40-8903

HOMESTAKE

RECLAMATION PLAN

REVISION 10/93

HOMESTAKE MINING COMPANY

OF CALIFORNIA

GRANTS OPERATION

VOLUME 1

TEXT, TABLES, AND FIGURES

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TABLE OF CONTENTS

VOLUME 1

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 General

This plan describes the designs, activities, schedule, and estimated costs of reclaiming Homestake Mining Company of California's (HMC's) Grants uranium mill site. It was prepared originally (January 1991) in accordance with pertinent federal regulations, guidelines and standards as well as those sound technical practices not addressed by regulation. Specifically, this plan has been prepared to comply with the requirements of 10 CFR 40, Appendix A, 1-1-89 Edition (NRC, 1989A). Other specific requirements or guidelines developed by or for the Nuclear Regulatory Commission (NRC) have also been used in the preparation of this plan and are referenced as appropriate in the following sections. This current revision (10/93) also includes relevant portions of HMC's License No. SUA-1471 Amendment 15, of 8/25/93, in accordance with the requirements of License Condition 37H.

This plan has been prepared by sections that generally correspond to the subdivisions of the NRC's "Recommended Outline for Site-specific Reclamation and Stabilization Cost Estimates" (NRC, 1988). The following portions of Chapter 1.0 describe the Homestake Grants Operation site and the history of its operation. Chapter 2.0 describes the plans for decommissioning the mill facility and includes sections describing the health and safety plan (2.1), decontamination (2.2), mill demolition (2.3), mill area cover and grading (2.4), and contaminated soil clean-up (2.5). Chapter 3.0 describes the radiological surveys associated with the reclamation process. Sections of this chapter address the soil radium and gamma surveys performed before, during and after contaminated soil clean-up, as well as radon flux measurements performed after radon barrier construction. Chapter 4.0 describes the restoration of the tailing impoundments, including interim stabilization (4.1), long-term stabilization (4.2), revegetation and fencing (4.3), and other restoration and protection measures (4.4). Chapter 5.0 describes the ground water restoration and monitoring program in summary form; the complete ground water restoration plan has been prepared and submitted under separate cover. Chapter 6.0 addresses post-closure care and monitoring. The schedule for site reclamation is discussed in Chapter 7.0, and the estimated costs are addressed in Chapter 8.0.

1.2 Site Description

The Homestake uranium mill is located approximately 5.5 miles north of Milan, New Mexico in Section 26, Township 12 North, Range 10 West, in Cibola County (Figure 1). Homestake's Mine Ion Exchange (IX) plant was located in the southwestern part of McKinley County, New Mexico in the Ambrosia Lake area adjacent to Homestake's mine facilities approximately 18 miles northwest of Grants, New Mexico in Section 25, Township 14 North, Range 10 West. The IX plant was disassembled in 1992 and transported to the mill site for subsequent burial and the five-acre plant site has been reclaimed.

The facilities that existed at the mill site at the time of the current revision (10/93) of this plan are illustrated on Figures 2 and 3 and listed in Table 1. During mill operations, ore was stockpiled at the ore pad north of the mill after being weighed on the receiving scale. These two components made up the ore receiving section. Ore was passed through the Crushing and Sampling Section, consisting of a grizzly impact breaker, rotary dryer and reciprocating samplers. Crushed ore was temporarily stored in the fine ore bins. Ore was passed through the Grinding Section, consisting of two ball mills and thickener tanks into the Uranium Leaching Section and then through the Precipitation Section. Uranium and vanadium were removed before packaging, storage and shipping. The mill site also contains a variety of miscellaneous structures needed to support and manage the milling operations. The solid byproduct material, mill tailings, was transported by slurry pipeline initially to a small tailing impoundment located southwest of the main mill facility and, subsequently, to a large tailing impoundment located directly west of the main mill facility.

1.3 History of Operations

The Homestake mill was a major producer of uranium concentrate from 1958 until 1990. Homestake's milling facilities were constructed and originally operated as two distinct partnerships, with Homestake Mining Company acting as the managing partner of both. The larger of the two mills was organized as Homestake-Sapin Partners, with a nominal milling capacity of 1750 tpd. The smaller mill was organized as Homestake-New Mexico Partners, with a nominal milling capacity of 750 tpd. Both mills were designed to be alkaline leach-caustic precipitation processes for concentrating uranium oxide from ores with average grades of 0.05 to 0.30% U_3O_8. Combining these two milling facilities in 1961 resulted in a mill with a nominal through-put capacity of 3400 tpd.

The Homestake-New Mexico Partners Mill commenced operations in April, 1958, while the Homestake-Sapin Partners Mill started up in May, 1958. Both mills operated independently, each with its own tailing impoundments, until November 9, 1961, when the partnerships were merged. Homestake-Sapin Partners was the surviving organization.

In January, 1962, the former New Mexico Partners Mill ceased operations as a complete and independent mill. The Sapin Partners Mill continued to utilize a portion of the smaller mill's facilities. In April, 1968, through a change in the distribution of ownership, Homestake-Sapin Partners became United Nuclear Corporation's interest, and the operation became United Nuclear-Homestake Partners. United Nuclear's interest was purchased by Homestake in March, 1981, and the operation became Homestake Mining Company-Grants.

Two tailing impoundments were developed on HMC's property. In December, 1956, the U.S. Atomic Commission (AEC) and Homestake-New Mexico Partners signed a contract for the delivery of yellowcake to the federal government. The second contract was signed with the AEC in 1961 for the delivery of additional yellowcake. Subsequently, HMC produced yellowcake for the AEC under four additional contracts. The first and smaller of the two impoundments resulted entirely from these contracts with the federal government. The total quantity of tailings placed in this first impoundment was 1.22 million tons. It is located in the S.W. 1/4 of Section 26, Township 12 North, Range 10 West, NMPM. Tailing material deposited within this impoundment was contained entirely by an embankment composed of compacted natural soils. The embankment was compacted by heavy equipment and brought to a height of 20-25 feet. The crest was a minimum of 10 feet wide, with the base being approximately 40 feet wide. The impoundment covers an area of about 40 acres. In 1990, an evaporation pond was constructed in this impoundment to assist in the dewatering of the large tailing impoundment and to hold water pumped from the collection wells of the ground water restoration plan. After ground water restoration is completed (10-15 years), the evaporation pond and small impoundment will be reclaimed as discussed is Section 4.2.2.

The larger of the two impoundments, located in the N 1/2, Section 26, Township 12 North, Range 10 West, NMPM resulted from production under both federal government and commercial contracts. Homestake-Sapin Partners and the AEC entered into a contract to deliver yellowcake to the federal government in April, 1957. Two other contracts were signed with the AEC in 1960 and 1961. In addition, numerous contracts were placed with electric utilities for nuclear reactor fuel production. The total quantity of tailings generated under AEC contracts was 13.45 million tons. In addition, another 7.6 million tons of commercial tailings were generated and comingled with the AEC tailings. Until 1966, HMC deposited tailing material into only one cell of the large impoundment. Subsequently, HMC added an additional cell adjacent to and west of the existing cell. Since that time tailing disposal has been alternating between the two cells (east and west) whenever necessary to maintain optimal operating conditions. The starter dike for the large impoundment was constructed in compacted six-inch lifts of natural soils excavated within the tailing area. The dike was constructed to a height of about 10 feet and a width of about 10-15 feet at the top and 25-30 feet at the bottom. The impoundment was built out by centerline method until 1981, when an inboard offset of the crest was made to improve stability conditions of the impoundment. Successive lifts were added by centerline method to the offset crest dike around the entire circumference of the impoundment. Throughout its operation the large impoundment was operated with a two-cell configuration. The impoundment presently covers approximately 170 acres and is approximately 85-100 feet high. The east and west ponds cover approximately 55 and 40 acres, respectively, as measured from the crest centerline.

Throughout most of its operation, the large impoundment was constructed by splitting the slurried mill tailings into coarse and fine fraction using a cyclone separator. The coarse fraction was hydraulically placed along the centerline and outslope to build out the impoundment by the centerline method. The fine split of tailings was discharged across the beach toward the pond. Mill tailings are composed of uranium-depleted fine and coarse sand fractions and slimes consisting of -#200 mesh-sized materials. The clarified liquid that was discharged into the ponds was recycled through decant towers back to the mill for reuse as process water. During the latter stages of mill operations, when production rates were low, cyclone separation was not used and the tailing slurry was discharged directly across the beaches into the tailing pond. This method of operation confined disposal to a single pond at a time, with the other pond used for evaporation as needed. To date, the large tailing impoundment has received 21.05 million tons of tailings. HMC discontinued milling operations in February, 1990 and has no plans to resume operations of the tailing impoundments. HMC performed mill washdown and other cleaning activities in preparation for reclamation, which is expected to follow the schedule shown on Table 2.

During the last years of mill operations, the placement and maintenance of tailings were performed in accordance with the Tailings Management Plan (D'Appolonia, 1982). This plan specified practices which assured compliance with the NRC Regulatory Guide 3.11 and 3.11.1 (NRC, 1977), as well as New Mexico State Engineer requirements. At least 5 feet of freeboard and 50 feet of beach width were maintained at all times. The piezometric levels and movement monitoring points of the tailing embankment were surveyed on a regular basis. Stability analyses were performed at least annually and more frequently in most cases to ensure that the static and pseudostatic factors of safety of the embankment were at least 1.5 and 1.0, respectively.

HMC's NRC-licensed mine Ion Exchange (IX) facility was located on Section 25, T14N, R10W, NMPM and encompassed two buildings. The main IX building enclosed the process equipment such as IX columns, pipes, pumps and elution vessels. The main building also enclosed the eluate loading-unloading area and equipment used in transferring the material to the tank truck for transport to and from the mill. The smaller building which was the original IX building was converted to a warehouse and was used for storage of spare IX equipment and supplies. As stated in Section 1.2, the IX facilities have been disassembled and transported to the mill site for subsequent burial. The five-acre site was reclaimed in 1992.

2.0 FACILITY DECOMMISSIONING

HMC plans to decommission the mill facilities in two phases to allow some flexibility in the use of existing structures during the demolition and reclamation of the mill facilities and reclamation of the large and small tailing ponds. In the first phase, all processing facilities will be decommissioned. Phase one began in 1992 with asbestos removal and its on-site burial in the northeast toe of the large tailing impoundment. The major portion of the first phase, to be completed in 1994, will be removal of all mill facilities not needed for site management and ground water restoration. The second phase consists of removal of the administration building, change house, laboratory building, shop building, water towers, and ore truck shops that will be used during the first phase and until completion of ground water restoration. The mill components of each phase are identified on Figure 3. The schedule for facility decommissioning and other reclamation is shown on Table 2.

All the decommissioning activities will be guided and monitored by the Health and Safety Radiation Procedures which are contained in Section 2.1. The Resident Manager will be responsible for all activities associated with the decommissioning of the HMC facilities. The Radiation Protection Administrator (RPA), as designated in NRC License Condition 21, shall be responsible for the radiation protection program and training described in Section 2.1.

HMC will bury in place or in the east outslope of the large tailing impoundment the non-asbestos siding and roofing, structural supports and other materials that can be cut or crushed to flat shapes with very little void space. Equipment or materials that cannot be flattened will be placed in the large tailing impoundment or in trenches or pits in the mill area that will be backfilled.

The HMC mill contains the following major processing and miscellaneous structures that will be dismantled during decommissioning :

- Ore receiving section and receiving scale
- Crushing and sampling section, to include grizzly, impact breaker, rotary dryer, and reciprocating samplers
- Fine ore storage section with four ore storage bins and receiving bin
- Grinding section with ball mill and thickening tanks
- Uranium leaching section with leaching autoclaves, leaching pachuca tanks, solution storage tanks, and Ion Exchange facility
- Precipitation section with pregnant solution tank, precipitation and precipitate thickener tanks
- Vanadium removal section and associated roasting furnace

- Packaging storage and shipping section with yellowcake drying, packaging drum storage, and loadout
- Shops, warehouses, administrative building, laboratories, water towers change house, ore truck maintenance shops, miscellaneous structures, and old mill facilities that have been inoperative since 1961

A plan view of all the mill structures that will be dismantled is shown on Figure 3. In addition, Figure 3 also shows in which phase these facilities will be dismantled. Table 1 lists the major mill components.

HMC has no plans to salvage any equipment or structural components of the mill facilities. However, the demolition contractor may choose to salvage some components. Prior to release for unrestricted use, any material or equipment to be salvaged will be monitored in accordance with License Condition 14 which specifies the procedures contained in NRC "Guideline for Decontamination of Facilities and Equipment Prior to Release from Unrestricted Use or Termination of License for Byproduct or Source Material," dated September, 1984.

2.1 Health and Safety Radiation Procedures

Decommissioning of the HMC uranium mill facilities will be conducted under the guidance of Radiation Work Permits (RWP's) developed in accordance with NRC License Condition 24 and with the programs listed in License Condition 10 pertaining to ALARA, quality assurance, bioassay, respirator protection, emission control and monitoring programs. The standard procedures already established for these programs are included in Appendix A of this plan. The primary internal radiological hazard associated with decommissioning and decontamination is resuspension of surface contamination resulting in concentrations of airborne radioactive material. The primary external radiological hazard is gamma and beta radiation exposure. Beta radiation exposure will be predominantly associated with areas and equipment where aged yellowcake may still exist.

The Radiation Work Permit procedures require that each area of the mill be inspected to evaluate potential hazards, especially radiological hazard, prior to sequential dismantling. In all cases the equipment and general work area will be de-energized (electricity shut off) and washed down with water, as necessary, prior to work performance. This has been shown to be an effective method of reducing the resuspension of radioactive material.

The health and safety procedure for decommissioning contains the following sections:

- Management control

- o Radiation safety training
- o Radiation work permits
- o Radiation protection and monitoring
- o Security
- o Hazard Control

2.1.1 Management Control

The Resident Manager is responsible for all activities associated with the decommissioning of HMC's mill site. The Radiation Protection Administrator (RPA) is responsible for the radiation protection programs and training including:

1) Compliance with established radiation protection measures
2) Inspections to verify compliance with applicable requirements
3) Collection and interpretation of monitoring data
4) Training
5) Suspension, postponement, or modification of any work activity that is or could be potentially hazardous to workers

At least once a year an audit of all radiation activities associated with the decommissioning plan will be conducted. Results of the audit, with recommendations, will be provided to the Resident Manager. The audit will also determine if workers' exposures are kept As Low As Reasonably Achievable (ALARA).

HMC has an active ALARA review program consisting of worker training in radiological hazards, independent inspections by management and RPA as well as individual and on-site monitoring programs. This ALARA program will continue during the mill decommissioning phase of reclamation.

2.1.2 Radiation Safety Training

Radiation Safety training will be conducted for all employees, including contractor employees, who are participating in the decommissioning, decontamination and site reclamation. The radiation training will comply with applicable NRC regulations 10 CFR 19.12, "Instructions to Workers" and NRC Regulatory Guide 8.31, "Information Relevant to Ensuring that Occupational Radiation Exposure at Uranium Mills will be As Low As Reasonably Achievable". Female workers will be provided a copy of NRC Regulatory Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure".

The radiation safety training program will include the following topics:

1. Fundamental radiation chemistry - primarily terms and definitions related to radiation
2. What radiation is and what are its sources
3. Types of radiation exposure
4. Heath effects

5. ALARA definition and measures to maintain ALARA exposures
6. Radiation protection regulations
7. Site-specific radiation types
8. Site-specific radiation hazards
9. Fundamentals of health protection
10. Personal hygiene
11. Facility-provided protection
12. Health protection measurements and instrumentation

A written test with questions directly relevant to the principles of radiation safety will be administered after the training course, with each individual required to achieve a passing score of 70% before being allowed to work in the restricted area. The results will be reviewed, with incorrect answers discussed with the workers to assure worker's understanding of safety protection. During decommissioning, "safety huddles" will be held weekly to review radiological safety practices as well as hazard and task training.

All visitors will be instructed in industrial and radiological safety requirements relating to their specific function. All visitors admitted within the restricted area will be escorted by knowledgeable HMC personnel.

2.1.3 Radiation Work Permit

An initial inspection of the areas to be decommissioned and decontaminated will be performed by the RPA or delegate prior to the issuance of a Radiation Work Permit (RWP). The inspection results will be used to identify sources of radiation exposure, hazard, and protective equipment necessary to keep exposures ALARA. Mill dismantling activities will be conducted using RWP's. The RWP will describe the following:

- Area(s) where the dismantling activities will be performed
- Scope of work to be performed
- Any potential residual radioactive materials and the precautions necessary to reduce exposure to radiological material and other hazards
- Protective clothing and equipment needed to perform the job
- Supplemental radiological monitoring and sampling necessary prior to and following completion of the work
- Maintenance of RWP file

HMC's operating procedures for RWP's are contained in "Homestake's Official Compliance Procedure Manual" (HOCPM), a copy of which has been provided to the NRC.

2.1.4 Radiation Protection and Monitoring

To ensure that worker exposures are ALARA, HMC will perform the following protection measures during mill decommissioning, decontamination and reclamation. Details of the radiation protection monitoring procedures are contained in the HOPCM.

Internal Radiation Protection

The RPA will determine the need for individual personnel lapel sampling as well as area sampling for airborne radioactive material. If area sampling is required, calibrated high-volume samplers will be placed in the work area. The sample locations and frequency will be determined by the physical layout of the plant and the location of key equipment in the process (i.e. drying, packaging, ore receiving, grinding) in relation to the work being performed. The air samplers will be calibrated according to the manufacturer's specifications.

In areas such as the precipitation, vanadium removal and yellowcake packaging sections, and in areas where high volume samplers are not practical, workers will wear lapel samplers. The RPA will determine the internal exposure protection and monitoring required for the dismantling of tanks. A specific RWP will be used for tank entry.

Air sample filters will be analyzed for Gross Alpha based on uranium on a daily basis. Results of the area airborne samples will be correlated with the personnel lapel sampling data to calculate employee exposure.

Radon daughter samples will be taken with instant working level monitors on a monthly basis at key locations in the plant until dismantling activities in the area are completed. If the initial concentration at any sampling location exceeds 0.04 WL, weekly samples will be collected in conjunction with an investigation by the RPA to implement means to reduce radon daughter concentrations.

External Radiation Exposure

External radiation exposure, resulting from gamma and beta radiation, will be monitored for all employees by use of thermoluminescent dosimeter (TLD) badges. The badges will be worn during the working hours and stored in designated badge storage areas. Badges will be exchanged quarterly and returned to the supplier for processing. The supplier will provide immediate notification if a worker has been overexposed. If overexposure should occur, assignment of the individual will be changed, and a review by the RPA will be conducted.

Bioassay Program

Urine samples will be collected and analyzed in accordance with the NRC Regulatory Guide 8.22, "Bioassay at Uranium Mills", including origination and termination samples. Samples will be collected in a clean surveyed area or outside of the restricted area, after the worker has showered. When respirators have been used where soluble uranium may be present, urine samples will be taken within 48 to 96 hours following respirator usage. For dismantling activities involving such areas as the precipitation/drying/packaging as well as others identified by the RPA, urine samples will be collected weekly. For all other dismantling work in areas of possible contamination, urine samples will be collected monthly.

Urine samples will be collected and sent to an outside contractor. Blanks and spikes will be submitted, when possible, with the samples. The laboratory will report any analysis in excess of five micrograms per liter uranium. Table 1 of HMC's Uranium Mill Bioassay Program, contained in the HOCPM, provides details on corrective action based on urinary uranium results.

Whole body counting (in-vivo) will be conducted on any individual suspected of exceeding the quarterly MPE for insoluble airborne uranium.

Contamination Survey Program

Surface contamination surveys will be conducted on a weekly basis for lunch rooms and change facilities. These surveys will be conducted by smear testing and alpha counting of the wipe, or by alpha survey meters, to determine the levels of removable alpha contamination. Any sample approaching or exceeding 250 dpm alpha/100 cm^2 removable will be cause for investigation by the RPA and subsequent decontamination and/or removal of equipment from use.

Workers involved with dismantling activities in the precipitation, drying and packaging areas will be required to shower or monitor themselves prior to leaving the site. Clothing change facilities will be provided for the workers. Workers that are not required to shower or to monitor themselves prior to leaving the site will be afforded the use of these facilities and monitors. Written procedures for proper use of the personnel contamination monitoring equipment will be posted by the equipment and workers will be trained in equipment use. Results of exit monitor surveys will be documented. In the event that a worker monitors 250 dpm/100 cm^2 removable alpha, the worker will shower and/or wash clothes.

The alpha survey meter will be calibrated according to the manufacturer's specifications and at any time that verification checks indicate deviation of the readings by more than 20% from the reference reading. The RPA or designee will conduct a spot check of the employee survey techniques and survey documentation at least monthly.

Respirators and protective clothing will be made available to all workers. Protective clothing and respirators will be worn by workers when deemed appropriate by the RPA. The use of respirators will be in accordance with the NRC Regulatory Guide 8.15, "Acceptable Programs for Respiratory Protection."

Site Monitoring

HMC will continue to monitor at the mill site in accordance with NRC License Conditions. This monitoring will continue throughout decommissioning and reclamation.

2.1.5 Security

HMC maintains strict control of access to the restricted area through security personnel, fencing and posting. Access restrictions will be maintained until all surface reclamation is completed. Visitors will be required to register at the administrative building and will not be permitted into restricted areas without proper HMC authorization or escort.

2.1.6 Hazard Control

At least daily inspections in areas of activity will be performed to identify potential hazards, including radiological safety hazards. In the event of a fire, the Milan fire department will be called for assistance.

2.2 Decontamination

Before the mill can be demolished, some equipment and structures will be decontaminated sufficiently to eliminate potentially harmful levels of both radiological and non-radiological contaminants. All PCB's and solvents have been removed from the site to a licensed disposal site. Other potentially hazardous chemicals will be used up on-site or removed from the site and sent to licensed disposal facilities. The remaining non-radiological contaminant on site is asbestos, which was used primarily as insulation in buildings and around pipes. All asbestos has been assumed to be radiologically contaminated, requiring burial on site. A properly qualified/certified contractor has been removing all asbestos and disposing of it in an on-site burial area (at the northeast toe of the large tailing impoundment) approved by the New Mexico Environment Department (NMED).

Radioactive materials were processed in the main mill buildings, leaving some residual radioactive material on various equipment and structures. Upon cessation of operations in February, 1990, HMC began the process of washing down and cleaning the mill facilities and equipment. In accordance with the decommissioning sequence discussed below, this clean-up procedure will continue as decommissioning progresses, with follow-up radiological surveys to identify radiation levels in the various areas. Some mill components are likely to retain some sludge or scale after washdown. These residual solids will be minimized through decontamination procedures. Surfaces that show elevated levels of contamination after the initial cleaning will be rewashed prior to dismantling. With this clean-up effort in the mill process areas, potential exposure from uranium decay products will be minimized. Radiation work procedures outlined in the Health and Safety Plan (Section 2.1) will be implemented through RWPs issued for each area to be dismantled.

Decontamination activities will be documented and reported in accordance with License Condition 29F.

2.3 Demolition

Demolition of mill buildings and equipment will begin early in the reclamation schedule. The process areas will be dismantled by a demolition contractor under supervision of the RPA and in accordance with demolition specifications (Appendix B1). With approval by the RPA, the contractor may dismantle equipment and structures in any sequence, provided safety and environmental controls are implemented. Contamination control, weather, and personnel availability will be considered by the RPA when approving the sequence of activities in each phase. During Phase 1 the uranium leaching section, vanadium removal section, packaging-storage and shipping section, ore receiving section, crushing and sampling section, grinding section, old facilities and miscellaneous structures will be dismantled. The administrative and maintenance buildings, shops, laboratory, change house, water towers, and ore truck shops will be left for dismantling in Phase 2 after reclamation activities have been substantially completed. Figure 3 shows which facilities will be dismantled during each phase, Table 2 shows the schedule for decommissioning and reclamation schedule for the mill, and Appendix C1 contains the estimated demolition quantities.

In general, the mill process and miscellaneous structures will be buried in place or in on-site pits, where practicable. Material that cannot be buried in place or in nearby pits will be placed in the large tailing impoundment (in the outslope toe or the ponded slimes). Pits on site must be backfilled as part of site reclamation. Where demolition debris and equipment are buried in pits, the demolition materials will be placed in lifts up to five feet thick, then flooded with a sand-cement slurry grout to fill voids in the debris lift.

As work is designated to be performed in each area of the mill, a RWP will be filled out by the RPA or designee prior to performance of the work. In all cases electricity to the equipment and general work area will be shut off as necessary, and all surfaces will be hosed down with water prior to work performance. HMC has been successfully using this method of reducing resuspension of radioactive particles during maintenance operations at the mill.

Because no salvage value for equipment is anticipated, the process area can be dismantled while minimizing the potential exposure to personnel. The facilities will be dismantled from the outside in, with the roof and sides being dismantled first from the outside of the buildings. This procedure will be followed using equipment such as fork lifts, loaders and cranes, thus increasing the distance from potential radiation sources and providing shielding. Removing the sides and roof of the facilities also provides increased ventilation, further reducing the potential of exposure to personnel. Following removal of the sides and roof of a building, equipment and material within the building will be removed, cut and crushed to shapes and sizes that facilitate disposal and minimize residual void spaces. Wooden materials will be pulverized and mixed with inorganic debris. The structural elements will be brought down and cut or crushed, then compacted and buried in the immediate vicinity. Most foundations will be buried in place. Any machinery or other uncrushable components with significant void space will be filled with a sand-cement slurry grout before burial. Finally, gravelly sand fill will be placed to fill voids in and form a cover over the mill debris, as described in Section 2.4. This method of dismantling facilities meets the goal of ALARA. The estimate of volumes and weights of demolition debris is included in Appendix C1.

Demolition activities will be documented and reported in accordance with License Condition 29F.

2.4 Mill-Area Cover and Grading

The total area of reclamation within the mill area is approximately 50 acres, of which approximately 42 acres could contain buried mill debris. A flood diversion levee, described in Section 4.4.2 and shown on Figure 4, will divert the Lobo Canyon floods to the north and west of the mill and the reclaimed tailing embankments. The entire mill site south of the levee will be recontoured to achieve the final grades illustrated in Figure 4. These grades will be attained through compaction of mill debris, filling voids in the debris with sand-cement slurry grout and gravelly sand and covering the mill area with a minimum depth of two feet of gravelly sand or sand in accordance with the technical specification in Appendix B2. An estimated 176,800 cy of borrow material (Appendix C2) will be required to cover the burial area with two feet of soil. Adequate volumes of gravelly sand or sand (Appendix C3) are available in designated borrow areas as shown on Figure 4.

2.5 Contaminated Soil Clean-Up

Contaminated soils will be removed from the restricted area and all adjacent areas as needed to reduce soil radium levels to not more than background +5.0 pCi/g RA-226. The soil radium and gamma survey (Figure 5) conducted in 1990 has been used to estimate the volume of contaminated soil to be cleaned up during reclamation. From the 1990 survey, it is anticipated that excavation of soil to an average depth of six inches (6 in) will be required in the areas shown on Figure 5. In addition, in the vicinity of the ore pad it is anticipated that two to three feet of soil material will require excavation. The estimated volume of contaminated soil requiring clean-up is 250,000 cy (Appendix C4). Contaminated soil material will be excavated using scrapers, which will place this soil in the tailing impoundments prior to placement of the radon barrier. Soil contaminated by windblown tailings will be excavated and placed in the large tailing impoundment by 12/31/96 and in the small impoundment by 5/31/97 in accordance with License Condition 36A(1). Contaminated soil clean-up and verification activities will be documented and reported in accordance with License Condition 29F.

3.0 RADIOLOGICAL SURVEYS

HMC has been conducting annual radiological surveys for several years. These surveys have not included gamma measurements or soil radium samples in the mill area, which is assumed to be contaminated to levels high enough to require clean-up of surficial soil throughout the mill area. The 1990 soil and gamma survey conducted by HMC has been used as the basis for the estimated extent of soil clean-up described in this plan.

Annual surveys up to 1987 indicated that an area north and northeast of the large tailing impoundment had soil radium concentrations that exceeded the 10.5 pCi/g Ra-226 limit allowed by License Condition 19D. Because these radium levels were apparently due to windblown tailings, the NRC directed HMC to remove soils with excessive radium. HMC performed these clean-up activities in 1987-1988, disposing of the contaminated soils at the north and east toes of the large impoundment and on the small impoundment. Subsequent radiological surveys of the cleaned-up area showed that the clean-up efforts were successful in reducing soil radium to the required limit.

3.1 Verification Survey

Radiological verification surveys will be performed following initial contaminated soil clean-up to delineate areas of residual excess radium content in soils and, otherwise, to verify adequacy of soil clean-up. These include gamma measurements using a calibrated microR meter and laboratory tests to measure radium concentrations in the soil. Prior to the performance of verification surveys, correlation between gamma measurements and soil radium concentrations will be established in accordance with License Condition 29C. Subsequent to the establishment of this correlation, clean-up verification surveys will be conducted in accordance with License Conditions 29A and 29B. Within the area of known contamination, delineated by the dashed green line on Figure 5, soil samples for Ra-226 testing will be collected at 50-meter grid points and gamma measurements will be taken at 10-meter grid points. Areas outside the green line will be sampled for Ra-226 testing at 100-meter grid points and measured for gamma readings at 10 meters until background levels of Ra-226 in the soil are reached, using the action-level procedures required under License Condition 29C. For the surveys, a quality control program in accordance with License Condition 29E will be followed.

3.2 NESHAP Radon Flux Measurements

Recently enacted (EPA, 1989) amendments to the Clean Air Act require measurements of radon flux through the soil cover constructed as a radon barrier over tailings. HMC will use Method 115 of 40 CFR 61, Subpart T (EPA, 1989) to measure actual radon flux through the completed radon barrier (soil cover). One hundred canisters will be distributed across the surface of each tailing impoundment. These canisters will be placed on the large impoundment after major portions of cover construction are completed and on the small impoundment after cessation of evaporation pond operations and the reclamation of that impoundment is completed, estimated to be 10-15 years from the date of this submittal.

Prior to radon barrier construction on the large tailing impoundment, a field test of various radon barrier designs will be conducted as described in section 4.2.1 of this plan. After each cover test configuration has been constructed, radon measurements using Method 115 will be taken on at least five locations within each configuration. Results of these measurements will be compared with the soil properties and thickness of the tested configurations to evaluate the actual radon barrier thickness needed. A radon barrier design revision based on these results will be provided to the NRC to support an amendment to the Materials License Conditions 37A and 37B.

4.0 TAILING IMPOUNDMENT AREA RESTORATION

At the time of the current revision (10/93) of this plan, the large tailing impoundment had little to no standing water in the east and west ponds. The crests of the large impoundment were more than five feet higher than the ponds, and the east pond was approximately 20 feet higher than the west pond. Present outslopes are between 2H:1V and 3H:1V gradient. The small tailing impoundment presently holds the new lined evaporation pond over the northern three-quarters of its surface area. A mixture of scrap materials, contaminated soil and tailings occupies the south one-quarter of the small impoundment south of the south dike of the evaporation pond. The existing tailing impoundments are shown on Figure 2.

4.1 Interim Stabilization

During the period between the original submittal (Rev. 1) of this plan and this current revision (10/93), various stabilization measures were used to prevent the release of windblown particulates from the tailing surfaces. On the large impoundment Curlex mat, chemical binder and water sprays were used on exposed surfaces. Water sprays will continue to be used during the reclamation process until the tailing surfaces are recontoured to a configuration that is ready for placement of interim soil cover or radon barrier. At least one foot of interim soil cover will be placed over the top surface of the large impoundment. This interim cover will be placed not later than 12/31/96 in accordance with License Condition 36A(2). Outslopes of the large impoundment will be covered with radon barrier immediately after recontouring and will not require an interim soil cover.

The exposed tailing surfaces of the small impoundment are presently limited to the south portion of the impoundment (Figure 2). All surfaces within the dike system of the evaporation pond are covered with liner; and the north, east and west outslopes are covered with native soil, in most places approximately two feet thick. The outslope of the south dike of the evaporation pond and the south one-quarter of the small impoundment may receive additional contaminated soils and scrap materials during mill demolition. After that time an interim cover of approximately one foot of clean native soil will be placed over these surfaces not later than 5/31/97 in accordance with License Condition 36A(2). Calculations of quantities of interim stabilization materials and activities are contained in Appendix C5.

4.2 Long-Term Stabilization

Both tailing impoundments will be stabilized to satisfy the criteria contained in Appendix A of 10 CFR 40. Activities to stabilize the large impoundment are already underway and will continue over at least the next three years. Stabilization of the small tailing impoundment will be completed after cessation of operations of the evaporation pond, which was constructed on the small impoundment during 1990.

4.2.1 Large Impoundment

Stabilization of the large impoundment involves four distinct but overlapping steps:

Dewatering

Until 1993, both ponds of the large impoundment (east and west) contained standing water. The first step of stabilization of the large impoundment was the removal cf the free-standing pond water. Although some of this water infiltrated into the tailings and became pore fluid within the tailings, most of the pond water was removed by evaporation, both natural and spray-enhanced. With the diversion of collection well water to the new evaporation pond, HMC has sent to the large impoundment only enough water to maintain dust control. The spray systems presently operating in the beach areas of both ponds will continue to operate at least until recontouring of the large impoundment is completed.

There is a large volume of pore water within the tailings of the large impoundment. Much of this pore water will be retained (specific retention) in the pore space of the tailings, especially the slimes, for an indefinite period of time. However, a substantial volume of the moisture is drainable under the influence of gravity. This water will drain through the outslope toes and the bottom of the impoundment. Water draining from the bottom of the impoundment is being and will continue to be collected by wells and directed to the existing brine ponds. Water draining through the outslopes is being collected by a buried pipe drain installed around the entire outslope perimeter in 1992. This drain system will be augmented by a shallower french drain with perforated pipe constructed around the existing outslope toe and five feet outboard of the toe drain alignment. Both drain systems will discharge to sumps, and the collected water will be recirculated back to the impoundment for use in interim stabilization; i.e. this water will be sprayed on exposed tailing surfaces at a rate that will minimize wind erosion of tailings but will not be sufficient to create additional recharge to the saturated zone within the tailings. As interim cover or radon barrier is being placed, the spray systems will be removed and the water will be diverted to the brine and evaporation ponds. If the natural rates and processes of drainage of pore water from the tailings will not result in dewatering within a reasonable time frame, to be determined later, HMC might consider one or more possible measures to enhance the dewatering of the tailing pore water.

Recontouring

The top and outslopes of the large impoundment will be reshaped to the final configuration depicted in Figures 6 and 7. Recontouring will follow the technical specifications in Appendix B3. The initial phase of this recontouring will be the displacement of the pond dike crests inward to fill in the pond basins. These basins will be filled primarily with sand tailings but might also receive some scrap or demolition debris, contaminated equipment, contaminated soils, or any combination of these. This first phase of recontouring will be accomplished primarily by dozers, with additional earth movement by scrapers as appropriate. The most significant factor which will limit the rate at which the pond basins can be filled is the ability of the pond slimes to support the weight of fill and resist the vibration of earthmoving equipment. Based on experience of other operators as well as Homestake with attempts to cover saturated slimes, HMC plans to start filling the pond basins at the earliest possible time (September, 1993). Because the dewatering and densification of the slimes under the influence of a surcharge is a time-dependent process, HMC plans to achieve the filling of pond basins by successive short pushes of fill material from the outsides of the ponds inward, each successive push being performed only after the slimes under the preceding increment of fill have stabilized enough to support the fill and heavy equipment required for the next successive push.

After the process of filling pond basins has started and while the necessary time passes between successive pushes in the filling of the basins, HMC will perform the earthwork required to flatten the impoundment outslopes from their present configuration to 5H:1V as shown on Figure 7. This flattening will be achieved primarily by displacing sand tailings from higher on the slope to positions lower on the slope by a combination of pushing by dozer and excavation and fill placement by scrapers.

In the final phase of recontouring, the top of the impoundment will be crowned with fill placement and final grading to create the contour shapes depicted in Figure 6. The shape of the recontoured impoundment top has been designed to 1) concentrate surcharge loads over areas of greatest slime thickness and 2) distribute surface runoff as uniformly as possible over the north, west and south outslopes and to minimize runoff over the east outslope. In most places at least 15 feet of tailing sand will overlie pond slimes. In other places not underlain by thick slimes (i.e. upper beach areas), the thickness of sand tailing fill will be less but will be sufficient to provide a firm working surface for subsequent cover placement. The thickness of sand tailings placed or left in any location will be determined by a) the design contour of that location and b) the minimum thickness of sand over slimes needed to support construction equipment. Given the properties of the slimes and the sand tailings (Appendix D), the cover thickness will not be significantly influenced by whether it is underlain by slimes or tailing sand.

At least 1.467 million c.y. of sand tailings will be moved in the process of recontouring the large impoundment (Appendix C6). Except for the top four feet of the recontoured areas requiring fill, the sand tailings will be compacted by the passage of earthmoving equipment in the normal course of redistributing the tailings. No specific compactive effort will be required for these tailings. The final or topmost four feet of sand tailings on the fill areas of the recontoured impoundment will be compacted to at least 90% Standard Proctor density (per ASTM Method D-698) in accordance with the technical specifications for impoundment recontouring contained in Appendix B3. Although no specific compaction moisture content will be required for the upper four feet of tailings, some moisture conditioning probably will be needed to consistently achieve the 90% density requirement.

<u>Radon Barrier (Soil Cover)</u>

Criterion 6 of Appendix A, 10 CFR 40 requires placement of an earthen cover over the tailings that will control radiological hazards for up to 1000 years and limit average radon release rates to not more than 20 pCi/m^2 s. Borrow sources for the cover soils are alluvial sand and clay deposits located on HMC property north, west, and south of the large impoundment. The radium content of the cover soils will be limited in accordance with the quality control program required by License Condition 37C. The radon barrier soil will be placed in lifts and compacted to at least 95% Standard Proctor density, with moisture contents from minus 2% optimum to 2% above optimum, in accordance with the technical specifications contained in Appendix B4. A quality control program in accordance with License Condition 37D will be implemented to assure that the earthwork achieves these design parameters.

The soil cover or radon barrier design is based on methods described in USNRC Regulatory Guide 3.64 (NRC, 1989b). These methods use the physical and radiological properties of the tailings and cover soils to calculate the radon flux at the cover surface for a set of tailing and soil layers of specific thicknesses. When these properties are used in the RADON computer code calculations, the cover thickness needed to meet the flux limit (Appendix C7) is 1.7 to 2.0 feet of locally-available alluvial clay (CL and CH soils) placed over either slimes or tailing sand. If soils with less clay are used (i.e. SC soils), up to 5.4 feet of radon barrier might be needed. Design parameters and calculations for cover design, in accordance with the procedures in the NRC Regulatory Guide 3.64 (NRC, 1989b), are contained in Appendix C7.

According to License Condition 37A issued by the USNRC in July of 1993, 8.0 feet of radon barrier must be placed over the large impoundment, as illustrated in Figure 8, not later than 12/31/96 in accordance with License Condition 36A(3). However, satisfaction of this License Condition will not be possible if the 90% settlement prior to barrier construction, required by License Condition 37F, takes longer than a few months. The total volume of cover soil for 8.0 feet of barrier thickness is estimated to be approximately 2,315,000 c.y. (Appendix C6).

Several field and laboratory investigations of tailings and borrow (candidate cover) soils have been conducted since 1986; the details and findings of these studies are included in Appendix D and summarized in Table 3. Logs of test pits of these investigations (see Figure 2 for locations) as well as soil test data have been submitted previously to the NRC, and some are contained again in Appendix D. The parameters used in the design calculations are either default parameters contained in Reg. Guide 3.64 and the RADON computer code or are averages of actual test results contained in Appendix D. These data and resulting calculations (Appendix C7) support HMC's radon barrier design and show that the 8.0 foot barrier thickness mandated in License Condition 37A is excessively conservative.

Settlement Monitoring

Settlement within the large impoundment caused by consolidation of compressible tailings, specifically slimes, cannot be predicted with confidence. A settlement calculation was performed previously and submitted to the NRC on April 27, 1987 (HMC, 1987) that provided a rough estimate of 3.7 feet of settlement in the center of a pond area containing 90 feet of slimes. This calculation was based on assumed lateral and vertical distribution of the slimes and important slime properties. Variations from any one of these properties could change the amount of consolidation and resulting settlement of the top of the impoundment.

Although the design has allowed for relatively large settlements of the top of the impoundment by providing for additional height of fill over the centers of the pond, the actual settlements that develop as a result of slime consolidation will be monitored. This will be accomplished by the installation and periodic survey of settlement monitoring points. The technical specifications for the settlement points and the monitoring surveys are contained in Appendix B5. Fifty settlement points will be installed on the top surface of the large impoundment at the node points of a 250 to 300-foot square grid, as shown on Figure 6. Each point, illustrated in Figure 8, will be installed at its designated location as soon as possible after recontouring earthwork has established a stable working surface at that location. After installation of each point is completed, the X, Y and Z coordinates of the point will be surveyed. Subsequent readings of elevation of each point will be made biweekly-to-monthly for six months or to the end of primary consolidation. If measurements are needed after the first six months, appropriate points will be measured on a monthly-to-quarterly schedule until it has been determined that primary consolidation has been achieved at all points throughout the large impoundment. Settlements will be determined by the difference in successive elevation readings at each settlement point based on standard survey intruments and methods. The elevation at the top of the settlement point or gauge cap will be measured to a precision of 0.01 feet, with an accuracy of 0.05 feet.

The settlement data will be used to monitor and evaluate the rate and the magnitude of the consolidation of the slimes and to identify the total and differential settlements that could result in negative gradients, depressions, or other disturbance to the cover. The settlement data will also be correlated with the water levels of piezometers in the impoundment, the discharges from pipe drains and french drains at the outslope toe, and ground water collection well discharge data in an effort to predict 1) the end of ground water discharge from the tailing impoundment to the alluvial aquifer and 2) the 90% point of settlement due to primary consolidation in the impoundment. License Condition 37F requires that 90% of primary settlement be demonstrated before placement of the radon barrier.

Structural Stability and Liquefaction

In 1980 an extensive study was performed to determine the structural stability and potential for impoundment failure due to liquefaction (D'Appolonia, 1980). That study included sampling and testing of tailings, including cyclic triaxial tests. This study determined that the only zone subject to liquefaction was the exposed seepage face at the toe of the outslope; only a few feet of covering material increases the factor of safety to more than 1.5. Some static factors of safety at that time were slightly below the required minimum of 1.5. Modification to the impoundment configuration (inboard displacement of the embankment crests) in 1981 increased the static and pseudostatic factors of safety to more than the limiting values of 1.5 and 1.0, respectively, for all portions of the impoundment. Stability assessments performed since that time have documented that factors of safety have remained above the required minimums.

The principal variable conditions affecting the stability of the impoundment are the height and gradient of the outslopes and the elevation of the phreatic surface within the outslopes. Both of these will be substantially improved (flattened outslopes, lowered phreatic surface) by the reclamation of the large impoundment. Consequently, the factors of safety after reclamation will be significantly higher than they are presently. Therefore, no additional or post-reclamation stability analyses are necessary. However, License Condition 12 requires annual technical evaluation of the impoundments.

4.2.2 Small Impoundment

The small impoundment has been inactive with respect to tailing disposal since 1961. However, in 1990 a 27-acre evaporation pond, designed and constructed with NRC's approval, was placed in operation on approximately the northern three-fourths of this impoundment. The pond lies completely within the boundaries of the impoundment, as shown on Figure 2. Final stabilization of the small tailing impoundment will be performed after cessation of evaporation pond operations, approximately 10-15 years from present. Stabilization of the small impoundment will follow approximately the same steps as those used for stabilization of the large impoundment.

Dewatering and Evaporation Pond Closure

After the ground water restoration program has achieved the required results of reducing specific contaminant concentrations in the ground water to allowable limits, the evaporation pond will no longer be needed. At that point all subsequent discharges of water to the evaporation pond will cease, and the standing water contained in the evaporation pond will be evaporated using natural evaporation enhanced by sprays as necessary. After evaporation of the standing pond water is complete, the pump station and the pond slope (inside slope) liner will be removed and placed on the bottom of the pond. Phase 2 demolition debris as well as any residual contaminated soil or equipment will be placed within the pond for subsequent burial.

Recontouring

The pond will be closed and recontoured by pushing in the earthfill dikes on all sides of the pond and, if necessary, by also relocating debris and contaminated soil from the disposal area in the south end of the impoundment to the pond in order to establish the final impoundment top shape and gradients shown by the contour lines in Figure 9. Recontouring will be accomplished using the same methods and standards specified for the large impoundment and contained in Appendix B3.

Radon Barrier (Soil Cover)

According to License Conditions 36A(3) and 37B, the small impoundment will be covered with 14.0 feet of radon barrier by 12/31/2001 over portions not covered by the evaporation pond. Within two years after ground water restoration work is complete, the remainder of the small impoundment radon barrier will be placed. Clay and sand soils used for this cover must meet the quality control requirements for radon content contained in License Condition 37C. They will be excavated from alluvial soils like those used for material placed in the large impoundment cover These cover soils must also be placed to satisfy the quality control requirements of License Condition 37D. Given the properties of these borrow soils and the calculations in Appendix C7 , no more than 7.0 feet of soil would be required to provide the necessary barrier to radon. The total volume of the 14-foot cover, less that already in place on the outslopes, is about 1.21 million c.y. (Appendix C6).

Settlement Monitoring

No significant settlement is likely in the small impoundment after reclamation. Soft wet tailings that existed under the evaporation pond within the small impoundment were reworked and compacted during evaporation pond construction. Slimes under the south dike and in the south one-quarter of the small impoundment have been surcharged with fill since 1990. This surcharge will impose loads that will cause consolidation during the period of pond operations. Therefore, after recontouring of these surfaces, the surcharge loads on the slimes will be less than those that had existed before recontouring; no significant subsequent settlements should occur before barrier placement, and no settlement monitoring will be performed.

Structural Stability and Liquefaction

After reclamation the small impoundment will have a maximum height of about 20 feet and will be contained within a compacted earthen dike. Saturated tailings, if any occur in 10-15 years from present, should be no thicker than about four feet (based on observations made during evaporation pond construction in 1990) and will be confined by at least seven feet of dry tailings and by compacted radon barrier. Therefore, the factor of safety against liquefaction should be at least equal to that for the large impoundment tailings, 1.5 or better, with a few feet of cover. Comparison of post-reclamation configuration of the small impoundment to that of the large impoundment makes it readily apparent that if the pre-reclamation static and pseudostatic safety factors of the large impoundment are greater than 1.5 and 1.0, respectively, the post-reclamation safety factors of the small impoundment will be much higher. The annual technical evaluation report required by License Condition 12 will examine these issues as necessary.

4.2.3 Erosion Protection

The primary mechanism that could cause release of tailings from the impoundment is erosion by surface water runoff. Criterion 4 of 10 CFR 40, Appendix A requires use of several measures to minimize the potential for erosion of the tailings. Sections (a) and (b) of Criterion 4 call for minimization of the upstream watershed and for topographic features that provide good wind protection. The Homestake Grants site, established long before these requirements were written, lies partially within the broad floodplain of San Mateo Creek with 291 square miles of upstream watershed (Figure 10). Therefore, the site cannot satisfy sections (a) and (b) of this criterion. Sections (c) and (d) of this criterion require relatively flat slopes with erosion-resistant covers for final stabilization; these requirements have been satisfied in the reclamation design.

<u>Design Runoff Events</u>

Protection against erosion by surface water has been designed for the runoff that would be caused by the greatest possible precipitation event, the Probable Maximum Precipitation (PMP) storm. For the Homestake site, two PMP events are applicable - the regional or general PMP storm that affects the entire San Mateo watershed and the local PMP that affects the mill site. The former determines the parameters of the flood, the Probable Maximum Flood or PMF, that would originate upstream and pass across portions of the site, while the latter determines the maximum rainfall (PMP) directly onsite and the resulting PMF runoff originating on the site itself. Consequently, the erosion protection designs took into account two different and separate PMP/PMF events.

The general storm or regional PMP/PMF event has been analyzed on several occasions, the most recent being in 1988 (HMC, 1988). That analysis used the hydrometeorlogical data contained in HMR 55a (BuRec, 1988), the watershed hydrograph calculated with the computer code THYD and the flood-water surface profiles determined with the HEC-2 computer code. These analyses were documented in detail in Enclosure 7 of HMC's responses to the NRC dated October 31, 1988. The results of those analyses are summarized in Table 4 of this plan. These analyses show that the peak PMF discharge would be 169,800 cfs resulting from a PMP of 12.2 inches over a storm duration of 24 hours. The HEC-2 analyses of surface-water profiles for this PMF are illustrated for several cross sections of the San Mateo floodplain at the Homestake site in Figures 11 and 12. Figure 11 shows the location of several cross sections used in these analyses and the peak water surface elevations that would result from the PMF at each of these sections. Figure 12 shows these sections in profile. The analyses show that the large impoundment creates a constriction in the floodplain with resulting backwater effects from the northwest corner of the impoundment to several thousand feet upstream. Appendix C8 contains a copy of the HEC-2 output file that was previously submitted to the NRC in October, 1988. The water surface elevations shown on Figures 11 and 12 were obtained from the HEC-2 output included in Appendix C8. The hydrologic analyses of the regional or general storm of the San Mateo watershed indicate that the toe portions of the north and west outslopes of the large impoundment will require protection against potential erosion caused by the regional PMF.

The other PMP/PMF event that affects potential erosion of the site is the local one-hour PMP/PMF, the rainfall and resulting runoff from the site itself. For the purposes of hydrologic analyses, the mill site can be subdivided into separate small watersheds which are separately and collectively less than one square mile. For a watershed of this size, the Rational Method (Chow, 1964) is the approved method for runoff analysis (Nelson et al, 1986; NRC, 1990). The local one-hour PMP would result in rainfall totalling 9.94 inches, which would produce the velocities and discharges of runoff documented in Appendix C9 and summarized on Table 4.

To reduce the potential for erosion due to on-site precipitation to a minimum, several design measures were used in the reclamation plan. To reduce the potential for erosion of the tailing impoundments themselves, the impoundment top surfaces will be contoured to minimize slope gradients and flow-path lengths to the extent possible without compromising other design objectives. Outslopes will be reshaped with a maximum gradient not to exceed 5H:1V. For the rest of the site, cover placement and recontouring in the mill area are designed to keep surface gradients sufficiently flat that PMP runoff will produce shear stresses less than the allowable shear stresses for the cover materials being used (gravelly sand). In addition, a diversion levee, described in Section 4.3.2, has been designed to divert not only the San Mateo flood flows but also a large portion of what would otherwise be the upstream end of the on-site watershed. The local runoff and resulting shear stress calculations (Appendix C9) indicate that the tops and outslopes of both the large and small reclaimed tailing impoundments will require protection against erosion due to runoff of the PMP rainfall. The combination of recontoured gradients and physical properties of surface soils will be sufficient to resist erosion on other surfaces of the reclaimed site, including the diversion levee. However, HMC has agreed to place the same rock cover on the diversion levee outslopes as specified for the top of the large impoundment. The final site contouring, discussed in a later section, will be implemented and controlled by grade stakes and elevations surveys to promote sheet flow across all surfaces of the site. The following paragraphs discuss the design of this and other erosion protection measures.

Types and Sources of Protection

Reclaimed surfaces of the HMC site will be protected from long-term erosion by one or more of three primary types of protection - natural gradients and vegetation, coarse-grained soil cover, or rock cover. Most of the ground surface on the site is very flat, with natural gradients usually less than 1%. These surfaces have no established drainage courses, and there is no evidence either on site or within the vicinity of the site of drainage channel headcutting, channel meander migration, or other signs of active erosion or geomorphic instability. Therefore, the flat surfaces of the site that do not cover either tailings or mill debris will be protected by their flat gradients and by vegetative cover. The resistance of these flat surfaces to erosion under design precipitation events is supported by calculations in Appendix C9.

Those surfaces that are established over mill debris or that have final contours significantly different from earlier natural contours will be protected by gravelly sand soils which have allowable shear stresses in excess of peak shear stresses that would develop from the PMP runoff event. Although vegetation cover, described in section 4.5, will provide additional protection against erosion, this benefit has not been considered in the design of erosion protection.

Impoundment Surfaces

All surfaces that overlie or are directly adjacent to stabilized tailings will be covered with basaltic lava with a durability score of at least 80 or oversized in accordance with NRC, 1990 (see Appendix C10). Rock cover will be placed over the large tailing impoundment by 9/30/99 in accordance with License Condition 36B(1) unless delayed as a result of settlement impacts as discussed in section 4.2.1. Small impoundment rock cover will be completed by 4/1/2014 as required by License Condition 36B(1). The rock source is the Malpais lava flow located in the NE 1/4 of Section 28, approximately 1.5 miles west of the large tailing impoundment. This rock source will be developed as a quarry by drilling and blasting of the rock and by crushing to appropriate sizes if necessary. The rock will be hauled and placed in locations shown on Figures 4, 6, 8 and 9.

The rock cover protection will be similar for both impoundments and for the diversion levee. The top covers will be protected by at least six inches of basaltic lava with a D_{50} of not less than 1.0 inches. No bedding layer will be required under this rock cover. The rock properties, summarized on Table 3 and the calculations contained in Appendix C10 show that this rock protection is sufficient to resist the erosive forces that could be generated by the runoff from a one-hour local PMP storm. The outslopes of both impoundments will be protected by a rock cover of at least eight inches of basaltic lava with a D_{50} of not less than 4.7 inches. Rock sizes and rock cover thicknesses will be reevaluated, and changed if necessary, in accordance with License Condition 37G. The outslope rock cover will be placed over a six-inch layer of bedding material consisting of sand and gravel or basalt crushed to sand and gravel sizes. This cover has sufficient resistance to erosion to protect the outslopes against erosion due to runoff of the local one-hour PMP, according to the NRC (1990) and calculations contained in Appendix C10. Appendix B6 contains the rock cover specifications.

Riprap and Scour Protection

Because the western half of the large impoundment is located within the PMF floodplain of San Mateo Creek (Figure 11), the toe portions of the west and north outslopes of this impoundment will require protection against scour that could be caused during the PMF event. The peak discharge, peak flood elevations, over-bank velocities, and over-bank depths that would affect the large impoundment were calculated using the HEC-2 computer program; and these calculations, summarized in Table 4, were submitted to the NRC on October 31, 1988 (HMC, 1988). Copies of the HEC-2 printout are contained in Appendix C8 of this plan.

The October 31, 1988 submittal to the NRC also contained a set of calculations to estimate the maximum depth of scour that could be caused by the peak over-bank velocities associated with the PMF. These calculations, revised in Appendix C11, yield estimated depths that averaged 7.7 feet along the base of the impoundment outslope. The 7.7 feet of scour depth is considered by HMC to be conservative, because it assumes that the soil materials will be sands with no cohesion. In fact, borrow soil investigations (Appendix D) indicate that much of the soil within this depth is likely to be clay and therefore more resistant than the sand to scour. Nevertheless, assuming that sands comprise the top 10 feet of natural soils at the toe of the impoundment, the necessary scour protection will consist of a layer of rock, not less than one foot thick, containing basaltic lava of the same gradation as used in the outslope rock cover. This riprap layer will extend from final ground surface to a vertical depth of at least 7.7 feet. This scour protection will be extended up the 5H:1V outslope to an elevation equal to the calculated PMF peak flood crest at each of the analytical sections used in the HEC-2 calculations. The riprap layer and buried scour protection are depicted in Figure 8. Calculations supporting this design are contained in Appendix C10. Construction of riprap and scour protection will follow the technical specification in Appendix B6.

4.3 Other Restoration and Protection Measures

4.3.1 Brine Pond Removal

In 1985 HMC constructed two brine ponds south of the large impoundment (Figure 2). These brine ponds will not be reclaimed initially but will be used in conjunction with the evaporation ponds to achieve ground water restoration. The collection well water will be pumped to the brine ponds initially, where it will be retained for a short period of time to allow carbonate precipitation; then this water will be pumped to the evaporation pond. When the ground water restoration program is completed, brine ponds will be dewatered, the liners removed and buried in the small impoundment, any contaminated soils removed, and the basins filled with the soils that were used to construct the surrounding dikes of the at-grade ponds. The surface of the brine pond area will be final-graded to match the surrounding contours as described in Section 4.4.

4.3.2 Diversion Levee

Surface water discharges from the Lobo Canyon portion of the San Mateo watershed follow a drainage course that cuts across the northeast corner of the mill site. The channel of this water course is poorly defined, and during flood events some of this discharge would flow across a portion of the mill area and between the tailing impoundments. To prevent this and to minimize the watershed area within the reclaimed mill site, a diversion levee will be constructed from the east outslope toe to the highest elevation point in the mill area at the north side of the parking lot of the administration building, as shown on Figure 13. The crest of this levee will be at elevation 6595, more than two feet above the Lobo Canyon PMF crest as determined by HEC-2 calculations submitted previously to the NRC (HMC, 1987). The levee will have a top width of 15 feet and sideslopes at 10H:1V. The levee will be constructed of uncontaminated soils from the borrow area east of the highway and directly east of the mill area. These latter borrow soils are primarily gravelly sand as determined by field and laboratory investigations (Table 3 and Appendix D). The levee fill will be compacted in lifts to average densities not less than 95% Standard Proctor density per ASTM Method D-698. The slopes of the levee will be protected against erosion using the same rock cover specified for the tailing impoundment top surfaces. The location and configuration of the diversion levee are shown on Figure 13. The technical specification for levee construction is in Appendix B7.

4.4 Final Grading

After the mill area and the large tailing impoundment are reclaimed, the mill site and borrow areas used for the large impoundment cover will be graded in accordance with the technical specification in Appendix B8 to provide positive sheet flow drainage, smooth contours, and minimum surface gradients. The borrow areas used for the small impoundment cover will also be final graded, but this phase of final grading will be performed approximately 10 years after the initial phase of final grading. Final grading is expected to require minimal dozer work; most will be finish work using a motor grader. The final grades will be as close as possible to the original natural grades, with surfaces sloping generally to the south and southwest from the mill and tailing impoundment areas. Final site grading design has not been developed because of present uncertainty about the actual depths and extents of borrow areas and areas of contaminated soil clean-up.

4.5 Revegetation and Fencing

Approximately 750 acres disturbed during mill operations and reclamation will require revegetation. These areas include:

- Mill facilities (50 acres)
- Borrow areas, less brine pond and contaminated soil area (517 acres)
- Contaminated soil areas (175 acres)
- Brine pond area (8 acres)

The revegetation plan is based on vegetation species currently on site and in adjacent borrow areas, on the ability to provide species diversity, and on adaptability of the species to the soil conditions. Both sod and bunch-grass species have been selected to help provide soil stability and minimize erosion. Due to climatic conditions, the seeding will be accomplished between mid-June and mid-September. This period of time has the most favorable average moisture and temperature conditions for seed germination. Seed bed preparation will be conducted following grading of each area listed above. Table 5 lists the selected permanent seed mixture and seeding rates.

The agronomic soil in the area is primarily the Aparejo-Venadito complex. This soil unit is found on floodplains and within large drainage areas. In addition, the Penistaja Fine Sandy Loam soil unit is in the vicinity of the mill area. The soils from the borrow areas will be used for fill and cover and are capable of sustaining vegetative cover. A soil survey conducted by the Soil Conservation Service in 1986 further defines these soil units (USDA, 1986).

The areas to be revegetated will have seedbeds prepared as follows:

- Mill Area: The reclaimed mill area, shown on Figure 4, will have two feet of clean soil cover that will be disked or harrowed to provide a surface for drill or broadcast seeding. Any area outside of the burial area that has been compacted due to demolition activities will be ripped with a bulldozer or equivalent equipment with ripper shanks which will make parallel cuts on the contour. The area will then be disked or harrowed to provide a surface for drill or broadcast seeding.

- Borrow Areas and Contaminated Soil Removal Areas: Areas that have been compacted through the use of heavy equipment during soil excavation will be ripped as discussed above. The total area affected will then be disked or harrowed to provide a surface for drill or broadcast seeding.

- Brine Ponds: Upon removal of the liner material and final grading, the area will be scarified as discussed above for preparation of drill or broadcast seeding.

All seeding will follow as closely as possible after seedbed preparation has been accomplished for each area within the constraints of climatic conditions. As discussed above, optimum seeding time is between mid-June and mid-September. Planting in other time periods may be limited to the planting of preparatory crop.

Two methods of effectively seeding the area to be revegetated include drill and broadcast seeding. Drill seeding will be the primary method of seeding. Drill seeding offers uniform placement of seeds, requires fewer seeds per acre, can be drilled directly into preparatory crop stubble, and provides a uniform stand of seeded plants. All seeding will be conducted along the contour or at a right angle to the prevailing wind.

If broadcast seeding is used, seeding will be accomplished using a cyclone-type broadcaster. After seeding, the area will be conditioned by raking, harrowing, or other methods to ensure proper seed coverage with soil. Conditioning will be conducted on the contour or at a right angle to the prevailing wind.

During some years the revegetation program may not achieve desired results. A yearly evaluation will be made to determine revegetation success. If revegetation is not successful, the area(s) requiring revegetation will be reseeded with the appropriate seed mixture, contained in Table 5.

Mulch will be applied to all seeded areas to conserve soil moisture and protect against erosion. Application will immediately follow seeding and fertilization. Areas that were seeded with a preparatory crop may not require mulching when perennial species are seeded due to the stubble stand. This will have to be determined on an area-by-area basis. All slopes within the affected area will be gentle, so no special mulch (e.g., cellulose wood fiber, burlap netting, etc.) will be required. Straw or hay mulch will be used, applied at 2,000 pounds per acre. The straw or hay mulch will be anchored with a straw crimper. A commercial fertilizer will be applied at a rate recommended by the manufacturer.

Fencing will be used to control access into the license area. The fencing will inhibit casual entry and exclude livestock from the license area. The license area is already fenced, so only replacement or extension of this fence should be necessary. To enclose the property and separate it from public road rights-of-way, about 19,500 feet of three-strand barbed wire has been estimated, but only a fraction of this will be new fencing.

5.0 GROUND WATER RESTORATION AND MONITORING

As a result of ground water impacts found during the regional ground water survey conducted by the U.S. Environmental Protection Agency in 1975, HMC entered into an agreement with the New Mexico Environmental Improvement Division (NMEID), now the New Mexico Environment Department (NMED) to restore water quality outside the restricted area to background concentrations, or better, and to prevent the future migration of tailing seepage from the property. This agreement with the NMEID was formalized in August, 1976. Fresh water injection wells were installed along the southern border of HMC's property in June, 1977. This system of wells was designed primarily to reduce elevated concentrations of selenium, uranium and sulfate into ground water located in the subdivision to the south of HMC's operations. Additionally, a mound of water was to be formed by fresh water injection to create, in effect, a hydrologic barrier to prevent the future migration of waters containing elevated concentrations from HMC's property. In 1983 a second series of fresh water injection wells was installed along the southeast border of HMC's property. This system was designed to create a mound, or hydrologic barrier, to prevent the migration of waters containing elevated concentrations beyond the property boundary, as well as to accelerate the process of pushing these waters back toward the collection wells located around the downstream periphery of the tailing impoundments. The fresh water injection rate for each of these systems has averaged approximately 400 gallons per minute for the last several years. The locations of these wells are shown in Figure 14.

In addition to the ground water reclamation programs described above, HMC installed a system of collection wells (pump-back system) on the downstream side of the large tailing impoundment. This system was installed in 1978 and was designed to intercept all seepage from the tailing impoundment. The wells of the collection system are designed to pump at such a rate that an hydraulic gradient toward the wells from both the north and the south is created uniformly along the downstream side of the tailing impoundment. This local change in gradient toward the collection wells not only creates a barrier to future seepage flow (a trough), but pulls back and collects past seepage. The collection rate of this system has averaged slightly greater than 250 gallons per minute over the last several years.

In May, 1984, the NMEID approved HMC's Ground Water Protection Discharge Plan (Hydro-Engineering, 1981), acknowledging that the programs comply with the State's Ground Water Protection Regulations. A comparison of 1976 and 1986 San Mateo alluvial aquifer piezometric information shows that water levels and flow directions have been greatly changed by the remedial measures implemented by HMC. Collection wells around the tailing impoundment are presently intercepting all seepage from the facility and, in fact, are drawing water far out in the aquifer back toward the pump-back system. The injection systems have reversed the direction of flow from southward, toward the subdivisions, to northward, back toward the collection wells. The injection of fresh water has also greatly reduced the chemical constituent concentrations in ground water to well below background levels in the subdivisions downgradient of HMC's facilities. Through an extensive monitoring program, HMC has demonstrated that all ground water outside their restricted area has been returned to better water quality than background, or that allowed by the State's Ground Water Protection Standards.

In its Ground Water Protection Discharge Plan, submitted to the State of New Mexico, HMC has committed to continuing its ground water protection program until it can be demonstrated that when the systems are turned off any future seepage from the tailing facility will not cause the State's Ground Water Protection Standards to be exceeded at the property line. According to License Condition 36B(2), this program is projected to be completed by 5/1/2010. The collection system (which includes the collection wells, brine ponds and evaporation pond) will require operation for a considerable period of time after the reclamation of the tailing facility. This is because seepage will continue for some time after elimination of standing water from the tailing impoundment until storage of water in the tailings is down to or near its specific retention.

The complete ground water restoration plan has been submitted previously to the NRC under separate cover (Hydro-Engineering, 1989). The following is a summary of the current plan:

a) Ground water restoration at the Homestake mill must reduce the concentrations of the hazardous constituents on the average to the Site Standards for the San Mateo alluvial and Upper Chinle aquifers. The Site Standards for the Homestake site are as follows:

Chromium	0.06 mg/l
Molybdenum	0.03 mg/l
Selenium	0.10 mg/l
Vanadium	0.02 mg/l
Uranium	0.04 mg/l
Thorium-230	0.3 pCi/l
Radium-226 + Radium-228	5.0 pCi/l

b) The restoration program consists of collection and evaporation of impacted water to remove the hazardous constituents and injection of ground water from the San Andres aquifer to aid the collection. The injection systems drive the ground water with elevated concentration from Homestake's downgradient property boundary to the collection wells, where it is intercepted and then pumped to the evaporation pond.

c) To achieve satisfactory ground water restoration, seepage from the tailing impoundment must decline to a small enough value that after mixing of the seepage with the alluvial ground water flow and the transport of these constituents to the Points of Compliance, hazardous constituents do not exceed the Site Standards on the average. The estimated time to reach this condition is 10 to 15 years. It will take the majority of this period to push all of the hazardous constituents that are downgradient back to the collection wells. Wells in the small impoundment area will likely have to be used initially for collection and finally for injection to enable the southern area to be restored in this time frame. For example, wells KE, K2, and Y are currently being used for collection but will be switched to injection in the near future when this area is restored. Injection wells will be installed on the east side of the small tailing impoundment and on the west side of the mill near the zero saturation line to push elevated concentrations to the collection wells. This type of program will enable a steeper gradient to be maintained, thereby decreasing the time to push these constituents back to the collection wells.

d) The ground water underneath the tailing impoundments will also have to be restored toward the end of the restoration. The Upper Chinle is being restored by injection into well CW5 (Figure 14) and collecting the elevated concentration with the alluvial collection wells. The Upper Chinle and alluvium are connected near the tailings. The CW5 injection may be moved to CW4 after concentrations in this well are lowered.

e) A thorough monitoring program complying with License Condition 35 will be used to make adjustments in the restoration and also to prove the adequacy of the restoration.

f) The ground-water collection system, toe drains, and potential tailing dewatering programs will likely produce 400 gpm of water for several years. The present evaporation system and the use of water for construction purposes on the large tailing impoundment will enable the present system to handle the collection rate in 1994. Additional capacity will be needed after 1994. Additional lined evaporation ponds or water treatment with a reverse osmosis (RO) unit is being considered. The treated water would be used for injection while the poor quality portion would be evaporated. A 300 gpm RO unit, which would produce 200 gpm of treated water for injection, is being evaluated. The other option being evaluated is an additional 200 gpm of lined evaporation pond capacity. A license amendment will be submitted to the NRC after the design of selected options.

6.0 POST-CLOSURE CARE AND MONITORING

Upon completion of reclamation through Phase 1 demolition and large impoundment reclamation, it is anticipated that a modified ground water and settlement monitoring program will be performed. The following provides a brief description of the monitoring programs that will be implemented.

6.1 Ground Water Monitoring Program

During and after reclamation of the mill and large tailing impoundment, HMC will perform ground water monitoring in conjunction with its Ground Water Discharge Plan approved by the NMED and the NRC. Ground water samples will be taken from selected wells downgradient of the reclaimed tailing impoundment and from three wells upgradient. As indicated in Chapter 5.0, HMC will continue to operate the injection/collection well system to further clean up ground water in the San Mateo alluvium. This system will operate until it can be demonstrated, in accordance with License Conditions 35 and 36B(2), that the ground water will meet New Mexico State standards at HMC's property boundary or the exemptions/alternate concentration limits established by NRC. Monitoring will be conducted on an annual basis for a limited suite of parameters that have shown elevated levels in the past.

6.2 Monitoring and Inspection

Because the buildout of the large impoundment placed only tailing sands in the embankments enclosing the ponds, the only potential for settlement due to consolidation of slimes will be in the pond areas in the middle of the large tailing impoundment (see Section 4.2.1). To determine if settlement has occurred, HMC will install 50 settlement monitoring points at locations on the large impoundment top shown in Figure 6.

The monitoring points will be surveyed bi-weekly to quarterly to determine the amount of settlement until 90% of settlement due to primary consolidation has been achieved in accordance with License Condition 37F. The cover over the pond areas will be inspected annually for signs of depressions or other deformation which could compromise cover performance. In addition to the embankment top survey and inspection, an annual inspection of the rock cover on the impoundment slopes will be conducted to detect deterioration or erosion of the rock. These inspections and restoration maintenance will continue until transfer of ownership of HMC's interest to the state or federal government upon termination of the license.

7.0 SCHEDULE

The mill decommissioning process started in February, 1990 with HMC's mill closure. The decommissioning activities conducted during 1990 included removal of some PCB's and other hazardous chemicals from the site to licensed disposal facilities. These materials were not contaminated with radioactivity. General clean-up during 1990 was conducted as well, including a washing down of the mill equipment and buildings and removal of residual resource materials. As a necessary first step in the dewatering of the large tailing impoundment, Homestake constructed an evaporation pond on the small tailing impoundment during 1990. This allowed the discharge of collection well water to be switched from the large impoundment to the evaporation pond to initiate the process of dewatering the large impoundment. Most of the asbestos was removed from the mill facilities and buried in the large tailing impoundment during 1992. Also in 1992, HMC constructed a buried pipe drain system (toe drain) for collection of seepage around the entire perimeter of the large impoundment. In 1993 HMC started recontouring of the large impoundment and demolition of the mill facilities.

Table 2 shows the schedule for reclamation activities, beginning in October, 1993. If the sequence and timing of reclamation activities shown on Table 2 can be executed as shown, most reclamation activities of the site, with the notable likely exception of the radon barrier and rock cover on the large tailing impoundment, will be completed by the end of 1996. Activities remaining after 1996 include the completion of ground water restoration and monitoring program, the completion of dewatering of the large tailing impoundment pore water (directly linked to the ground water restoration time schedule), and the placement of the top radon barrier and rock cover if primary consolidation is still occurring in the large impoundment by the end of 1996.

8.0 COST ESTIMATE

HMC has prepared an estimate of all costs associated with the reclamation of its Grants operation. This estimate has been prepared in the format and sequence of the "Recommended Outline for Site-Specific Reclamation and Stabilization Cost Estimates," (NRC, 1988) and in accordance with the requirements of Criterion 9 of Appendix A, 10 CFR 40.

Although HMC would prepare a cost estimate for an undertaking this size under any circumstances, the primary purpose for the cost estimate that has been prepared and presented with this plan is to provide the basis for the surety arrangements required under the above-referenced Criterion 9. Therefore, the cost estimate includes some cost categories that would not necessarily be included in or incurred by Homestake in the actual reclamation process. Specifically, project management costs, long-term surveillance and contingency sums might be considerably different for a cost estimate for Homestake's internal purposes than for the primary purpose of a surety arrangement.

The estimates for each reclamation activity are described in Appendix E and summarized in Table 6. To the extent possible HMC's cost estimates are based on actual costs incurred by Homestake for identical or similar activities in the Grants area or at other HMC facilities. Where actual cost experience is not available, HMC has relied on unit prices for identical or similar activities in contractors' bids received during the last year, specifically for construction work related to large impoundment recontouring, rock quarrying, and mill demolition. Where neither actually-incurred costs nor bid unit prices were available, HMC has used unit prices from the 1993 Means Site Work Cost Data, 12th Annual Edition (R.S. Means, 1992) adjusted as appropriate for local economic conditions.

Taking into account all the elements contained in the above-referenced NRC guidelines in Criterion 9, the total estimated cost for reclamation of the Homestake Grants operation is $37.7 million.

REFERENCES

Bureau of Reclamation, 1988, "Probable Maximum Precipitation Estimate - United States between the Continental Divide and the 103rd Meridian," Hydrometeorological Report #55A.

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D'Appolonia Consulting Engineers, 1982, "State of New Mexico Environmental Improvement Division, Uranium Mill Licensing Renewal Application, Environmental Report," prepared for Homestake Mining Company - Grants, Albuquerque, New Mexico.

Environmental Protection Agency (EPA), 1989, "National Emission Standards for Hazardous Air Pollutants; Radionuclides; Final Rule and Notice of Reconsideration," 40 CFR 61, Federal Register Volume 54, No. 240, 12/15/89.

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Homestake Mining Company (HMC), 1988, "Responses to NRC Comments of August 12, 1988 on Homestake Reclamation Plan, 10/31/88."

Hydro-Engineering, 1981, "Ground Water Discharge Plan for Homestake's Mill near Milan, New Mexico," prepared for Homestake Mining Company.

Hydro-Engineering, 1989, "Ground Water Restoration Plan, Homestake Mining Company, Grants, New Mexico."

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Nelson, J.D., et al, 1986, Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments, NUREG/CR-4620, prepared for U.S. Nuclear Regulatory Commission.

NRC (U.S. Nuclear Regulatory Commission), 1977, "Design Construction and Inspection of Embankment Retention Systems for Uranium Mills," Regulatory Guide 3.11, Office of Standards Development.

NRC (U.S. Nuclear Regulatory Commission), 1988, Recommended Outline for Site-Specific Reclamation and Stabilization Cost Estimation.

NRC (U.S. Nuclear Regulatory Commission), 1989A, "Criteria Relating to the Operation of Uranium Mills and the Disposition of Tailings or Waste Produced by the Extraction or Concentration of Source Material from Ores Processed Primarily for Their Source Material Content," 10 CFR 40, Appendix A.

NRC (U.S. Nuclear Regulatory Commission), 1989B, "Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers," Regulatory Guide 3.64.

NRC (U.S. Nuclear Regulatory Commission), 1990, "Final Staff Technical Position, Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailing Sites."

SCS (U.S. Soil Conservation Service), 1986, "Draft Report, Soil Survey, Cibola County, New Mexico," excerpts provided by Steve Park, SCS, Grants, New Mexico.

TABLE 1

MILL FACILITIES AND COMPONENTS

- **ORE RECEIVING SECTION**
  1. ORE RECEIVING SCALE
  2. ORE STORAGE PAD
- **CRUSHING AND SAMPLING SECTION**
  3. GRIZZLY
  4. CRUSHER
  5. ROTARY DRYER
  6. RECIPROCATING SAMPLERS
- **FINE ORE STORAGE SECTION**
  7. FINE ORE BINS
- **GRINDING SECTION**
  8. BALL MILLS
  9. THICKENER TANKS
- **URANIUM LEACHING SECTION**
  10. PRESSURE LEACHING AUTOCLAVES
  11. ATMOSPHERIC LEACHING PACHUCA TANKS
  12. FILTERS
      12A. VACUUM PUMPS
  13. SOLUTION STORAGE TANK
  14. TAILING SLURRY PIPELINE
  15. TAILING POND ION EXCHANGE
- **PRECIPITATION SECTION**
  16. PREGNANT SOLUTION
  17. PRECIPITATION TANKS
  18. PRECIPITATION TANKS
  19. PRECIPITATE THICKENER TANKS
- **VANADIUM REMOVAL SECTION**
  20. ROASTING FURNACE
- **PACKING-STORAGE AND SHIPPING SECTION**
  21. YELLOWCAKE DRYING FURNACE
  22. YELLOWCAKE PACKAGING
  23. YELLOWCAKE DRUM STORAGE AND LOADOUT
- **MISCELLANEOUS STRUCTURES**
  24. ADMINISTRATIVE BUILDING
  25. GARAGE
  26. SHOP
  27. WAREHOUSES
  28. LABORATORY
  29. OLD FACILITIES (INOPERATIVE SINCE 1961)
  30. ELECTRIC SHOP
  31. INSTRUMENT SHOP
  32. CARPENTER SHOP
  33. CHANGE HOUSE
  34. POWER HOUSE
  35. ENVIRONMENTAL LAB
  36. COMPRESSOR HOUSE
  37. ELECTRICAL STORAGE
  38. WATER TOWER
  38A. WATER TOWER
  39. ORE TRUCK SHOPS

```
                                                                           CALENDAR MONTHS
CONTRACT # / Activities Included   |                       1993                          |                       1994                          |                       1995                     |
                                   |  1    2    3    4    5    6    7    8    9   10   11   12 |  1    2    3    4    5    6    7    8    9   10   11   12 |  1    2    3    4    5    6    7    8    9   10   11   12 |

EARTHWORK

     LARGE IMPOUNDMENT:

#4152  Recontouring                                                  >====*====*====*=============================================.
                                                                                     *
       Scrap Cleanup                                                 >=============================================================.
                                                                                     *
       Contaminated Soil Cleanup.                                                    *         > = =*= = * = =*= = * = =*= = *= = = = = = = = = = = = = = =
                                                                                     *         *                             *
       Borrow Area Preparation                                                       *====*====*=====                        *
                                                                                                                             *
                                                                                                                             *
       Interim Cover, Top and                                                                                                *====*====*====* (top large pile) ===== (S. end Small Pile)
        S. end Small Impoundment                                                                                                            *
                                                                                                                                            *
       Radon Barrier, Outslopes                                                           .= = = = = ==================================
                                                                                                                          (stockpile cover soils as surcharge on top of pond centers)
       Radon Barrier, Top                                                                                                .= = = =*= = * = =*= = * = =*= = * = =*= = * = =*= = * = =*                   .(1)
       Rock Cover, Outslopes                                                                                              ===============================
        (includes scour trench)
       Rock Cover, Top                                                                                                                                            .= = = = = = = = = = = = = = = = = = = = (2)
       Radiological Soil Sampling                                          = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = = =

     MILL AREA:

       Mill Area Cover                                                                                 ======:=========
       Diversion Levee                                                                                                                               ================

     ROCK QUARRYING AND CRUSHING.                                                              ==================================================================

     SMALL IMPOUNDMENT:

       Ponds Removal                                                                                                                                                                          .(3)
        (evaporation and brine)
       Recontouring                                                                                                                                                                           .(3)
       Radon Barrier                                                                                                                                                                          .(3)
       Rock Cover                                                                                                                                                                             .(3)

MILL AND SITE DECOMMISSIONING

     Asbestos Removal/ Burial        (started in 1992)             ======
#4153 Mill Demolition                                              ========================================================
     Long-term Maintenance
      and Ground Water
      Cleanup Facilities

SITE RECLAMATION

     Regrading, Revegetation
      and Fencing:
     1st Phase - Most of Site                                                                                                                              .==================================.
     2nd Phase - Pond and                                                                                                                                                                     .(3)
       Maintenance Areas
```

> Start activity ===== Continuous Activity = = = Intermittent activity * Critical Path activity

Notes: (1) Placement of radon barrier on top of large impoundment will begin when settlements allow, as approved by NRC. 4-8 months to complete, depending on final thickness.
(2) Rock cover placed immediately after completion of top radon barrier. See note (1).
(3) Performed after completion of ground water restoration.

APERTURE CARD

Also Available on Aperture Card

9810280099-1

TABLE 3 Revised 10/93

SUMMARY OF TAILING, SOIL AND ROCK PROPERTIES

HOMESTAKE MINING COMPANY, GRANTS OPERATION

MATERIAL	PROPERTIES (listed in order of input to RADON calculation)							
	Porosity	Density, dry; g/cm^3	Radium Activity pCi/g	Emanation Coeff.	-#200 sieve fraction	Moisture Content, weight %	% Clay Content -.002mm	Organic Content %
Large Pile								
Sand tailings	0.42 (a)	1.54 (1)	167 (2)	0.34 (2)	0.15 (1)	11.50 (3)	n/a	n/a
Slimes	0.55 (a,3)	1.19 (3)	582 (2)	0.33 (2)	n/a	41.7 (3)	n/a	n/a
Small Pile								
Sand tailings	0.47 (a,3)	1.41 (3)	408 (2)	0.39 (2)	n/a	11.50 (3)	n/a	n/a
Slimes	0.55 (a,3)	1.19 (3)	732 (2)	0.47 (2)	n/a	41.70 (3)	n/a	n/a
Alluvial Soil (at 95% max. density per ASTM D-698)								
Clay (CL, CH)	0.42 (a,8	1.53 (4,6,8)	5	n/a	0.732 (4,6,8)	19.41 (c)	46.4 (4,6,8)	2.47 (5,8)
Clayey Sand (SC)	0.36 (a)	1.66 (4,6,8)	5	n/a	0.349 (4,6,8)	10.00 (c)	21.8 (4,6,8)	1.92 (5,8)
Silty Sand (SM, SP-SM)	0.38 (a)	1.65 (4,6,8)	5	n/a	0.233 (4,6,8)	6.6 (c)	11.6 (4,6,8)	1.53 (5,8)

Rock Properties - Malpais Basaltic Lava

Depth ft	No. of Samples	Spec Grav SSD	Absorp. %	Soundness % loss	Abrasion % loss	Hardness SRU	Tensile psi	Ave. Rating
0-5	8	2.43	2.48	1.18	33	52.4	853	67.2
below 5	22	2.60	1.66	0.75	27.71	40.2	1074	83.0
0-50	27	2.57	1.81	0.79	26.2	39.7	1059	80.7

References for listed properties

(1) D'Appolonia Consulting Engineers, 1980, "Stability Assessment, Uranium Mill Tailings Pond"
(2) Rogers and Associates Engineering Corp., 1989, letter report of tests of radium and radon emana active and inactive tailings; 2/24/89
(3) Daniel B. Stephens and Associates, Inc., 1989, "Laboratory Analysis of Hydraulic Properties of Uranium Mill Tailings from the Homestake Mine in Grants, New Mexico", Sept. 1989
(4) Soil Test reports of Fox and Associates dated 11/5/87, 10/12/87, 10/1/87, and 9/30/87
(5) Assaigai Analytical Laboratories, 1989, Organic content test results, March 13, 1989
(6) Sergent, Hauskins, and Beckwith, 1986, soil test reports of 7/28/86, 7/31/86, 8/22/86, 9/3/86
(7) Vinyard and Associates, 1990, laboratory tests of 12 rock samples from Malpais lava, Sec. 28
(8) Vinyard and Associates, 1991-1993, laboratory tests on borrow soils samples from test pits TP58

Calculation equations for listed properties

(a) 1-(dry density/2.65)
(b) Eqn. 14, NUREG/CR 3533, with 10.37"/yr rainfall and 60"/yr evap.
(c) Eqn. 5, Reg. Guide 3.64, June 1989

TABLE 4

PMP/PMF PARAMETERS FOR SAN MATEO CREEK

Watershed Area	291 square miles
Design Storm (PMP)	
Duration	24 hours
Rainfall	12.2 inches
Peak PMF Discharge	169,800 cfs
Time to Peak	5.75 hrs.
Hydrograph Length	31.5 hrs.
Peak Water Surface Elevations on Large Impoundment Outslopes	
at SW corner	6572.5
at NW corner	6585.5
at NE corner	6592.8

References:

1) USGS "Grants" and "Chaco Mesa" Topographic maps; 1:250,000
2) Hydrometeorological Report 55A
3) THYD and HEC-2 computations, Jan. 1988

TABLE 5

REVEGETATION SEED MIXTURE

SCIENTIFIC NAME	COMMON NAME	SEEDING RATE (DRILL SEEDING)		
		GROWTH HABIT[1]	LBS PURE LIVE SEED/ACRE	NUMBER OF SEEDS/FT²
Grasses				
Agropyron smithii	Western wheatgrass	NS	4.0	10.1
Bouteloua gracilis	Blue grama	NB	2.0	37.9
Sporobolus cryptandrus	Sand dropseed	NB	0.5	60.8
Oryzopsis hymenoides	Indian ricegrass	NB	3.0	9.7
Sporobolus airoides	Alkali sacaton	NB	0.5	20.2
Shrubs				
Atriplex canescens	Four-wing saltbush	--	0.5	0.6

[1]NB - Native Bunchgrass
NS - Native Sod

TABLE 6

SUMMARY OF RECLAMATION COST ESTIMATE - REVISED 10/93

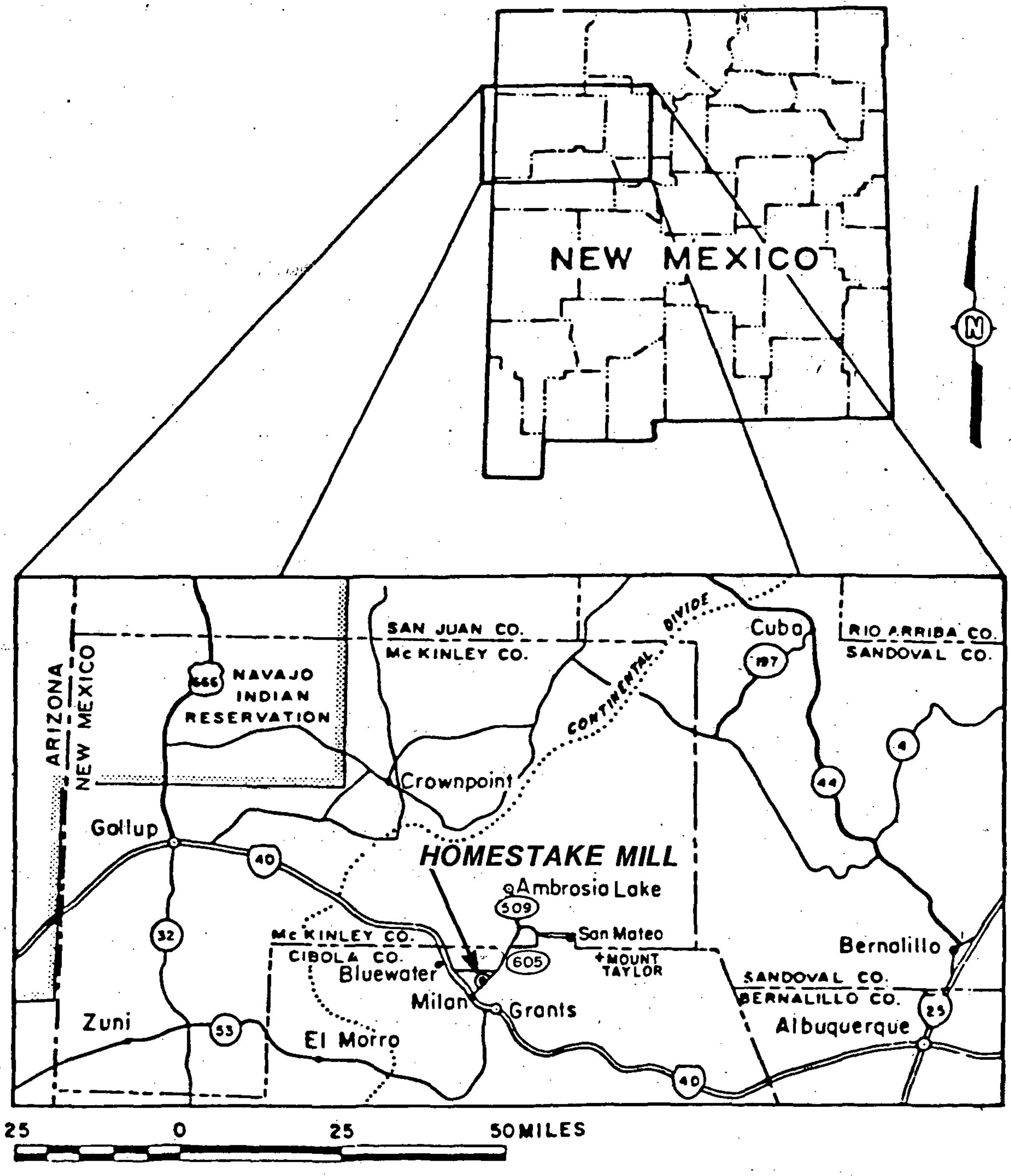
HOMESTAKE GRANTS OPERATION

TASK	Activity/units	UNIT PRICE	QUANTITY	ACTIVITY OR ITEM COST	TASK COST
I. FACILITY DECOMMISSIONING					$2,375,062
	Heavy Contamination and PCB Removal			$10,000	
	Asbestos removal (contractor estimate)	80% complete, 20% left		$35,000	
	Mill Demolition (see Appendix E)	lump sum	actual bid	$1,635,000	
	Cover and regrade mill area			$359,408	
	Soil Cleanup			$300,000	
	Site Recontouring			$35,654	
II. GROUND WATER RESTORATION AND WELL PLUGGING					$8,255,000
	Ground Water Restoration and Monitoring			$8,216,000	
	Well Plugging			$39,000	
III. INTERIM STABILIZATION OF TAILINGS					$460,785
	Interim Soil Cover, top of large impoundment			$398,577	
	Interim Soil Cover, small pile			$62,208	
IV. TAILING IMPOUNDMENT AREA RESTORATION					$19,512,334
	Recontouring, c.y.				
	Large impoundment		1867000	$3,650,775	
	Small impoundment		222000	$112,936	
	Settlement Monitoring, large pile			$35,000	
	Soil Cover				
	Borrow area prep/acre		627	$24,604	
	Large pile/c.y.		2314566	$7,036,281	
	Small pile/c.y.		1211600	$3,683,264	
	Erosion Protection of Piles (rock cover)				
	Rock quarrying, crushing, screening /c.y.		334506	$2,090,663	
	Rock cover placement /c.y.		320339	$1,698,559	
	Riprap placement/c.y.		14167	$5,608	
	Revegetation/acre	$600	750	$450,000	
	Levee Construction/c.y.		55880	$169,875	
	Brine Pond Removal			$97,735	
	Quality Control			$435,000	
	Fencing/lineal ft	$1.13	19500	$22,035	

TABLE 6 continued

TASK	Activity/units	UNIT PRICE	QUANTITY	ACTIVITY OR ITEM COST	TASK COST
V. RADIOLOGICAL SURVEY AND ENVIRONMENTAL MONITORING (1991 costs x 1.1)					$746,972
	Radiological Surveys				
	Soil surveys			$108,781	
	Gamma surveys			$99,025	
	Decommissioning Equipment and Smears			$124,355	
	Radon Flux Measurements			$30,030	
	Radiological Health and Safety Procedures (Environmental and Occupational Radiological Monitoring)			$373,560	
	Bioassays and TLD's , for contractor personnel			$11,220	
VI. PROJECT MANAGEMENT					$900,000
VII. LABOR AND EQUIPMENT OVERHEAD, CONTRACTOR PROFIT	These costs included in the work units				
VII. LONG-TERM SURVEILLANCE AND CONTROL	(1991 costs x 1.1)				$539,000
SUBTOTAL					$32,789,153
CONTINGENCY	15% of Subtotal				$4,918,373
TOTAL ESTIMATED COST OF PURPOSES OF SURETY					$37,707,525

(See Appendix E for cost details)



REFERENCE

STATE OF NEW MEXICO HIGHWAY MAP,
RAND MC NALLY AND COMPANY, 1970,
SCALE : 1" = 25 MILES.

FIGURE 1

SITE LOCATION MAP

HOMESTAKE GRANTS MILL

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

AK GeoConsult, Inc.

Date: 11/15/90

THE FOLLOWING PAGES ARE OVERSIZED DRAWINGS OR FIGURES,

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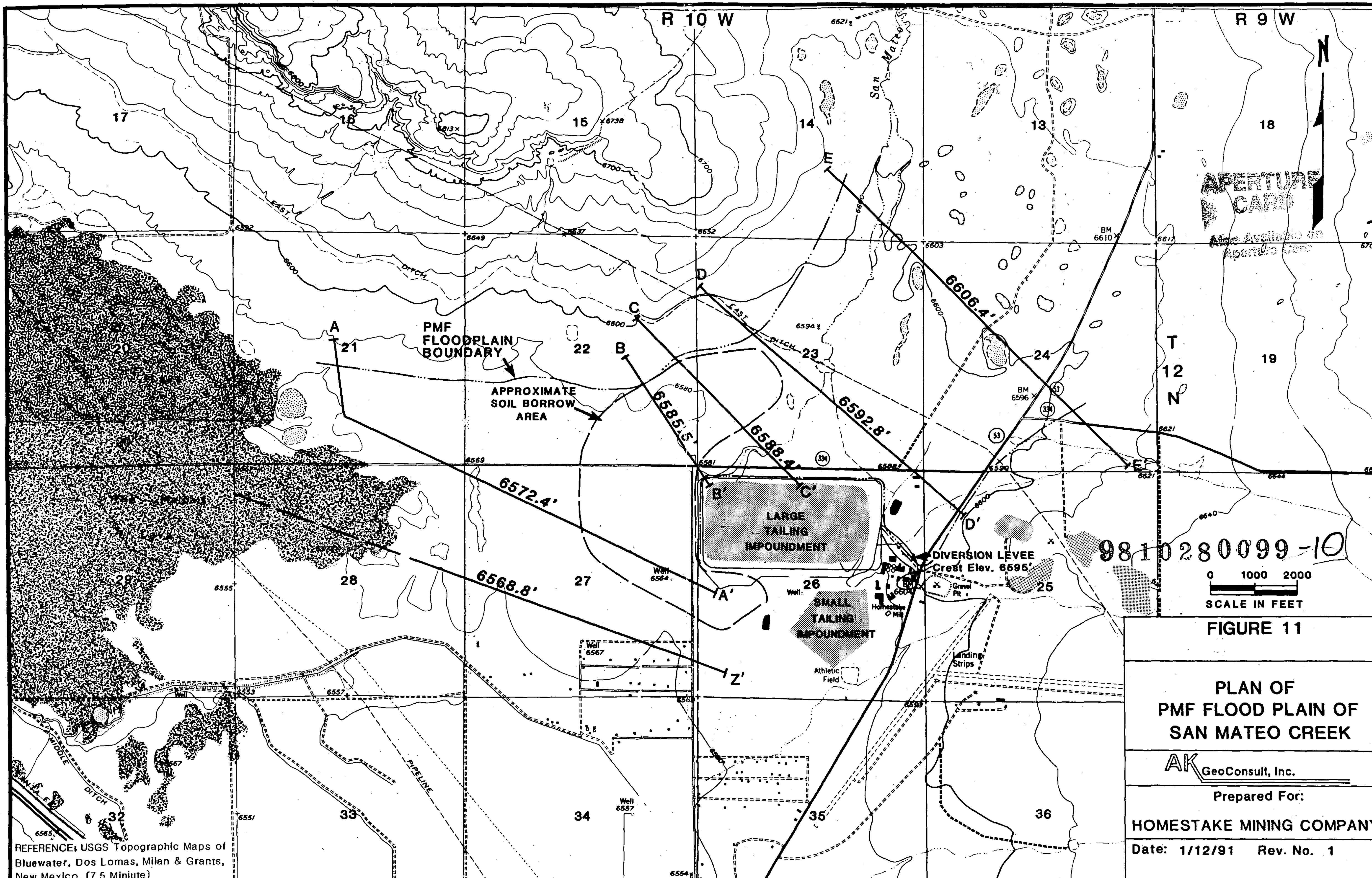
FIGURES 2 THROUGH FIGURES 10

D-01 THROUGH D-09


R 10 W
R 9 W
N
T
12
N
PMF FLOODPLAIN BOUNDARY
APPROXIMATE SOIL BORROW AREA
LARGE TAILING IMPOUNDMENT
SMALL TAILING IMPOUNDMENT
DIVERSION LEVEE Crest Elev. 6595'
Homestake Mill
Gravel Pit
Athletic Field
Landing Strips
EAST DITCH
MIDDLE DITCH
PIPELINE
San Mateo
6572.4'
6568.8'
6585.5'
6588.4'
6592.8'
6606.4'
A
A'
B
B'
C
C'
D
D'
E
E'
Z'
Well 6564
Well 6567
Well 6557
BM 6610
BM 6596
0 1000 2000
SCALE IN FEET
FIGURE 11
PLAN OF PMF FLOOD PLAIN OF SAN MATEO CREEK
AK GeoConsult, Inc.
Prepared For:
HOMESTAKE MINING COMPANY
Date: 1/12/91 Rev. No. 1
REFERENCE: USGS Topographic Maps of Bluewater, Dos Lomas, Milan & Grants, New Mexico. (7.5 Miniute)
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D-10 THROUGH D-12