mesa Uranium Project, Blanding, Utah, by Energy Fuels Nuclear, Inc., Denver, Colorado. The initial phase construction consists of the following major items:

- Cell 1 - Initial
- Cell 2
- Surface water diversion ditches
- Mill facilities area sedimentation pond

Specific features, concerning the construction of the above items, that are covered by these Guideline Specifications are:

- Site clearing and grubbing
- Earthwork, soil and rock excavation
- Earthfill and rockfill requirements
- Synthetic lining installation
- Miscellaneous construction items
- Groundwater monitoring well installation

DRAWINGS

The Drawings illustrating the above items and referred to in these Specifications are the 16-sheet set entitled "Construction Drawings, Tailings Management System, White Mesa Project, Blanding, Utah, Issued for Construction June 1, 1979.

DEFINITION OF TERMS

For the purposes of these specifications, the Owner shall mean Energy Fuels Nuclear, Inc., Denver, Colorado. The Engineer shall be a designated representative of the Owner.

SITE CONDITIONS

Conditions at the site and cross sections shall be examined by the contractor and he shall verify to his satisfaction the contours and the character of the earth, rock, water and other items that may be encountered during the execution of this work. The interpretation of the top of rock or other subsurface conditions were determined for design purposes only. Logs from previous borings are available for viewing at the Owners office in Blanding, Utah and in Denver, Colorado.

274 004

SECTION 1

CLEARING AND GRUBBING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The Work covered by this Section consists of furnishing all plant, labor and equipment and performing all operations in connection with clearing and grubbing in accordance with the Drawings and these Specifications.

B. Limits of Clearing and Grubbing

1. The limits for clearing and grubbing shall be five (5) feet outside the limit of work for the construction as indicated on the Drawings, unless an archaeological site exists within this limit, in which case clearing and grubbing shall not be conducted in the archaeological site.

PART 2 - PRODUCTS

Not required

PART 3 - EXECUTION

3.01 CLEARING

A. General

1. Clearing shall consist of the removal and disposition of boulders, trees, brush, down timber, logs, trash and other growth and objects on or above the ground surface. Within the limits of excavation, brush may be removed during the excavation operations. Brush at the top of cut slopes, the roots or parts of which are exposed by the excavation operations, shall be removed completely.

2. Brush, stumps, down timber, and partially buried logs and snags shall be removed completely from all areas to be occupied by fill and these areas shall be stripped. On areas outside of and contiguous to the top of the cut slopes and the toe lines of fill sections, brush shall be cut off and the areas shall be grubbed as specified for areas to be occupied by fill. Cleared material shall be disposed of as specified hereafter. Cleared materials shall not be placed in the fill sections or left on the Work area.

3.02 GRUBBING

A. General

1. Grubbing shall be done in all areas to be occupied by fill. Grubbing shall consist of the removal and deposition of stumps, roots, buried logs, boulders, and other objectionable material below the ground surface. Stumps, roots over 1-1/2 inches in diameter, buried logs and boulders shall be removed completely. Roots 1-1/2 inches and under in diameter shall be removed to a depth of 2 feet below the surface of the ground in the area. Excavations made for removal of stumps, roots, and buried material shall be backfilled to the ground surface with suitable material, and the areas shall be graded to present a neat and pleasing appearance. Within the limits of excavations, grubbing may be done during excavation operations.

3.03 WASTE MATERIAL DISPOSAL

A. General

1. All brush, logs, roots, trash and other combustible debris from the clearing, and grubbing operations shall be disposed of by burning (with an approved permit) and/or hauling to an approved disposal site as designated by the Engineer. No such material shall be placed in the fill sections. All durable stone and boulders from clearing and grubbing may be salvaged for use in construction.

274 006

SECTION 2

EARTHWORK

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The Work covered under this section includes the furnishing of labor, materials, required equipment and performing all operations for the following items of work:

   a. Removal of plants and stripping and stockpiling topsoil, where appropriate.

   b. All excavation, stockpiling, filling and rough grading for site work required by the Drawings and Specifications.

   c. Placing and compacting fills as required.

   d. Placing and compacting synthetic lining subgrade layer as required.

   e. All dewatering and/or diversion required by the Work.

B. Project Survey Layout

1. The project work shall be staked out by a qualified surveyor, including establishing elevations and all other layout work required. He shall also establish a datum point from which all grades are to be taken.

C. Safety Precautions

1. All barricades, fences, red lights, torches and enclosures necessary to protect construction and mill personnel from injury due to the Work set forth herein shall be erected, maintained as required and removed when the need for them no longer exists.

274 007

D. Haul Roads

1. All haul roads or other disturbance to areas outside the limits of the Work shall be carefully planned to avoid archaeological sites as shown on the Drawings, and as may be designated by the Engineer.

PART 2 - PRODUCTS

Not required

PART 3 - EXECUTION

3.01 STRIPPING AND SITE PREPARATION

A. General

1. All topsoil in the area of work shall be stripped to its full depth, where appropriate, and stockpiled in areas as shown in Drawings or as directed by the Engineer, where it will not interfere with the Work. Topsoil shall be reused in reclamation work.

2. Topsoil is defined as that material having a significant organic content which will readily support vegetation and is approximately 12 inches thick at this site.

3.02 EXCAVATION

A. General

1. All open-cut excavations shall be performed to the lines, grades, and dimensions shown on the Drawings or established by the Engineer. All necessary precautions shall be taken to preserve the material below and beyond the lines of all excavations in the soundest possible condition. Where required to complete the Work, all excess excavation and overexcavation shall be refilled with suitable materials acceptable to the Engineer as specified herein.

2. Rock excavation shall be achieved by mechanical means unless blasting of hard lenses or areas of rock is approved by the Engineer. A detailed blasting plan must be submitted to the Engineer prior to issuance of approval for blasting. Furthermore, all blasting shall be conducted in accordance with applicable federal, state, and local laws and regulations.

3. All suitable materials removed from all types of excavations embraced in the Specification shall be used appropriately in the formation of fills, as bedding or cover material for synthetic lining, as reclamation cover material or other uses as indicated on the Drawings or as directed. Material suitability for these various uses is discussed in these Specifications. Materials to be used as reclamation cover shall be placed in designated stockpile areas shown on the Drawings. Materials for lining bedding or cover may be temporarily placed in approved stockpile areas during excavation and later removed for use as required.

4. Excavated material which will be suitable for dike construction or other fills when dry, shall be taken from the excavation, dried, and then placed in the fill area.

5. Where practical, suitable materials shall be excavated separately from unsuitable materials. All materials removed from all excavations which are considered unsuitable shall be disposed of in a suitable manner as discussed in these Specifications.

B. <u>Unsuitable Material</u>

1. Excavated materials shall be considered unsuitable for use in fills or as synthetic lining bedding or cover if they have expansive properties, are highly calcareous, or other unsuitable properties. Clay material shall not be used for lining cover. Materials with these properties may be mixed with other material and used as suitable material only with the approval of the Engineer. Materials not so mixed shall be stockpiled in the soil stockpile area separately from suitable materials. These materials shall be considered suitable for use as reclamation cover.

2. Excavated materials containing rubbish or other foreign material shall be considered unsuitable for any use and shall be wasted as directed by the Engineer.

C. Stockpiling

1. Excess excavated materials or materials considered unsuitable shall be hauled to stockpile areas as shown on the Drawings or as directed by the Engineer. This applies to reclamation cover material and suitable material for other uses as discussed above.

2. Material excavated as rock which breaks down rapidly so it does not meet the requirements for rockfill material shall be considered soil and stockpiled accordingly.

3.03 PREPARATION OF FILL AREAS

A. Stripping

1. The areas to be filled shall be stripped of all topsoil, frozen soil, organic material, rubbish, and other foreign material prior to filling. These materials shall be stockpiled or wasted as directed by the Engineer.

B. Fill Foundations

1. Prior to the placement of any fill the stripped areas shall be inspected by the Engineer for wet materials, soft spots, small local zones or pockets of soft silts or clays, or other unsuitable materials that were not defined during the course of the exploration program. Areas of unsuitable materials shall be overexcavated and replaced with suitable earthfill compacted in accordance with the Specifications. The determination of unsuitable materials shall be made by the Engineer.

3.04 FILLS

A. Earthfill

1. The fills shall be constructed to the lines, grades and cross-sections indicated on the Drawings.

274 010

2. All fills shall be constructed of suitable material from the excavations. All excavated material is considered suitable unless it has unsuitable properties as discussed in Paragraph 3.02. Also, the material shall contain no large rocks, frozen or organic material, topsoil, rubbish or other foreign material.

3. All earthfills shall be compacted as specified in Paragraphs 3.05 or 3.06 depending on type of materials.

4. The distribution of mater' 's throughout the compacted earthfill shall be such that it will be free from lenses, pockets, streaks, and layers of material differing substantially in texture or gradation from surrounding fill material.

5. Where fill is to be placed on natural slopes steeper than one vertical to seven horizontal, the existing slope shall be benched prior to placing fill. The width of any bench should not be greater than 25 feet or less than 5 feet. The width of each bench should be maintained within the specified limits, and the height of the cut face varied in accordance with the slope of the natural ground surface. The height of cut at the face should not exceed 5 feet. The slope of the temporary cut face should be no steeper than one vertical to one horizontal. All benches should be sloped at a minimum of 1 percent away from the cut face to maintain proper drainage.

6. After specified benches have been cut, the fill should proceed. The lowest elevations shall be filled first, in horizontal layers with a thickness no greater than specified limits and sloped to the outer edge of the fill. As each layer is spread it shall be thoroughly compacted with proper rollers. The top and bottom of all fills shall be rounded or eased to form a pleasing transition in change of grade.

7. Particles larger than 5 inches, but less than 10 inches in maximum dimensions shall be worked into the fill in such a manner as will disintegrate friable material and orient and distribute resistant particles to effect a compact well-knit mass with spaces between larger particles thoroughly choke with compact finer

274 011

materials. To aid in accomplishing this, material containing more than 20 percent (by volume) of particles exceeding 5 inches in maximum dimensions, shall be spread in lifts not exceeding 8 inches in thickness (loose measure), and tracked with at least four passes of the treads of a crawler type tractor which, by means of sufficient overlap, will assure complete coverage of an entire layer by the tractor treads. Second and subsequent passes of the treads shall not be made until each pass, as defined above, is completed. If the size and content of resistant particles in the fill material precludes proper compaction, the material shall be disposed of or mixed with finer materials before placement.

8. The fill on each side of structures shall be kept at approximately the same level as placement of the fill progresses.

B. Rockfill

1. The fills shall be constructed to the lines, grades and cross-sections indicated on the Drawings.

2. All required fills shall be free-draining and constructed of suitable materials selected from the excavation.

3. Suitable rockfill materials shall consist of sound, angular rock fragments, reasonably well-graded in size from 3 to 18 inch, minimum to maximum dimension. Material less than the minimum size may be used only in minor amounts to fill voids in the fill and still have a free-draining fill. Material greater than the maximum size shall be moved to the edge of the fill during placement to function as slope protection.

4. The rockfill shall be placed by dumping and spreading in layers not more than 24 inches thick. The material shall be compacted by passes of the spreading equipment as the fill is placed. The layer shall not be excessively compacted so the material on the surface becomes completely broken down into small sizes.

5. The distribution of materials throughout the rockfill shall be such that it will form an interlocking, well-keyed fill with no large voids and be free from lenses, pockets, streaks, and layers differing substantially in texture or gradation from surrounding fill material.

6. The rockfill on each side of structures shall be kept at approximately the same level as placement of the fill progresses.

3.05 COMPACTION SPECIFICATION - EARTHFILL-GRANULAR MATERIAL

A. General

1. All granular fill placed at the site shall be spread in one-foot lifts (loose material) and each lift compacted to 75 percent relative density (ASTM-D2049-69) as defined by:

$$D_D = \frac{E_1 - E_N}{E_1 - E_D} \text{ (percent)}$$

where:

D_D = relative density in percent

E_1 = void ratio of the granular soil in its loosest state (minimum dry density)

E_D = void ratio of the granular soil in its densest state (maximum dry density)

E_N = void ratio of the soil in its natural state

2. All granular fill shall be clean, nonexpansive, free of trash, rubble, debris, frozen, and other foreign materials.

3. For uniformity, a minimum of five passes of a 10-ton vibratory roller or its equivalent shall be required on each lift of fill.

3.06 COMPACTION SPECIFICATION - EARTHFILL-COHESIVE MATERIAL

A. General

1. All cohesive fill placed at the site shall be spread uniformly in six- to eight-inch lifts

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(loose material) and compacted to approximately 90 percent of the Modified Proctor density (ASTM-D1557-70). Upon placement and compaction of a lift of cohesive material, the surface shall be scarified to a depth of 2 inches prior to the placement of the next lift unless the compaction equipment leaves a surface sufficiently roughened to tie the two lifts together. Cohesive earth embankment material shall be compacted at a water content of between 1 and 2 percent above optimum water content as determined by the modified Proctor method (ASTM-D1557-70).

2. All cohesive fill shall be free of trash, rubble, debris, roots, organic, frozen, and other foreign material. Fill shall not be placed on any subgrade that is under water, muddy, frozen, or contains frost.

3. For uniformity, a minimum of four passes of a sheeps-foot or segmented wheel roller in the 20- to 30-ton class shall be required on each lift.

3.07 WORK AREA DRAINAGE

A. Fill Protection

1. To protect the surface of the fill, the top of all fill areas shall be crowned and sealed at the end of each working day to minimize the infiltration of water in the event of rainfall.

2. All fill saturated due to precipitation shall be dried or removed prior to placement of additional fill.

3. All impervious fills which become dried and/or cracked due to exposure, shall be wetted and reworked prior to application of additional fill.

B. Slope Protection

1. As interim protection of the cut and fill slopes, adequate surface drains shall be provided at both the top and bottom of slopes to intercept and conduct runoff from the developed areas and to reduce saturation and erosion of the slopes.

3.08 ACCURACY OF COMPLETED GRADING

A. General

1. The grades as shown on the Drawings or as specified shall be met within 3 inches at the completion of the site grading.

3.09 SYNTHETIC LINING SUBGRADE

A. General

1. The synthetic lining subgrade shall be prepared or placed as specified below after excavations and fills have been completed and approved by the Engineer.

2. The subgrade shall consist of a specially inspected and prepared surface for fill sections and shall consist of a specially placed and compacted bedding layer for excavated sections.

B. Preparation of Subgrade on Fill Sections

1. The fills shall be constructed to the lines, grades, and cross sections indicated on the Drawings and a specified under Section 2, Paragraph 3.04 of these Specifications.

2. The fill surface in areas to be covered by a synthetic lining shall be free from loose earth, ruts, sharp breaks in slope, rubbish, roots, vegetation or other foreign material, and all cobbles or rock fragments protruding from the final smooth surface.

3. All areas that do not meet these requirements shall be corrected to the satisfaction of the Engineer.

4. The fill surface shall be maintained in an acceptable condition during installation of the synthetic lining. Any areas that are disturbed shall be corrected prior to lining installation in that area.

274 015

C. Preparation and Placement of Subgrade on Excavated Sections

1. The excavations shall be constructed to the lines, grades, and cross-sections indicated on the Drawings and as specified in Section 2, Paragraph 3.02 of these Specifications.

2. The excavated surface in areas to be covered by a synthetic lining shall be free from all loose earth and rock fragments over 6 inches in size, rubbish, roots, vegetation, or other foreign material. The excavated surface shall also be free from sharp breaks in slope and shall be fairly smooth with no pieces or fragments protruding more than 4 inches from the general plane of excavation.

3. A bedding layer 6-8 inches, compacted thickness, consisting of suitable earthfill material from the excavations, shall be placed on the prepared excavated surface.

4. Suitable bedding material shall consist of material meeting the requirements of suitable earthfill as specified in Section 2, Paragraph 3.04 of these Specifications. In addition, suitable bedding material shall contain no calcareous soils or pieces 3 inches in size or larger.

5. The bedding layer shall be placed and compacted as specified in Section 2, Paragraph 3.05 or 3.06 of these Specifications.

6. The compacted bedding layer shall meet the requirements for subgrade on fill sections as specified under the previous Item B.

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SECTION 3

SYNTHETIC LINING

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The work covered under this section includes the furnishing of all labor, materials, and equipment to perform all operations required under the following items of work:

   a. Provide a technical representative experienced in PVC lining handling and installation.

   b. Installation of the synthetic lining.

   c. Digging of the anchor trenches.

   d. Placement of lining cover material.

PART 2 - PRODUCTS

2.01 SYNTHETIC LINING

A. General

1. The synthetic lining shall be manufactured from sheet roll goods, factory fabricated into large panels for field seaming into a single impermeable tailings cell lining. The lining shall be made from the highest quality materials and manufactured, fabricated and installed by qualified, well known companies.

B. Lining Material Requirements

1. The lining shall be manufactured from domestic virgin polyvinyl chloride (PVC) resin. Reprocessed PVC material will not be permitted.

2. The lining shall be manufactured from calendered rolls of PVC sheeting a minimum of 54 inches wide, specifically compounded for use in hydraulic facilities and specially resistant to sulfuric

274 017

acid solutions. The sh ting shall be manufactured by a reputable, well known manufacturer and shall be free of pinholes, undisposed raw materials, or blisters or other defects.

3. The lining shall be 30 mil (0.030 inch) nominal thickness. It shall be black to dark gray in color and of uniform shade throughout.

4. As a minimum, the following information shall be supplied from the lining manufacturer.

    a. Manufacturer's name

    b. Manufacturer's experience with PVC

    c. Width of calendared rolls

    d. Physical properties (average value and standard deviation) of 30 mil PVC listed in Table 1.

C. Fabricated Lining Requirements

1. The lining shall be fabricated into large panels by a reputable, well known lining fabricator.

2. The panels shall be as large as practical to minimize field seaming but not inhibit installation from excessive panel weight or size.

3. The factory fabrication shall be done under strict quality control conditions with a seaming method that produces a sheet tearing bond of at least 80% sheet strength.

4. As a minimum the following information shall be supplied from the lining fabricator:

    a. Fabricator's Name

    b. Fabricator's experience with PVC.

    c. Method of Factory Seaming

    d. Width of Factory Seam

    e. Tear Strength of Factory Seam

    f. Physical properties (average and standard deviation) of 30 mil PVC listed in Table 1.

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TABLE 1

30-mil PVC LINING PHYSICAL PROPERTIES

PROPERTY	UNITS	TEST METHOD
Thickness (min. & max.)	inches	ASTM D-1593
Specific Gravity	--	ASTM D-792-A
Tensile Strength	pounds/inch	ASTM D-882, Method A
Maximum Elongation	percent	ASTM D-882 Method A
Modulus at Max. Elongation	pounds/inch	ASTM D-882 Method A
Graves Tear	pounds	ASTM D-1004
Elmendorf Tear	grams	ASTM D-1922
Cold Crack	°F	ASTM D-1790
Dimensional Stability	percent	ASTM D-1204
Water Extraction	percent	ASTM D-1239
UV Resistance	hours	--
Volatility	percent	ASTM D-1203

PART 3 - INSTALLATION REQUIREMENTS

3.01 INSTALLATION SUPERVISOR

A. General

1. A technical representative from the lining fabricator or installer shall be present at all times during the installation of the lining. The representative shall be experienced in the proper handling, preparation, and installation methods for PVC lining.

B. Duties

1. The technical representative shall supervise all aspects of the lining installation including but not limited to, storage, handling, spreading, seaming, anchoring and covering.

2. The representative shall provide expert advice and recommendations to the Engineer concerning lining subgrade preparation, and other lining aspects. Field inspection of earthwork items associated with the lining shall be required as requested by the Engineer.

3.02 LINING SUBGRADE

A. General

1. The synthetic lining subgrade for fill and excavated sections shall be prepared or placed as specified in Section 2, Paragraph 3.09 of these Specifications.

2. The prepared subgrade surface shall be inspected by the Engineer and the technical representative and approved by the Engineer prior to placement of lining on that surface.

3.03 LINING HANDLING

A. Packaging

1. The fabricated lining panels shall be packaged, by the fabricator, such that damage during shipment, handling, or storage is prevented. Packaging shall prevent damage by any physical, chemical, and environmental means.

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B. On-Site Storage

1. The lining shall be stored as necessary such that damage will not occur.

2. The lining shall be kept at temperatures above 50°F and out of direct sunlight except for short time periods unless covered by protective material.

3.04 LINING INSTALLATION

A. General

1. The fabricated lining panels shall be handled such that no damage to them will occur. The panels shall be inspected prior to placement within the cell for damage. Damaged panels shall not be placed within the cell.

2. The panels shall be located and distributed within the cell to minimize excessive lining handling and movement during spreading and seaming.

3. The lining shall be placed and spread only on subgrade surfaces that have been inspected and approved by the Engineer.

4. No lining installation shall be permitted during cold weather or high winds. No field seaming shall be permitted during any precipitation.

B. Field Seams

1. The method and procedure for field seams joining factory fabricated lining panels shall be specified by the lining installer and approved by the Engineer.

2. Field seams shall be made only on lining surfaces that are cleaned of dirt, dust, moisture, or other foreign matter. The seaming shall be made on a firm surface with the lining manufacturer's approved adhesive. Adequate adhesive shall be used to completely seal the edges of the seam.

3. Seaming when the air temperature is 50°F or below shall be by special methods and with the approval of the Engineer only. No seaming shall be permitted when the air temperature is below 35°F.

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4. All field seams shall provide a film tearing bond of at least 80% of the tear strength of the parent material. All field seams shall be inspected and approved by the Engineer. Seams not approved shall be repaired to the satisfaction of the Engineer.

C. Joints to Structures

1. Lining joints to structures shall be made where indicated on the Drawings.

2. The joints shall be made with the manufacturer's approved adhesive.

3. The method of joining shall be supplied by the installer and approved by the Engineer.

D. Anchor Trenches

1. The lining shall be installed in anchor trenches as shown on the Drawings. The trench locations shall be marked by others.

2. The installation of the lining in the anchor trenches shall be inspected and approved by the Engineer.

3. The trenches shall be backfilled with suitable material as specified for the lining bedding and compacted as specified for the lining bedding.

E. Installation Restrictions

1. No lining panels shall be spread out without adequate control for wind.

2. Lining panels that will not be seamed together during that day's operation shall not be spread out without prior approval of the Engineer.

3. No lining shall be spread during high wind conditions or cold weather.

4. No lining shall be driven upon without the cover material in place.

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3.05 LINING COVER

A. General

1. Lining cover consisting of suitable earth materials from the excavation shall be spread over the installed lining as shown on the Drawings.

2. Suitable cover shall consist of soil material obtained from the excavation. It shall not contain any pieces over 3 inches in size nor any sharp, angular pieces or other foreign objects. It shall meet the requirements of the earthfill as specified in Section 2, Paragraph 3.04 of these Specifications.

3. The cover shall be placed as soon as practical over completed areas of the lining.

4. The cover shall be a minimum of 12 inches compacted thickness on the cell bottoms and 18 inches compacted thickness on the side slopes.

5. The cover shall be spread and compacted by the earth moving equipment with care to avoid damage to the lining.

6. Any damage to the lining shall be repaired immediately and to the satisfaction of the Engineer.

PART 4 - QUALITY CONTROL AND ASSURANCE

4.01 QUALITY CONTROL

A. Lining Tests

1. Lining tests specified on Table 1 shall be conducted on the fabricated lining for each 250,000 $ft.^2$ of panel(s) fabricated.

2. The results of these tests shall meet or exceed the lining specifications supplied by the manufacturer and fabricator under Section 3, Paragraph 2.01 or that panel(s) of lining will be rejected.

3. The test results shall be identified by a unique designation to the panel(s) from which the tested material was taken.

4. The test results shall be supplied to the Engineer prior to the installation of the lining.

B. Field Seam Testing

1. A sample of the field seam shall be cut from the installed lining for each 100,000 ft.^{2} of lining installed. The sample shall be tested immediately for tear strength as specified in Table 1.

2. The test results shall be supplied to the Engineer within 2 days of the test.

3. Any test which does not meet or exceed the specifications shall result in the area of that sample being reseamed. Also, additional test samples for every 50,000 ft.^{2} of lining installed shall be taken and tested for tear strength as specified in Table 1.

4. Placement of the lining cover shall not be delayed awaiting seam test results. Seams that fail the test will require removal of the cover to repair.

C. Fabricated Lining Samples

1. The lining fabricator shall supply a sample of the fabricated lining containing at least one seam for each 250,000 ft.^{2} of lining fabricated.

2. The sample shall be at least six foot square and shall be clearly marked by a unique designation identifying which panel the sample is from.

4.02 QUALITY ASSURANCE

A. Lining Guarantee

1. The lining manufacturer shall supply pertinent information regarding the material guarantee of its product.

2. The lining fabricator shall supply pertinent information regarding the material and workmanship guarantee of its product.

3. The lining installer shall supply pertinent information regarding the workmanship guarantee of its product.

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B. Test Results

1. All lining tests shall be conducted by a qualified laboratory or personnel approved by the Engineer.

2. All test procedures and methods shall be reported as part of the test result.

3. As a minimum, the test results shall be signed, dated, and uniquely identified to the lining from which the test sample was taken.

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SECTION 4

APPURTENANT FACILITIES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The work covered under this section includes the furnishing of all labor and materials to install or complete the following Work items:

a. Installing the slimes pool drain system to the limits as shown on the Drawings.

b. Installing the pipe trenches as shown on the Drawings.

c. Placing riprap as required by the Engineer.

d. Applying soil stabilizer to completed excavation and fill slopes as required by the Engineer.

PART 2 - PRODUCTS

2.01 SLIMES POOL DRAIN SYSTEM

A. Drain Pipes

1. The drain pipes shall be polyvinyl chloride (PVC) plastic pipe in the sizes as shown on the Drawings. The pipe shall be Schedule 40, PVC 1220 (Type I, Grade 2) according to ASTM 1785 or equivalent as approved by the Engineer.

2. Slotted lengths of the pipe, as indicated on the Drawings, shall be factory slotted with 0.040 inch wide slots, on approximately 0.25 inch spacings along the pipe, in 3 rows equally spaced around the pipe circumference.

B. Drain Pipe Riser

1. The drain pipe riser shall be Driscopipe 7600, Low Pressure, industrial pipe or equivalent as approved by the Engineer. The pipe shall be 24 inch nominal size.

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C. Drain Filter Material

1. The drain filter material shall be clean, sound sand meeting the requirements and gradation for Fine Aggregate in ASTM C 33 with the following limits:

Sieve Size	% Passing by Weight
3/8 inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

2.02 PIPE TRENCHES (Details to be supplied by the Owner)

A. Grating

1. The pipe trench grating shall be heavy duty steel grating designed to support the maximum loading specified by the Engineer. The width of the grating shall be specified by the Engineer.

B. Concrete

1. The pipe trench concrete shall meet the specifications in Paragraph 2.03. Reinforcement, however, shall be designed depending on the maximum loading specified by the Engineer.

2.03 CONCRETE AND REINFORCING STEEL

A. General

1. Concrete, reinforcing steel, forming, pouring, finishing, and curing for the concrete drain pipe riser base, pipe trenches, and other miscellaneous items shall conform to the requirements set forth herein.

B. Materials

1. The Portland Cement shall conform to ASTM C-150-77 specifications for Type V Portland Cement. The actual mixed proportion of cement, aggregates and water shall be determined by the Engineer.

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C. Forming

1. Forms shall be provided that are true, rigid and thoroughly braced. The forms shall be sufficiently strong to carry the dead weight of the concrete without excessive deflection and tight enough to prevent leakage of mortar through cracks and joints.

D. Reinforcing Steel

1. Reinforcing steel shall consist of No. 4 bars conforming to ASTM specifications (A 615, A 616, or A 617). All reinforcement shall be free from heavy rust, grease, dirt, oil or other debris that will interfere with the concrete to steel bond.

2. The reinforcement shall not have less than 3 inches between it and the outside concrete surface.

2.04 RIPRAP

A. Materials

1. Riprap shall consist of fragements of hard, sound, abrasion resistant rock. The size distribution of the rock fragments shall be such that a well-keyed, dense layer of riprap may be placed. The maximum size shall be 12-inch diameter. Rock from the excavations may be used as approved by the Engineer.

2.05 SOIL STABILIZER

A. General

1. The soil stabilizer shall be a chemical spray soil binder such as Aerospray 70 or 52, or equivalent as approved by the Engineer.

PART 3 - CONSTRUCTION REQUIREMENTS

3.01 SLIMES POOL DRAIN SYSTEM

A. General

1. The slimes pool drain system shall be installed to the limits as shown on the Drawings.

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Modifications to the installation may be made in the field by the Engineer.

2. The system shall be installed only on completed cell surfaces that have been inspected and approved by the Engineer.

B. Drain Pipes

1. The drain pipes shall be installed as shown on the Drawirgs. The PVC pipes shall be joined together with an approved adhesive employing manufacturer and Engineer approved methods and procedures. Appropriate fittings, including end caps and T-sections, shall be used to join pipe sections together.

2. The drain pipes shall be located on the completed cell surface so they will flow to the drain pipe riser. The filter material shall be placed, but not compacted, around the slotted pipes sections as shown on the Drawings.

C. Drain Pipe Riser

1. The drain pipe riser shall be installed as shown on the Drawings. The concrete base shall be placed according to the specifications in Paragraph 3.02, Item B of these Specifications. The riser shall be placed vertically on the base and the contact area between the riser and base sealed with an approved sealant or patching as required.

2. The drain pipes shall be inserted into the riser by cutting holes in the required locations. The opening around the installed pipes shall be closed with an approved sealant or patching as required.

3. The riser shall be supported in a vertical position as fill is placed around it. The fill surface shall be kept at about the same level around the pipe as the fill is placed to avoid unequal side loads on the riser. The riser may be cut into sections to facilitate installation, with the approval of the Engineer.

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3.02 PIPE TRENCHES

A. General

1. Pipe trenches shall be installed as shown on the Drawings or as required by the Engineer.

2. The pipe trenches shall be a maximum of 1.5 feet deep as shown on the Drawings, however, the other design details shall be specified by the Engineer.

3. Where appropriate an additional layer of synthetic lining shall be placed over the cell synthetic lining to protect it from the concrete pipe trench.

B. Concrete

1. Placing

Prior to the placement of concrete, the subgrade shall be thoroughly dampened to prevent the escape of moisture from the concrete into the subbase. The concrete shall be deposited in the forms as near to its final position as possible. Under no circumstances shall the agitation from the vibrator be used to move concrete laterally in the form.

Concrete shall be placed in layers not more than 24 inches in thickness. Each layer shall be thoroughly agitated by a vibrator. The vibrator, when used, shall be raised and lowered, always in a vertical position, and the vibrating head shall be allowed to penetrate and vibrate the concrete in the upper portion of the underlying layer. At no time shall the vibrator be permitted to lay in a horizontal position. Layers of concrete shall not be placed until the layers previously placed have been worked thoroughly as specified.

Concrete shall be protected against adverse weather conditions in accordance with "Recommended Practice for Cold Weather Concreting," ACI 306 and "Recommended Practice for Hot Weather Concreting," ACI 605. Accelerators, such as calcium chloride, shall not be used unless specifically approved.

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2. Curing

After finishing, curing shall be done by keeping the concrete moist and at a temperature above 50 degrees and below 100 degrees for one week. Liquid, membrane-forming, curing compounds may be used in lieu of moist curing when approved or directed, and shall be applied to exposed surfaces of formed concrete and to finished surfaces at conclusion of finishing.

3. Finishing

Any small surface voids which may appear upon removal of the forms, and holes due to form ties shall be thoroughly cleaned of all loose or defective material, flushed with water, and immediately filled with a nonshrink cement mortar.

Any fins or projections which may occur shall be removed and the area rubbed smooth and finished with a wooden float in a neat and workmanlike manner. Plastering of the surface with cement grout shall not be permitted. A smooth finish is of great importance where the liner is to be sealed against the drain pipe riser base.

4. Joints

Construction joints shall be located only at points shown on the Drawings or as directed or approved by the Engineer. They shall be so located as not to impair the strength of the structure, and so as to least impair its appearance. All construction joints shall be keyed.

5. Placement of Reinforcing Steel

Fabrication shall be accurate and to the dimensions specified by the Engineer. Stirrups and ties shall be bent around a pin having a diameter at least twice the bar diameter. All other bars shall be bent around a pin having a d[illegible] of at least six times the diameter of the bar. All bars shall be bent cold.

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The reinforcement shall not have less than 3 inches of concrete between it and the outside concrete surface.

All reinforcing shall be free from heavy rust, grease, dirt, oil or other debris that will interfere with the concrete to steel bond.

Reinforcing steel shall be installed in accordance with ACI-318-71 Specifications. All bars shall be lapped a minimum of 24 diameters.

3.03 RIPRAP

A. Placement

1. Riprap shall be placed in ditches or other areas as required by the Engineer. The riprap shall be placed on a well compacted subgrade.

2. The riprap shall be spread in a single lift. After placement, the riprapped surface shall appear well graded with the voids choked with smaller cobbles and stones. The smaller size riprap shall be placed against the slope to avoid migration of fines through the riprap.

3.04 SOIL STABILIZER

A. Application

1. The soil stabilizer shall be mixed with water to a concentration for spray application according to the manufacturers recommendations.

2. The stabilizer shall be applied to completed excavation and fill slopes, to minimize erosion as directed by the Engineer.

3.05 CLEAN-UP

A. General

1. After the earthwork and construction specified herein is complete, the work area shall be cleaned up and any excess construction materials removed from the site or stored as designated by the Engineer. Disturbance to the work area shall be minimized by removing any excess fill or spreading it to maintain a uniform contoured surface. Haul roads and other disturbed areas

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outside the construction limits shall be regraded and revegetated to minimize surface disturbance.

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SECTION 5

GROUNDWATER MONITORING WELLS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Scope of Work

1. The Work covered under this section includes the furnishing of all labor and materials to install the groundwater monitoring wells shown on the Drawings and attached Figures B1-B3, and as required by the Engineer.

PART 2 - PRODUCTS

2.01 WELLS

A. Well Pipe

1. Well pipe shall be polyvinyl chloride (PVC) plastic pipe in sizes as shown on the Figures. The pipe shall be Schedule 40, PVC 1220 (Type I, Grade 2) according to ASTM 1785 or equivalent as approved by the Engineer.

2. Slotted pipe sections shall be factory produced with a 0.045 inch slot width, on 0.25 inch spacings, in 3 rows equally spaced around the pipe circumference.

PART 3 - INSTALLATION

3.01 DRILLING

A. General

1. The well locations shall be specified by the Engineer.

2. The holes shall be drilled with the diameters shown on the Figures. All drilling shall be conducted with air, foam, or degradable organic polymer, drilling mud as approved by the Engineer.

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3.02 WELL INSTALLATION

A. General

1. The wells shall be installed as shown on the Figures a' ' under the direction of the Engineer or their designated representative.

B. Casing

1. The casing shall be PVC plastic pipe. The driller shall have approved elevators and slips manufactu. ed for use with PVC pipe in the sizes specified.

2. The casing shall be joined by approved adhesive and allowed to set for sufficient time to support the weight of the casing. If screws are used for additional support, they shall not penetrate the interior of the casing. Each joint shall be inspected by the Engineer before lowering into the hole.

C. Fittings

1. Fittings, such as centralizers and cement baskets shall be attached at locations as directed by the Engineer. These fittings shall be secured so they do not slide on the casing.

D. Gravel Packs

1. Gravel packs shall be installed by pouring at a slow rate, as directed by the Engineer, from the surface.

E. Bentonite Seals

1. The annular space shall be sealed by placement of a sand pad on the cement basket. After placement of the pad, as directed by the Engineer, bentonite balls shall be placed and compacted with a tamper in lifts no greater than 6 inches.

F. Grout Seals

1. All grout seals shall be neat cement with a weight of 15.5 pounds per gallon. The grout shall be placed by pumping through a tremmie tube, as approved by the Engineer.

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G. Protective Pipe

1. The protective pipe shall be installed over the end of the well casing PVC and cemented into the surface seal. The pipe shall be fitted with a locking cap.

3.03 WELL DEVELOPMENT

A. General

1. The deep monitoring wells shall be air lift pumped or bailed until the water is clear, as approved by the Engineer.

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DRAWN BY	D.J.P.	CHECKED BY	CGD	5/23/79	DRAWING NUMBER	RM78-682-A1
	4-19-79	APPROVED BY	[illegible]	5/31/79		

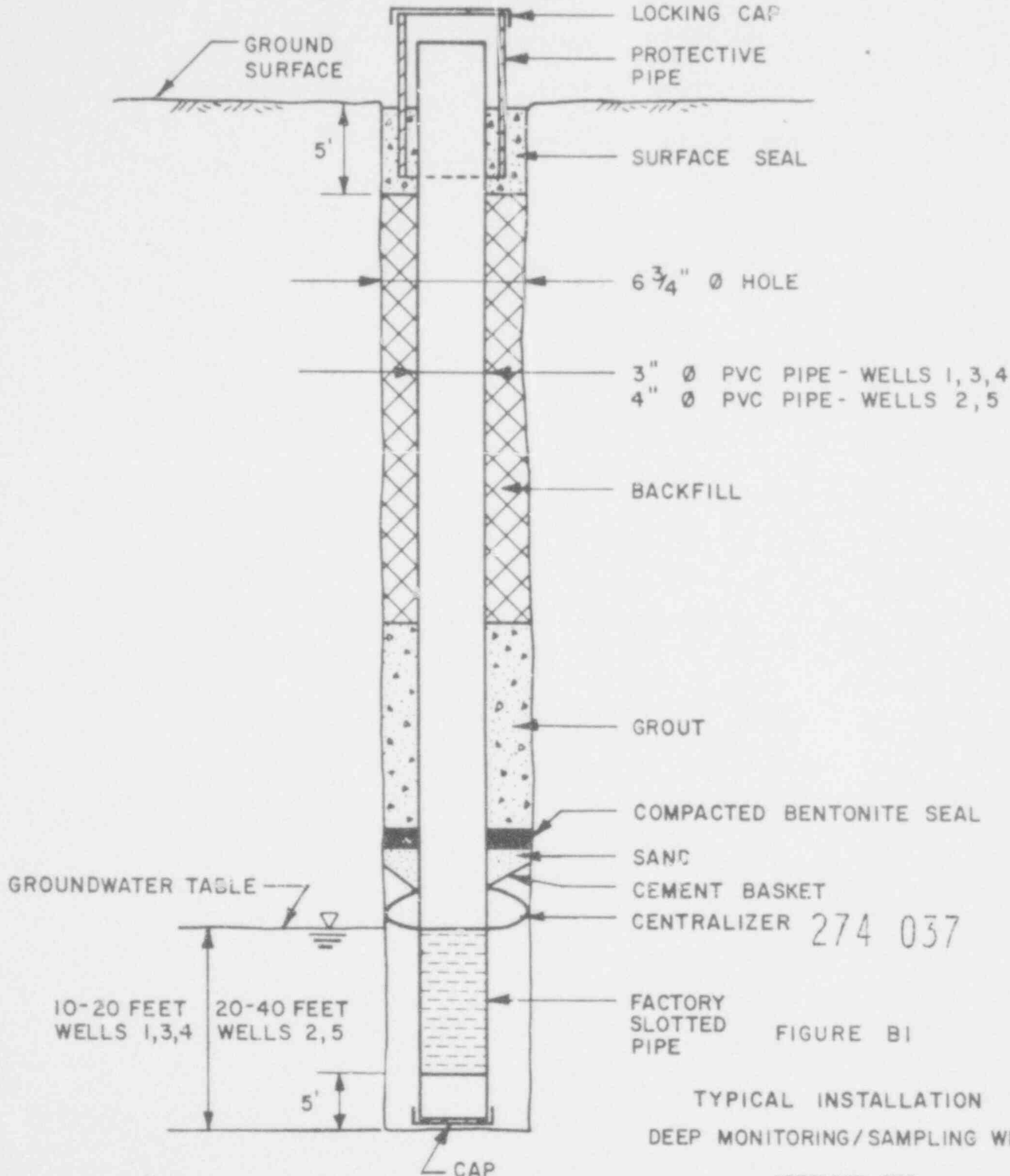

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FIGURE B1

TYPICAL INSTALLATION
DEEP MONITORING/SAMPLING WELL

PREPARED FOR

ENERGY FUELS NUCLEAR, INC.
DENVER, COLORADO

D'APPOLONIA

"NOT TO SCALE"

DRAWN BY: B.K.H. 4-19-79 | CHECKED BY: SEO 5/23/79 | APPROVED BY: MJT 5/30/79 | DRAWING NUMBER: RM78-682-A3

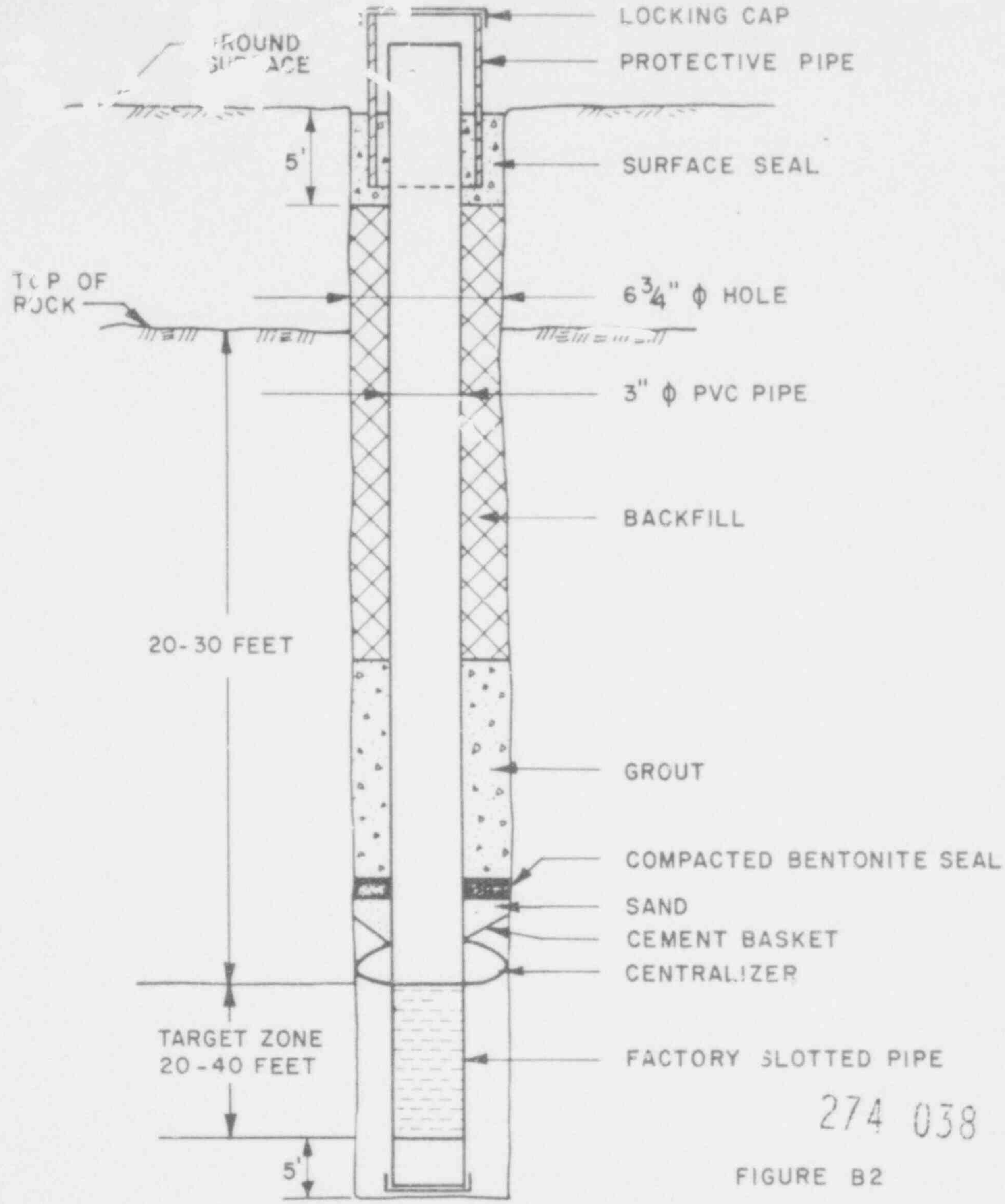

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FIGURE B2

TYPICAL INSTALLATION
INTERMEDIATE DEPTH
MONITORING WELL

PREPARED FOR

ENERGY FUELS NUCLEAR, INC.
DENVER, COLORADO

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