ENCLOSURE 2

LIST OF PERTINENT REFERENCE DOCUMENTS

LIST OF PERTINENT REFERENCE DOCUMENTS

NUREG/CR-2642 - Long-Term Survivability of Riprap for Armoring Uranium Mill Tailings and Covers: A Literature Review, 6/82

NUREG/CR-2684 - Rock Riprap Design Methods and Their Applicability to Long-Term Protection of Uranium Mill Tailings Impoundments, 8/82

NUREG/CR-2768 - Literature Review of Models for Estimating Soil Erosion and Deposition from Wind Stresses on Uranium Mill Tailings Covers, 11/82

NUREG/CR-3027 - Overland Erosion of Uranium Mill Tailings Impoundments: Physical Processes and Computational Methods, 3/83

NUREG/CR-3199 - Guidance for Disposal of Uranium Mill Tailings: Long-Term Stabilization of Earthen Cover Materials, 10/83

NUREG/CR-3533 - Radon Attenuation Handbook for Uranium Mill Tailings Cover Design, 4/84

NUREG/CR-4076 - Determination of Compliance with Criteria for Final Tailings Disposal Site Reclamation, 6/85

NUREG/CR-4118 - Monitoring Methods for Determining Compliance With Decommissioning Cleanup Criteria of Uranium Recovery Sites, 6/85

NUREG/CR-3457 - Validation of Methods for Evaluating Radon Flux Attenuation Through Earthen Covers, 10/84

NUREG/CR-4075 - Designing Protective Covers for Uranium Mill Tailings Piles: A Review, 5/85

NUREG/CR-3747 - The Selection and Testing for Armoring Uranium Tailings Impoundments, 5/85

NUREG/CR-3397 - Design Considerations for Long-Term Stabilization of Uranium Mill Tailings Systems, 10/83

NUREG/CR-3751 -	Effects of Rock Riprap Design Parameters on Flood Protection Costs for Uranium Tailings Improvements, 7/84
NUREG/CR-3752 -	Effects of Hydrologic Variables on Rock Riprap Design for Uranium Tailings Impoundments, 1/85
NUREG/CR-2340 -	A Handbook for the Determination of Radon Attenuation Through Cover Materials, 12/81
NUREG/CR-2769 -	Comparison of Field-Measured Radon Diffusion Coefficients with Laboratory-Measured Coefficients, 4/83
NUREG/CR-2924 -	Radon Diffusion in Candidate Soils for Covering Uranium Mill Tailings, 4/83

HOMESTAKE MINING COMPANY
P.O. BOX 98
GRANTS, NEW MEXICO
87020-0011

June 13, 1986

CERTIFIED MAIL NO.: P 713 183 661

Mr. Robert D. Martin
Regional Administrator
United States Nuclear Regulatory
Commission
Region IV
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

Re: License No. SUA-708

Dear Mr. Martin:

This letter is written pursuant to your letter of March 22, 1986, asking for a voluntary commitment on Homestake's part to submit a detailed tailings reclamation plan. Homestake wishes to cooperate with your process in this matter, and will voluntarily submit such a plan. At the same time, Homestake wishes to reserve all of its legal positions in this matter, and will submit the plan without prejudice to any of its rights. We understand from our May 29 conference that this reservation is satisfactory to NRC.

Homestake and its contractor feel the NRC recommended date of October 1 is too tight for our operation. Homestake feels confident that a document can be provided by December 1, 1986. We will furnish you other details on the time schedule in the interim.

Sincerely yours,

HOMESTAKE MINING COMPANY

Edward E. Kennedy
Director of Environmental
Affairs

EEK:SC:jg

Enclosure

cc: Harry Pettengill
J. M. Parker
W. A. Humphrey
D. B. Crouch
G. S. Crout

HOMESTAKE MINING COMPANY - GRANTS

Schedule for Decommissioning and Reclamation
License SUA-708

1986

June	July	August	September	October	November	December
9 20 23	1 7 15 21 31	4 10 31	1 15 30	1 15 31	1 15 30	1

1. Corporate (SFO) Review and Approval of Study Proposal.
2. Bid Task 1 Job - Borrow Material Study
3. Task 1 Field and Lab Work
4. Task 1 - Compile Data and Perform Analysis (Final Report)
5. Bid Task 2 Job - Radon Emanation and Control Modelling Study -vs- Real Data
6. Setup Task 2 Model, Verify, Debug, Sample Run
7. Task 2 - Model HMC Site Specific Rn Emanation Control (Final Report)
8. Task 3 - Review HMC's Current Decommissioning and Stabilization Proposal and Compare With NRC Criteria (Variance Report)
9. Task 4 - General a Site Decommissioning and Reclamation Plan
10. HMC Review and Approval
11. Submit Site Decommissioning and Reclamation Plan to NRC

060586

fed gov 2.2.6

~~HOMESTAKE MINING COMPANY GRANTS~~ (COMPANY)

TO J. M. Parker **DATE** June 5, 1986

FROM E. E. Kennedy **SUBJECT** June 13, 1986 Submitted to NRC

Attached, please find a copy of the proposed compliance letter to be submitted to the Nuclear Regulatory Commission (NRC) on June 13, 1986, pursuant to their letter of May 22, 1986. The proposal includes a schedule for submitting a site decommissioning and reclamation plan, in compliance with federal criteria, to the NRC on December 1, 1986. It also includes time for HMC review of the study proposal and review of the completed document prior to submittal to the NRC. We will be provided estimated costs for completing the studies, analyses and report generation on June 16, 1986. This information shall be telecopied to the appropriate individuals on that date for their review.

Should any adjustments to the proposal be necessary, please notify me by June 12, 1986.

Ed

Edward E. Kennedy

EEK:jg

Attachment

cc: W. A. Humphrey
D. B. Crouch
G. S. Crout

HOMESTAKE MINING COMPANY
P.O. BOX 98
GRANTS, NEW MEXICO
87020

June 5, 1986

CERTIFIED MAIL NO.: P 713 183 661

Mr. Harry Pettengill, Branch Chief
U.S. Nuclear Regulatory Commission
Region IV
Uranium Recovery Field Office
Post Office Box 25325
Denver, Colorado 80225

Re: License No. SUA-708

Dear Mr. Pettengill:

This letter is written pursuant to Mr. Robert Martin's letter of May 22, 1986 concerning a commitment to submit for NRC review and approval a reclamation plan designed to meet the NRC standards.

This commitment to submit a reclamation plan designed to meet the NRC standards is not, nor should it be deemed, an agreement or acknowledgement that those standards are lawful or applicable in New Mexico or that Homestake Mining Company must comply with those standards. Homestake Mining Company reserves the right to challenge, in administrative or judicial proceedings, the lawfulness of the NRC standards and the imposition of those standards in New Mexico. This commitment is subject to the final judicial determination in Quivera Mining Company, Kerr-McGee Chemical Corporation, Homestake Mining Company of California, and United Nuclear Corporation v. United States Nuclear Regulatory Commission, No. 85-2853 (10th Cir.).

Attached, please find a schedule for submitting Homestake Mining Company's (HMC's) site decommissioning and reclamation plan designed to comply with the NRC standards. You will note that HMC's proposed schedule shows a submittal date of December 1, rather than the NRC recommended October 1 deadline. Homestake and its contractor feel that the October 1 deadline is too tight to provide the NRC with a document that would demonstrate sufficient compliance with federal standards. The NRC has expressed on numerous occasions the importance of submitting complete and quality information so that an efficient high-caliber review can be accomplished. Homestake feels confident that such a document can be provided for NRC review and approval by December 1, 1986.

If you have any questions or comments concerning this schedule, please don't hesitate to contact me.

Very truly yours,

HOMESTAKE MINING COMPANY

Edward E. Kennedy
Director of Environmental
Affairs

EEK:jg

Attachment

cc: J. M. Parker
W. A. Humphrey
D. B. Crouch
G. S. Crout

ALAN K. KUHN, Ph.D., P.E.
CONSULTANT IN GEOLOGICAL ENGINEERING AND APPLIED GEOSCIENCES
13212 Manitoba Drive NE, Albuquerque, NM 87111-2955 505-298-9839

June 13, 1986

Mr. Ed Kennedy
Homestake Mining Company
P.O. Box 98
Grants, NM 87020

PROPOSED WORK PLAN
MILL DECOMMISSIONING AND TAILINGS STABILIZATION STUDIES
FOR NRC COMPLIANCE

Dear Ed:

This letter describes the scope of work, schedule, and estimated costs of the several tasks that will be required to evaluate the Homestake decommissioning and stabilization plan for compliance with NRC standards. In accordance with our discussions of June 4, four tasks will be performed. The following section describes these tasks. Later sections lay out the proposed schedule and the estimated costs of each task and the entire effort.

SCOPE OF WORK

This work will be performed primarily by myself, as principal investigator, with major assistance from Gene Jenkins. We were instrumental in preparation of the 1982 UMLRA Environmental Report and, consequently, can bring that experience to bear on this study. I will direct and oversee all tasks. Gene will contribute primarily to tasks 3 and 4. A drilling contract and soil testing contract will be issued by HMC for Task 1 services. For Task 2 modeling I suggest that Triad, Inc. be contracted. I have confidence that they can do the work well and cost effectively and that they will cooperate closely with us.

Task 1 - Borrow (Cover) Material Study

This task will investigate the quantities and physical properties of soils on the Homestake property north of the main tailings pile. Test borings and possibly test pits will be made to profile the soils and to collect samples for testing. An area of about 2000 by 5000 feet will be studied using 15-20 borings to depths of 20-25 feet. I will prepare a brief specification for Homestake (HMC) to use in contracting a drilling service. I or my representative will supervise the drilling, log the borings, and collect soil samples. Depending on the results of the borings, several test pits might be recommended. It is assumed that these pits would be dug by HMC.

HMCSL024555

Selected samples will be tested for grain size analysis, Atterberg limits, moisture content and Standard Proctor density. HMC will probably perform the grain size and moisture tests, and a commercial lab will perform the other tests. For planning purposes we should expect that 40-50 grain size analyses, 30 moisture contents, 20 Atterbergs, and about 20 Proctor density tests will be performed.

Following testing, final logs will be prepared and cross sections of the borrow area will be developed as the documentation for evaluation of the soils as potential cover material. This evaluation will consider the types and quantities of soils available, their compaction characteristics and compacted properties (e.g.; porosity, permeability, cohesion) and their likely stability behavior.

Task 2 - Radon Emanation Modeling

This task will consist of several types of modeling of the radon flux from the pile. Input will include HMC radon monitoring data, Task 1 soil properties, site meteorological data, and assumed thicknesses of soil cover. The NRC-approved code RAECOM will be used for the "forward" model (prediction of flux/concentration based on radium/radon analysis of tailings). The code HAZMAT will also be used in the "forward" model and will be used to model the "back-fit" analysis (prediction of emanation from perimeter radon measurements). HAZMAT combines AIRDOSE, an NRC-approved code for modeling release rates and dispersions, with the RADMAT code, approved by NRC for radwaste package performance assessment and reviewed by NRC for radiation accident modeling. RAECOM will be run on a microcomputer while HAZMAT will be run on an IBM 3600 accessed locally.

Both "forward" and "back-fit" modeling will require input of HMC radon monitoring data and data from HMC testing of tailings. These data and the data collection program will be evaluated for statistical validity of sampling per the EPA 520 guidelines, and for comparison to the NRC-recommended procedures for radon flux measurement (NUREG CR-3166). The latter will be used to select data for input to the models.

The major portion of this task will be performed by Triad, Inc. of Albuquerque if approved by HMC. Triad is a relatively new firm but composed of staff with extensive backgrounds in modeling of radiation emissions, dispersions, and exposures. A statement of their capabilities is attached to this letter.

The "forward" modeling will include scenarios both with and without a soil cover over the tailings. The version without a cover will be compared to the "back-fit" model. However, scenarios that depict a covered pile will not be comparable to the "back-fit" version and will be used to evaluate the effectiveness of several (probably three) different cover thicknesses.

Triad's work will be directed and coordinated by Alan Kuhn with assistance from Gene Jenkins. This will assure that the results of Task 1 are properly included in this task, and that the output of the modeling is integrated with the other tasks.

Task 3 - Review and Evaluation of Existing Plan

In this task the stabilization and reclamation plan contained in the 1982 UMLRA Environmental Report (ER) will be evaluated with respect to current applicable NRC and EPA regulations. This evaluation will consist of several parts. First, the old NMEID regulations will be compared to the current federal regulations to identify the differences that need to be addressed. Second, the current HMC operational and build-out plans will be contrasted to the 1982 plans, and the differences will be quantified to the extent possible. These comparisons will lead to the next step, the identification of data categories requiring updating (e.g., final total volume of tailings) before an accurate compliance assessment can be made.

This task will be performed primarily by Alan Kuhn and Gene Jenkins. They will rely on input from HMC, of course, and will draw as needed on assistance from Triad.

Task 4 - Assessment of Compliance Status and Needs

This task brings together the results of the previous tasks and provides an assessment of HMC's status with respect to complying with federal standards. Each standard will be listed, HMC's level of compliance described, and the needed compliance measures, if any, identified. Recommendations for actions to achieve compliance will provided, as well.

The issues most likely to be in question as noncompliant include the thickness of the soil cover, provision for mill decommissioning and decontamination, and flood protection. The first two tasks will provide the data and analyses to address the soil cover question. The mill D & D issue is relatively straightforward and can be treated within the revised tailings stabilization plan. The flood protection issue will require calculations of the PMP and PMF; however, these calculations are not included in this work plan.

SCHEDULE

The schedule proposed for this scope of work conforms to the milestones and due dates that we discussed on June 4. The schedule for each task is outlined below and illustrated on the attached figure.

SCHEDULE OF TASK ACTIVITIES

Task 1 - Borrow Study

6/20 - 6/30 Prepare drilling and testing specs. and plan
7/1 - Request drilling and testing bids
7/10 - Award drilling and testing contracts
7/15 - 7/22 Soil drilling and sampling (test pits to follow if necessary)
7/17 - 8/10 Soil testing
8/10 - 8/31 Borrow material evaluation

Task 2 - Radon Emanation Modeling

6/20 - 7/1 Prepare task description and input data
7/1 - 7/21 Place modeling contract (If competitively bid: Issue RFP 7/1, Receive proposals 7/15, award 7/21). If Triad is sole source, this step is eliminated.
7/21 - 8/10 Model set-up and verification with sample run for approval.
8/11 - 8/31 "Forward" and "Back-fit" modeling and reporting

Task 3 - Review and Evaluation of Existing Plan

6/20 - 7/15 Compare old and current regulations
7/15 - 8/31 Evaluate plan and identify nonconformance issues

Task 4 - Assessment of Compliance Status and Needs

9/1 - 9/15 Assemble and integrate results of tasks 1,2, and 3.
9/15 - 10/31 Complete assessment and prepare report.
11/1 - 11/30 Report reviewed by HMC and revised as necessary.
12/1 - Submittal of report to NRC.

```
         JUNE     JULY      AUGUST   SEPT      OCT       NOV       DEC
       ---------*---------*---------*---------*---------*---------*---------*

TASK 1

 Drilling  20--30--15---22
              ^ spec
                  ^bid
                      ^drill

 Testing   20--30--15-------8
              ^spec   ^test
                 ^bid

 Evaluation                 8------31> (input to Task 3,4)

TASK 2
           20---1-------21----11----31> (input to Task 3,4)
              ^input
                    ^contract
                            ^sample run
                                  ^modeling

TASK 3
           20------15---------------31
               ^ regulation review
                          ^ plan evaluation

TASK 4
                                    1---15------------31----------1
                                      ^ integrate task results
                                              ^ compliance needs/ report
                                                            ^ HMC review/
                                                              revisions
                                                                  ^
                                                            Submit to NRC

          JUNE     JULY      AUGUST   SEPT      OCT       NOV       DEC
        ---------*---------*---------*---------*---------*---------*--------*
--------------------------------------------------------------------------------
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FIGURE 1. SCHEDULE OF TASKS

ESTIMATE OF COSTS

The scope of work described above is the effort that both you and I expect to be required. However, the actual work could be somewhat greater or less than anticipated. Given this uncertainty in level of effort, the following costs are only estimates, provided for planning and budgeting purposes. However, these estimates will be treated as upper limits not to be exceeded without prior approval of HMC. Furthermore, HMC will be informed as early as possible if any activity is likely to cost more than the estimate. In any case, accrued costs versus progress will be reported to HMC on a monthly basis.

The breakdown of estimated costs by category and task is given on the attached table. In summary, the estimated costs for each task are:

Task 1 - $16,530 ($5100 for drilling and testing)
Task 2 - $19,208 ($15065 for modeling)
Task 3 - $15,836
Task 4 - $13,948

The estimated total cost for all tasks, including all contracted parties, is $65,522.

If you have any questions about this study plan, please contact me. I look forward to working with you on these tasks.

Yours truly,

Alan K. Kuhn

Alan K. Kuhn

attachment

COST ESTIMATE
DECOMMISSIONING AND STABILIZATION STUDIES

TASK NO.	LABOR (category/hours/cost)	TRAVEL	OTHER DIRECT COSTS *	NMGRT	TOTAL
1	A/80/6000 C/80/3600 E/25/500	500	300	530	11,430
	Drilling Contract - mob/demob $400 + drilling $2160 + NMGRT + 10% contingency =				3,000
	Testing Contract (Proctor and Atterberg tests) - 20 each at $65 and $25, + NMGRT + 10% continency =				2,100
					16,530
2	A/50/3750	100	100	193	4,143
	Triad Contract B/90/5400 D/190/6665 E/25/500	400	1400 **	700	15,065
					19,208
3	A/120/9000 C/100/4500 E/10/200	1200	200	736	15,836
4	A/100/7500 C/80/3600 E/25/500	1200	500	648	13,948
	ESTIMATED TOTAL				$65,522

Categories and Rates
- A - A.K. Kuhn, $75/hr
- B - Health Physics/ Rad Safety Specialist (Triad), $60/hr
- C - Scientist, W.E. Jenkins, $45/hr
- D - Junior scientist/programmer (Triad), $35/hr
- E - Clerical/ Drafting, $25/hr

* Other Direct Costs - Includes communications, reproduction, word processing and freight
** Includes cost of line time and run time on IBM 3600

HMCSL024561

ATTACHMENT TO PROPOSED WORK PLAN OF 6/13/86

STATEMENT OF CAPABILITIES
MODELING OF RADON EMANATION AND DISPERSION

TRIAD, INC.

Triad personnel routinely utilize modern high-speed computers for the efficient and economical solution of engineering and scientific problems. Triad adapts existing computer programs or develops custom-made programs to deal with specific problems. Triad uses the computers of the CDC CYBERNET, IBM, and Westinghouse CRAY-1 systems for most large commercial computing requirements. Government computers such as the CRAY-1 and CD CYBER 176 are used for federally sponsored programs.

Triad utilizes mainframe computers, linked through its microcomputers, to do statistical analysis and compilations. We have on hand a large number of very powerful data base management programs, statistical analysis programs, and modeling programs that cover an extensive range of analytical requirements. The most relevant to Homestake's needs are:

HAZMAT - Intergrates a data-base management system, 3-D plotting routine, and a very powerful statistical analysis program for significant cost savings in data reduction, analysis and report preparation. The program models the distribution of any type of contaminant plume, either in the air and in groundwater, using statistically significant analysis with a minimal number of data points required.

RAECOM - An NRC-approved program for the determination of radon emissions from disposal sites of radioactive materials. This code allows determination of effects expected or achieved from placement of cover materials over tailings.

ACT - A program that calculates the source term activity from a set of initial activities as a function of discrete time steps. ACT also calculates "Probable Release," which is the activity at a given time multiplied by both the fraction released and the probability of the release. The program supports analysis of release from radioactive waste disposal sites such as those required by 40 CFR 191.

AIRDOS-EPA - Assesses exposure impacts from all pathways for continuous releases of radionuclides.

DACRIN - Assesses inhalation exposure from short term releases of radionuclides.

LADTRAN - Assesses the impact of releases of radionuclides in surface water systems.

RADTRAN-II - Allows assessment of the impact of transportation of radioactive material.

These are just a few of our computer programs that allow Triad to analyze almost any type of hazardous or radiological type of condition, incident, or change. All of the programs that Triad utilizes have been either benchmarked and/or verified from an NQA-1 review requirement. All programs except RAECOM run on IBM 3600 mainframes or can be run on CRAY-1 computers. All programs except RAECOM are written in Fortran. Triad has direct access to all the codes and computers listed above, and is able to support HMC with all Task 2 modeling.

To meet the Task 2 modeling requirements, it is anticipated that RAECOM will be used for the calculations of radon emanation from the tailings both before the proposed covering and after, and that HAZMAT will be used for calculation of the source term in the analysis of the emanations from the tailings based on the sampling/testing information obtained from Homestake. This will allow cross verification of the results of RAECOM as well as determination of the magnitude of the release. A plume history will also be generated by the HAZMAT program.

The extensive data base management programs that are in HAZMAT as well as our own DB management systems will allow for input and manipulation of the large amount of data that will be entered. This capability makes very economic and effective use of the information in a logical and efficient manner.

T.R. Beck

HOMESTAKE MINING COMPANY

P.O. BOX 98
GRANTS, NEW MEXICO
87020

December 1, 1986

Mr. Harry Pettengill, Chief
Uranium Recovery Field Office, Lic. Br. 2
Region IV
U.S. Nuclear Regulatory Commission
P.O. Box 25325
Denver, CO 80225

Re: License No. SUA-1471
Docket No. 40-8903

Dear Mr. Pettengill:

In accordance with our commitment dated June 13, 1986, Homestake Mining Company hereby submits 6 copies of its Tailings Stabilization and Site Reclamation Plan for the Grants, New Mexico Uranium Mill and Tailings Facilities. This plan addresses the design criteria and cost analysis as required under Title 10 CFR 40, Appendix A. It addresses mill decommissioning, land cleanup and complete tailings reclamation. It includes activities for interim stabilization to control dusting under 10 CFR 40, Appendix A, Criterion 8. It addresses the control of non-radiological protection criteria through extensive ground water protection programs as required under 10 CFR 40, Appendix A, Criterion 6.

This plan addresses Homestake's active tailing pile, the mill and mine ion exchange facilities, and their associated surrounding land areas. It does not address the Homestake-New Mexico Partners tailings pile, which has been inactive since 1962, per our telephone discussion of November 24, 1986. Your recommendation is being taken under advisement and Homestake will respond in a timely manner.

As set forth in our letter of June 13, 1986, Homestake wishes to reserve all of its legal positions related to this matter, and Homestake's voluntary submission of the reclamation plan is without prejudice to any of its rights. It is our continuing understanding that this reservation is satisfactory to NRC.

Homestake Mining Company is prepared to meet with you and other members of the NRC staff at any time to discuss the report or any of its sections in detail.

Very truly yours,

HOMESTAKE MINING COMPANY-GRANTS

ORIGINAL
Signed By:

Edward E. Kennedy
Director of Environmental
Affairs

Delivered by:____________________

Received by:____________________

Date:____________________

EEK/bgl

Text, Tables and Figures

Tailings Stabilization and Site Reclamation Plan License No. SUA-1471 Docket No. 40-8903

Homestake Mining Company-Grants

12/86

TAILINGS STABILIZATION

AND

SITE RECLAMATION PLAN

HOMESTAKE MINING COMPANY

GRANTS, NEW MEXICO

License No. SUA-1471

Docket No. 40-8903

Prepared by:

Alan K. Kuhn, Ph.D., P.E.
Consulting Engineer
Albuquerque, New Mexico

and

W. E. Jenkins
Environmental/Hazardous Waste Consultant
Englewood, Colorado

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1.0 INTRODUCTION

Homestake Mining Company (HMC) respectfully submits this Tailings Stabilization and Site Reclamation Plan to the Nuclear Regulatory Commission (NRC). The plan was developed to meet the criteria contained in NRC's 10 CFR 40, Appendix A (NRC, 1985 and 1986), for long-term stability and protection for 1,000 years against release of radioactive material from the tailings impoundment and associated mill site. Currently, the tailings impoundment covers approximately 170 acres, is 85 to 90 feet high, and contains approximately 21 million tons of tailings. This plan is based on the ultimate buildout configuration of the tailings impoundment after a five-year period of 2,000 tons per day (tpd) production. This production rate would add an additional 3,650,000 tons of tailings, increasing the impoundment height by 5 to 13 feet and the surface area to approximately 179 acres. The 2,000 tpd production rate is the maximum possible level being used as the basis for relicensing; actual production is expected to be near the present 3,500 tons per month (tpm) rate.

When milling operations are permanently ended, the mill will be decommissioned. The structures and equipment will be demolished and buried in the southeast corner of the stabilized tailings impoundment, as described in Chapter 3.0. The mill area and vicinity around the impoundment will be decontaminated by excavating soils with excessive radium levels, as described in Chapter 3.0, and placing those soils as fill at the toe of the impoundment, which will be protected by a soil cover. The extent of area receiving cleanup has been estimated at 644 acres, based on a gamma survey conducted previously by HMC. Subsequent radiological survey efforts,

described in Chapter 4.0, will include correlations between soil radium contents and gamma meter readings, delineating more precisely those areas requiring soil cleanup.

The major task in this plan is the long-term stabilization of the tailings impoundment. This task, discussed in Chapter 5.0, will begin with the interim stabilization (Section 5.2) required to limit erosion during the closure period. The long-term stabilization will consist of recontouring the impoundment, covering it with soil, and protecting the slopes with vegetation or rock cover (Section 5.3). Soil and rock covers have been designed to satisfy the criteria of 10 CFR 40, Appendix A. As a result of recontouring, the tailings slimes will be covered by sand tailings, effectively reducing the radon flux from the slimes and the resultant required thickness of the soil cover. The soil for this cover will be obtained from on-site clay and sand deposits. Rock to protect the steeper slopes will be limestone obtained from a quarry near the mill. Riprap from this quarry, as well as diversion ditches and rechannelization of San Mateo Creek, will be used to provide the necessary protection against flooding (Section 5.4). The soil cover properties, thickness, and vegetative or rock protection will limit erosion by wind and water to a small fraction of the total cover thickness (Section 5.5).

After the tailings impoundment has been stabilized and the mill site is cleared, the reclamation of the property will be completed by final regrading and revegetation (Chapter 6.0). The site will be recontoured to leave smooth, free-draining surfaces. Revegetation will establish a plant cover of hardy native species.

The only significant non-radiological impact will be elevated levels of some constituents in the ground water. HMC has implemented and will continue to operate a ground water protection program, as described in Chapter 7.0. This program will continue, as presently planned, for up to 15 years after mill closure. The only major difference in the post-closure program will be the construction and use of an evaporation pond for collection well discharge.

Post-closure care and monitoring (Chapter 8.0) will provide continuing surveillance of the stabilized impoundment, as-needed repairs, and operation of the ground water protection system. The stabilization plan is designed to allow remedial care to be performed with minimal manpower and equipment.

The costs for tailings stabilization and site reclamation, described in detail in Chapter 9.0, are based on unit prices obtained from construction industry sources and on quantities derived from the conceptual design. These costs are subject to review annually and will be adjusted to reflect changes in design or in unit prices.

A concept schedule for stabilization and reclamation has been developed (Chapter 10.0). Part of this schedule, the completion of soil cover and subsequent stabilization tasks, is dependent on the rate of consolidation and dewatering of the tailings slimes. The rate of consolidation is impossible to predict with confidence, so some activities can be scheduled only in a relative sense.

2.0 HISTORY AND EXISTING AND FUTURE OPERATIONS

2.1 HISTORY

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. Homestake's Mine Ion Exchange (IX) plant is located in the south-eastern part of McKinley County, New Mexico, in the Ambrosia Lake area (Figures 1 and 2). The IX plant is approximately 18 miles northwest of Grants, New Mexico in Section 25, Township 14 North, Range 10 West.

The HMC mill has been a major producer of uranium concentrate since 1958. Homestake's milling facilities were constructed and originally operated as two distinct partnerships, with Homestake Mining Company acting as the managing partner for both. The larger of the two mills was organized as Homestake-Sapin Partners, with a nominal milling capacity of 1,750 tpd. The smaller was organized as Homestake-New Mexico Partners, with a nominal capacity of 750 tpd. Both mills were designed to be alkaline leach-caustic precipitation mills. The combining of these two milling facilities resulted in a mill with a nominal throughput capacity of 3,400 tpd.

The Homestake-New Mexico Partners mill commenced operations in February 1958, while the Homestake-Sapin Partners mill started up in May 1958. Both mills operated independently, each with its own tailings pile, 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-Homestake Partners. In March 1981, Homestake then purchased United Nuclear Corporation's interest and the operation became Homestake Mining Company-Grants.

Two tailings impoundments were developed on HMC's property. In December 1956, the U.S. Atomic Energy Commission (AEC) and Homestake-New Mexico Partners signed a contract for the delivery of yellowcake to the federal government. A second contract was signed with the AEC in 1961 for the delivery of additional yellowcake. The first and smaller of the two impoundments resulted from these contracts with the federal government. The total quantity of tailings generated and impounded in this first impoundment was 1.22 million tons. It is located in the SW 1/4 of Section 26, Township 12 North, Range 10 West, N.M.P.M. Tailings material deposited within this impoundment was contained entirely by an embankment composed of natural, compacted soils. The embankment was compacted by heavy equipment and brought to a height of 20 to 25 feet. The crest was a minimum of 10 feet wide, with the base being approximately 40 feet thick. The impoundment covers an area of about 40 acres.

The tailings within this first impoundment are not comingled with any commercial materials. They were all generated under AEC contract. It is Homestake's contention that stabilization and reclamation of this tailings impoundment is the responsibility of the federal government and, as a

result, HMC has brought suit for a legal judgment in this matter (Homestake Mining Company of California, Inc. vs. United States, #580-84C, United States Claims Court). Consequently, Homestake has not addressed this first Homestake-New Mexico Partners tailings impoundment in this plan.

The larger of the two impoundments 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 approximately 10 to 11 million tons. In addition, another 10 to 11 million tons of commercial tailings were generated and comingled with the AEC tailings. This impoundment is located in the N 1/2 of Section 26, Township 12 North, Range 10 West, N.M.P.M. and is presently being utilized for tailings disposal at the Homestake mill.

Until 1966, Homestake deposited tailings material into only one cell of the impoundment. Subsequently, Homestake added an additional cell adjacent to and to the west of the existing cell. Since that time, tailings disposal has been alternating between the two cells (east vs. west) whenever necessary to maintain optimal operating conditions.

The starter dike for the larger impoundment was constructed from natural soils excavated within the immediate area. The dike was constructed in six-inch lifts and each lift was compacted by heavy equipment. The material was borrowed from within the tailings area. The dike was constructed to a

height of about 10 feet and a width of about 10 to 15 feet at the top and 25 to 30 feet at the bottom.

2.2 EXISTING OPERATIONS AT THE MILL

The mill employs the alkaline leach-caustic precipitation process for concentrating uranium oxide from ores that have historically averaged from 0.05 to 0.30 percent U_3O_8. The concentrate is a semirefined uranium compound known as yellowcake that averages 90 percent U_3O_8.

The mill has a nominal design throughput capacity of 3,400 tpd of ore. Currently (November 1986), due to contractual requirements, the milling rate has been reduced to approximately 3,500 tpm. In the event there is an increased demand for yellowcake, HMC may increase the throughput to the nominal capacity of 2,000 tpd averaged during each quarterly period for the next five-year time period. This production level is the maximum rate for licensing purposes over the next five years. Therefore, this plan assumes a 2,000 tpd production rate for design purposes.

Current tailings management at the mill site consists of disposal of the waste products from the milling operations in a rectangular impoundment located adjacent to the mill. The impoundment is divided into two cells designated the east and west ponds, contained and surrounded by an embankment (ring dike). The impoundment presently covers approximately 170 acres and is approximately 85 to 90 feet high. The east and west ponds cover approximately 55 acres and 40 acres, respectively, as measured from the crest centerline.

Except for a small clay starter dike around the east pond (now buried by tailings), the entire impoundment is constructed of hydraulically-placed tailings. The mill tailings are transported from the mill to the impoundment in slurry form. The tailings are composed of uranium-depleted fine and coarse sand fractions and slimes (minus No. 200 mesh sieve). The tailings are deposited above ground on the impoundment by means of wet cyclones which separate the material into coarse and fine splits. The coarse material is spigotted along the crest and downstream slope of the embankment of the impoundment, and the fine split is discharged into either the east or west pond. The cyclone travels along the crest of the embankment, building the embankment by the centerline method as it moves. The clarified liquid that is discharged into the ponds (east or west) is recycled through the decant towers back to the mill for reuse in the tailings slurry. At the current reduced milling rate, cyclone separation is not used and the slurry is discharged directly into the tailings pond. The present mode of operation confines disposal to a single pond at a time, with the other pond used for evaporation as needed. To date, the tailings impoundment currently in use has received about 21 million tons of tailings.

The placement and maintenance of tailings is performed in accordance with the Tailings Management Plan (D'Appolonia, 1982). This plan specifies practices which assure compliance with NRC Regulatory Guide 3.11 and 3.11.1, as well as New Mexico State Engineer requirements. At least 5 feet of freeboard and 50 feet of beach are maintained at all times. The piezometric levels and movement monitoring points of the embankment are surveyed on a regular basis. Stability analyses are routinely performed to ensure that

the static and pseudostatic factors of safety of the embankment are at least 1.5 and 1.0, respectively.

In addition to the mill site, HMC operates a small IX plant in the Ambrosia Lake area to recover water-solubilized uranium from the Applicant's mines. All of the IX tail water, without chemical additives, is recirculated back underground for recovery of additional uranium. Until February 1986, some water which was not recirculated was discharged to the Arroyo del Puerto after treatment with barium chloride for the removal of radium-226. A three-acre lined evaporation pond is currently being utilized for evaporating IX back-wash brine solutions.

2.3 PROPOSED CONTINUED OPERATION

HMC plans to continue use of the existing tailings impoundment for the next five-year period. The five-year buildout plan of the tailings impoundment is based on the following considerations:

- Maximum mill production rate for the next five years was estimated to be 2,000 tons of tailings solids per day.
- The structural embankment will be constructed of the coarse-split tailings, which constitute about 40 percent of the solids in the tailings slurry. Fine-split tailings will be placed in the ponds. Coarse split contains less than 10 percent fines, while fine split contains a large percentage of fine sand as well as slimes.
- The crest buildout, or structural embankment, must be sufficient to maintain five feet of freeboard and a 50-foot beach.
- At the present and anticipated rate of production, the required safety factors will be maintained by this disposal method.

Construction of the five-year buildout will be accomplished by centerline method, using the same placement procedures currently in use. The cyclone will travel along the crest, spreading the coarse split ahead and downslope to build the crest and outer slope of the embankment, and discharging the fine split toward the pond across the beach. As the slimes settle out, the clarified liquid is decanted from the center of the pond and is recycled back to the mill for use as process water. The structure will contain all fine tailings and liquid that are discharged into the ponds. At 2,000 tpd, the tailings impoundment would increase in height by about 13 and 5 feet in the east and west ponds, respectively. This increase would be nearly uniform across the slope, crest, beach and pond along any section of the impoundment, enlarging the surface area of the impoundment to about 179 acres.

The tailings impoundment configuration at the end of the five-year period of 2,000 tpd production is illustrated in Figure 3.

3.0 MILL DECOMMISSIONING AND DECONTAMINATION

3.1 MILL DECOMMISSIONING

At closure, HMC will decommission the mill buildings and equipment. HMC does not intend to decontaminate any buildings or material that are contained within the facilities area for salvage purposes. The mill and equipment are considered to be too old to have any reasonable salvage value. All material contained within the facilities area will be torn down and placed at the southeast toe of the tailings impoundment, as shown in Figure 4, and covered with site cleanup soils, as discussed below. Decommissioning will be a phased process rather than a single-step event. For example, conventional ore-processing equipment might be decommissioned before solution extraction circuits. The HMC mill, shown in plan in Figure 4, contains the following processing and miscellaneous structures that will be removed:

- Ore receiving section with receiving scale
- Crushing and sampling section, to include grizzly, impact breaker, rotary dryer and reciprocating sampler
- Fine ore storage section with four ore storage bins and one transfer bin
- Grinding section with ball mill and thickener tanks
- Uranium leaching section with leaching autoclaves, leaching pachuca tanks, solution storage tanks and tailings ion exchange facility
- Precipitation section with pregnant solution tank, precipitation and precipitate thickener tanks
- Vanadium removal section and associated roasting furnace
- Package, storage and shipping section with yellowcake drying, packaging, and drum storage and loadout

- Miscellaneous structures, to include administrative building, shop, laboratory, change house, etc.

All tanks will be removed or cut into pieces and placed in the toe area of the stabilized tailings impoundment. The tanks will be filled with tailings sands or soil material after placement so that void areas will not occur when the final cover material is placed on the tailings impoundment. Building materials, beams, foundations and other flat material will be stacked around or on the tanks. Asphalt from the parking area will be removed and placed in the disposal pile.

Foundations will be removed and the contaminated foundation material will be placed in the same area as mill buildings and equipment. Concrete material will be tested to determine if it can be cleaned for use as riprap in the redesigned drainage channel or for the flood protection of the toe of the impoundment. If it is determined that this material cannot be utilized as riprap, it will be disposed in the same location as the rest of the mill's building materials.

The mill IX plant will continue to operate until ground water restoration is complete, after which it will be demolished and buried in the impoundment toe or the reclaimed evaporation pond.

The demolished mill, placed at the southeastern toe of the tailings impoundment, will be completely covered by contaminated soils excavated from mill and other site areas found to have Ra-226 levels exceeding Criterion 6 limits of 10 CFR 40, Appendix A. Cleanup of contaminated soils and

protected disposal of these materials are discussed in the following sections.

The mine IX plant will continue to operate for an indefinite period. Subsequently, the plant might be sold if not excessively contaminated with radioactive materials. Otherwise, it will be demolished and buried in the tailings impoundment disposal area, or in the reclaimed evaporation pond at the mine.

3.2 FACILITIES SITE CLEANUP

After completion of demolition and removal of all mill buildings and material, the facilities area soil that has been determined to exceed the Ra-226 limits of Criterion 6 will be removed. The facilities area comprises 49 acres and for purposes of cost estimating, it is assumed that approximately one foot of soil material will have to be removed from these 49 acres to meet unrestricted area criteria. Approximately 79,000 cubic yards of contaminated soil material would be removed. On completion of contaminated soil removal, the mill area will be regraded to blend into the contours of the entire reclaimed property. The contaminated soil material will be utilized to fill in and around the mill demolition debris.

3.3 OTHER CONTAMINATED SOIL CLEANUP

HMC conducted a gamma survey to determine areas that may contain elevated concentrations of Ra-226 due to windblown tailings. Site-specific correlations with gamma readings and actual Ra-226 content of the soil were not made, but for this conceptual plan it was assumed that gamma readings above

25 μR/hr correlate with excessive soil radium levels. Excessive levels are concentrations of more than 5 pCi/g radium above background in the upper 15 cm of soil, and more than 15 pCi/g in successively lower 15 cm intervals (Criterion 6, 10 CFR 40, Appendix A). Figure 5 shows the area where HMC gamma readings indicate excessive levels of radium in soil due to windblown tailings. HMC intends to perform an additional gamma survey with Ra-226 correlations to define areas of soil material that have elevated levels of Ra-226 above background. For costing purposes, the area defined in Figure 5, containing 644 acres excluding the tailings impoundments, will require cleanup. Because the windblown tailings are distributed as a thin veneer, it is estimated that only about six inches of soil will require removal. A total of 520,000 cubic yards will be removed and used to cover mill demolition debris and the impoundment toe. Its estimated cost is included in the long-term stabilization costs, addressed in Chapter 9. The soil cleaned up during operations will be placed at or near the impoundment toe, close to its final disposal location.

4.0 RADIOLOGICAL SURVEY

Radiological surveys will be performed in compliance with NRC regulations. The first survey will be conducted prior to closure to delineate the areas in which radium levels exceed allowable limits. Soil in these areas will be removed and disposed as described in Section 3.3. A post-closure radiological survey will be conducted to determine the area around the mill that still has excessive residual radioactive contamination. The radiological survey will be conducted to delineate those areas that exceed the radium concentration limits for the unrestricted environment established by NRC's 10 CFR 40, Appendix A, Criterion 6. The survey will determine the areal extent and depth of soils that contain Ra-226 concentrations above 5 pCi/g average in the first 15 cm of soil and 15 pCi/g in any 15 cm layer of soil below the first 15 cm above established background levels in the proximity of the HMC operations.

4.1 MILL AREA

The radiological survey in the mill area will be conducted using a hand-carried gamma μR/hr meter, or equivalent type of equipment. Approximately 49 acres are contained within the facilities area. Gamma measurements will be made at approximate 10-meter intervals on a rectangular grid within the facilities area. The gamma exposure rates will be correlated with Ra-226 concentrations taken from selected boreholes. Additional soil samples will be taken where the gamma exposure rates exceed the allowable μR/hr-above-background readings, indicating Ra-226 concentrations that exceed Criterion 6 limits.

In addition to the surface gamma survey within the facilities area, where radium concentrations exceed Criterion 6, selected boreholes will be drilled to collect soil samples at 15 cm intervals for analysis of Ra-226 concentrations. Sampling depths will be limited to those in which gamma correlations indicate excessive radium levels. Gamma exposure rates will be measured at 15 cm intervals within the boreholes to assist in determining below-surface concentrations of Ra-226.

Upon completion of the radiological survey within the facilities area, the locations and depths of contaminated soils will be delineated. Residual contaminated soil material will be removed and disposed, allowing the contaminated locations to be upgraded from restricted to unrestricted area classification.

4.2 MINE IX PLANT

A post-closure radiological survey will be conducted in the mine IX plant vicinity. This survey will be conducted in the same manner as that for the facilities area. It is estimated that approximately five acres will need to be surveyed.

4.3 TAILINGS IMPOUNDMENT VICINITY SURVEY

The radiological survey in the vicinity of the tailings impoundment will be directed towards identification of areas that were affected by additional windblown tailings that have accumulated since cleanup during operations. The initial survey will be made using a hand-carried gamma μR/hr meter or meter of equivalent type. A radial grid system will be developed emanating from the center of the tailings disposal area in eight compass directions.

Gamma readings will be taken at 50-meter intervals in each compass direction. Measurements will be taken until consecutive readings indicate exposure rates less than correlated readings associated with Ra-226 concentrations in surface soils greater than 5 pCi/g above background.

Areas containing excessive levels of Ra-226 will be delineated. Within these areas, a rectangular grid system will be used for gamma measurements taken at 50-meter intervals and soil samples collected to a depth of 30 cm at selected locations for analysis of Ra-226. Correlations will be made between radium content and gamma exposure rates. Upon completion of the survey, the volume of soil material that must be removed will be calculated.

4.4 CURRENT RADIOLOGICAL CONTAMINATION ESTIMATES

HMC conducted a gamma survey in 1980 to obtain information on potential areas that may contain elevated levels of radium from windblown tailings. For this reclamation plan and until a new radiological survey is conducted, HMC is using this initial survey to outline the areas where potential excessive radium concentrations may be present. The area is shown in Figure 5 and contains 644 acres (excluding tailings impoundments). For costing it is estimated, due to the nature of windblown tailings, that six inches (15 cm) of soil will have to be removed from this area. Removal of a one-foot layer over the 49 acres within the facilities area will be assumed for costing purposes. Cost estimates for soil removal are contained in Chapter 9 of this plan.

5.0 LONG-TERM STABILIZATION

5.1 GENERAL APPROACH AND RATIONALE

HMC's long-term stabilization plan has been developed to both account for and take advantage of the unique characteristics of the Grants facility, especially the tailings impoundment. The HMC impoundment is enclosed by a full-perimeter embankment constructed of tailings sands. As a result, the amount of outer slope is proportionately much greater than in the typical impoundment with a cross-valley dam. In addition, the latter has to take into account the flood flows from the upstream catchment area; the HMC impoundment has no upstream catchment, but is located within a significant watershed.

These characteristics of the HMC impoundment mean that a large volume of tailings must be relocated to achieve the required maximum slope gradients. The stabilization plan has been designed to use these relocated tailings to promote consolidation of slimes and to suppress radon emanation from the slimes. Lacking any flow-through runoff from upstream catchment, the drainage measures for the top and sides of the impoundment can be relatively modest, accounting only for runoff from direct precipitation. However, the toe of the impoundment must be protected from the San Mateo Creek Probable Maximum Flood (PMF), which would pass directly along the north and west sides of the impoundment.

The foregoing considerations have guided the general approach and underlie the rationale for the stabilization plan. Of course, the fundamental requirements for the plan are those contained in the criteria of Appendix A,

10 CFR 40. While satisfying these regulatory requirements, HMC has sought also to achieve maximum cost effectiveness by realizing multiple benefits from stabilization measures. For example, to satisfy the regulatory requirement for maximum slope gradients of 5:1 (horizontal:vertical), a large volume of sand tailings on the outer embankment slopes must be moved. These tailings will be moved inward across the pond to surcharge the slimes (to accelerate consolidation) and to suppress radon emissions from the slimes, achieving three objectives with one measure. Similarly, the borrow pit for cover soil will be developed in the same location as the channelization and diversion of San Mateo Creek, part of the flood protection measures. The borrow pit will be excavated and reclaimed to leave a broad, shallow water course for control of flood flows. These and other multiple-benefit measures are characteristic of the stabilization plan described in the following sections.

5.2 INTERIM STABILIZATION DURING CLOSURE

After cessation of mill operations and before final stabilization is completed, interim stabilization measures will be used to minimize the erosion of tailings. These measures will provide a transition from interim stabilization during operations (described in a separate submittal) to long-term post-closure stabilization and will include some measures from both programs.

Homestake has found that the tailings that escape from the impoundment as airborne particulates are primarily fines (minus #200 mesh sieve). The principal source of these fines is the beach area around the ponds. Coarser fractions (sands) also become airborne in high winds but stay within a few

feet of ground surface and are redeposited on or close to the impoundment. Wind erosion has the potential for moving tailings more frequently, for longer periods, and consequently in larger volumes than water erosion. The effects of the latter are restricted to the impoundment toe areas. Consequently, the primary objective of interim stabilization during closure is to control wind erosion.

The interim stabilization measures include water spraying, covering of beach areas with sand tailings, and use of snow fences. Pond water (as well as collection well water) will be run through the IX plant to remove recoverable uranium, then returned through a system of movable pipes to impulse sprinklers located on the embankment. The locations of spraying will change as stabilization progresses, but initially water will be sprayed on exposed beaches and sand tailings surfaces not being actively excavated or filled. Spraying will maintain a moist surface that will inhibit wind erosion due to surface tension in the interstitial water. Spraying will also accelerate evaporation of pond water; in fact, the sprinkler system might be started at some time (to be determined) before cessation of mill operations to shorten the post-operational pond dewatering period. Unlike cross-valley impoundments, in which a large portion of the non-evaporated spray water returns to the pond, the infiltrating spray should seep downward and outward away from the ponds. Consequently, dewatering should be relatively rapid. Should additional evaporative capacity be desired or should the process of impoundment regrading overtake dewatering, the pond water will be diverted to the evaporation pond, described in Section 7.4 of this plan.

The period of time during which beaches will be sprayed will be brief because one of the first steps in long-term stabilization will be inward movement of sand tailings from the impoundment crest across the beach. Once covered, the fines on the beach will not again be exposed to wind. As necessary, the sand tailings fill will be sprayed, both for moisture conditioning to enhance compaction and to suppress wind erosion.

Sand tailings surfaces will be stabilized during closure with snow fences until they are covered with compacted soil. Snow fences have been very effective in controlling wind erosion of sand tailings in their extensive use at the Grants facility. They act as obstacles both to break up and reduce ground velocities of wind and to provide wind shadows in which saltating and suspended sands are deposited to form ridges. These ridges then further disrupt surface winds and promote deposition.

The snow fences provide much-needed versatility in interim stabilization. They can be moved around to stay ahead of or follow behind earthmoving equipment. The density, orientation, and pattern of fence placement can be adjusted to the level of protection required at each location.

Use of an interim soil cover is not appropriate for HMC's impoundment. The entire impoundment surface will be altered by excavation and fill; no surfaces developed during impoundment buildout and operations will remain after closure. Therefore, any soil cover placed for interim stabilization would have to be excavated or covered by tailings during regrading to final contours. In addition, any soil cover placed prior to cessation of tailings deposition, during operation, would be covered by tailings added later as

the impoundment is built out by centerline construction. Any soil cover placed at the toe during the operational phase of the impoundment would interrupt the drainage system designed to carry controlled toe seepage and water collected from the pump-back system for recycling back into the milling process. Finally, the outer slopes of the impoundment will be too steep for cover placement until they are cut back to 20% grade, at which time the final stabilization soil cover will be placed, as explained in Section 5.3.

5.3 RECONTOURING AND COVER OF IMPOUNDMENT

5.3.1 Impoundment at End of Operations

This stabilization plan is based on the impoundment configuration expected after five years of buildout at a milling rate of 2,000 tpd. At the time of this submittal, the impoundment contained approximately 21 million tons of tailings solids. The 2,000 tpd production would add an additional 3,650,000 tons of tailings over the next five years. HMC expects that 75% of these tailings will be placed in the east pond, 25% in the west. This distribution will result in about 13 feet and 5 feet of additional impoundment surface height in the east and west cells, respectively, assuming uniform distribution of tailings over those surface areas. The crest elevations of the two parts of the impoundment would differ by an average of 20 feet. The configuration at the end of operations in five years is illustrated in Figure 3.

5.3.2 Radon Emanation

Criterion 6 of Appendix A, 10 CFR 40 requires that a soil cover be used to limit radon release rates to not more than 20 pCi/m^2s. Conservative relationships between radium content and radon flux from tailings, contained in

the GEIS (NRC, 1980), indicate that radon exhalation from uncovered slimes and sands would be 1000 and 100 pCi/m^2s, respectively, assuming radium concentrations of 1000 and 100 pCi/g, respectively. These radium concentrations are conservatively high compared to the values determined from measurements at the HMC impoundment by others (EPA, 1986).

HMC recognized that the excavation required to reduce outer slopes to 5:1 (H:V) could generate a large quantity (up to 3.4 million cubic yards) of sand tailings. Consequently, HMC superimposed various depths of sand tailings on the slimes in successive RAECOM runs to see how effective the sand tailings could be in suppressing radon emissions. Using a density of 104 pcf and moisture content of 11% for the compacted sand tailings fill, the modeling showed that 8-9 feet of sand tailings would reduce radon flux from the slimes to the allowable limit of 20 pCi/m^2s, and 15 feet of this fill would reduce the radon flux from the slimes to 10 pCi/m^2s. RAECOM modeling indicated that the required flux limit from tailings sands over slimes could be achieved with 10 feet of sand tailings fill covered by less than one foot of sandy clay soil, as described in Section 5.3.4, compacted to 90% density, with 37% porosity and an average 12-14% moisture content. The required flux limit from the tailings sands alone can be achieved by less than one foot of this soil cover. However, as discussed in Section 5.3.4, a 2.0 foot cover is planned. This soil is available in the on-site borrow pit described below. The radon emanation modeling is described in more detail in Appendix A.

5.3.3 Recontouring

Criterion 4 of Appendix A, 10 CFR 40, limits final impoundment slopes to 5:1 (H:V). Slopes flatter than 5:1 would require extensive excavation and relocation of large volumes of tailings slimes, as well as outward extension of the impoundment. The outer slopes of the impoundment at the end of operations will range from about 2.5:1 to 3:1 (see Figure 3). Consequently, for final stabilization all slopes will be recontoured to comply with regulatory limits.

If the outer slopes are reduced to 5:1 along the cut line rising from the existing toe, a very large quantity of sand tailings, about 3.4 million cubic yards, would have to be excavated. Distributed across the top of the embankment as fill, additional thicknesses of up to 35 feet and 29 feet would be added to the east and west ponds, respectively. These thicknesses far exceed those useful in suppressing radon emissions (up to 15 feet) from the underlying slimes. Therefore, an alternative recontour surface, defining a 5:1 gradient cutting through the embankment slopes at a higher level, was selected to balance the volume of tailings excavation with the useful volume of tailings fill. This cut slope would start about one-third the slope distance from the toe.

A separate but significant source of contaminated material must also be disposed and stabilized. This material is the soil around the site containing radium levels exceeding the 5 pCi/g to 15 pCi/g limits of 10 CFR 40, Appendix A, Criterion 6, which requires that this soil be covered or otherwise protected to control release of its radiological hazards for 1,000 years, the same protection as that required for the tailings. Rather than cover

the contaminated soils in place, HMC will excavate them and include some or all of them with the tailings for impoundment stabilization. The most efficient means of handling these soils is to use them as fill material at the toe of the impoundment to form a 5:1 fill slope downhill from the 5:1 cut slope in the tailings.

The design selected for recontouring the impoundment combines the toe fill of contaminated soil with the elevated cut slope in the tailings embankment. This design will generate enough excavated sand tailings to make a fill at least 15 feet thick across the pond areas. The sand tailings in the divider dike between the ponds and in the decant tower access ramp in each pond will provide an extra quantity of material needed for compensating for settlement and for grading shallow slopes across the pond fills.

The configuration of the impoundment, recontoured for long-term stabilization, is shown in Figures 6 and 7. All outer slopes will be reduced to 20% (5:1) grade. The lowest portion of the outer slope, about 150 feet wide, will be the contaminated soil fill. This toe will be enlarged and flattened at the southeast corner of the impoundment to provide for burial of the demolished mill (see Chapter 3). The toe fill gradient may be flattened elsewhere as well to accommodate more contaminated soil, if required. The cut slope above the fill will extend up through the former beach, above which the 5:1 slope will be continued in sand tailings fill to the relatively flat tops of these fills above each pond. (On Figure 7, the cross sectional areas of fill in the ponds appear to be much larger than the cut areas in the cross sections. However, the cut areas enclose the entire impoundment, so that when these cross sectional areas are multiplied by the

length of cut, the cut and fill volumes are found to be equal.) The fill in the east pond will be separated from the west pond fill by a 5:1 slope 100 feet long, cut through the divider dike. This cut slope will connect the west pond fill surface, elevations 6670 to 6676, with the east pond fill surface where final elevations will be 6690 to about 6696. Each pond area will be contoured to provide positive, controlled drainage across slopes of 200:1 to 250:1 toward a central swale. The swale in each pond area will channel runoff toward the south and down the outer slope to a diversion ditch leading to San Mateo Creek (Figure 6).

The earthwork for recontouring slopes will probably start at one corner and proceed around the impoundment. Toe fill placement will precede slope excavation, which will be followed by soil cover placement. Filling of pond areas will be initiated by moving the crests inward by dozer. As dewatering and consolidation of slimes permit, coarse tailings will be advanced by dozer and scraper across the pond.

The processes of fill placement and consolidation in the pond could be accelerated by using the pneumatic stowage method. This method uses a high volume, low pressure air pumping system into which solids are fed. Transported by air pressure through pipe to a nozzle, the solids can be blown into place at locations not accessible to men or equipment. If initiated against a firm surface, pneumatic fills can achieve densities of better than 70% Standard Proctor (Maksimovic and Draper, 1982). This method could permit placement of several feet of tailings sands across the ponds early in the reclamation program, accelerating consolidation and providing a stable working surface for heavy equipment. HMC is seriously considering pneumatic

stowage, but for cost estimating purposes the more expensive conventional methods are assumed.

5.3.4 Soil Cover

To comply with the requirements of 10 CFR 40, Appendix A, Criterion 6, HMC will construct a soil cover sufficient to keep radon release rates to acceptable limits and otherwise prevent release of radiological hazards for a period of 1,000 years. The soil will be excavated from a borrow pit located on HMC property northwest and west of the impoundment (Figure 8).

HMC has conducted field and laboratory investigations of the borrow soils. These soils are alluvial sands and clays located in the area shown in Figure 8. At least two distinct clay soils have been identified in the borrow area. These clays are generally medium to low plasticity with lenses of highly plastic clay. The clays range from less than 2 feet to about 10 feet thick and occur within 15 feet of ground surface. The results of field and laboratory studies on these soils are contained in Appendix B. In the area in and adjacent to the borrow pit, as delineated in Figure 8, the volume of available clay is estimated to be about 580,000 cubic yards. Sand soils are at least double the clay volume. Although clays and sands can be excavated separately, HMC intends to excavate both soils and mix them to form a sandy clay to clayey sand soil (USCS classification of SC) which will have good workability and moisture retention characteristics. Laboratory tests show that this mixed soil can be expected to have a maximum dry density of about 115 pcf with 12-14% moisture content. Natural moisture contents of up to 8% in sands and 8-16% in clays indicate that a long-term retained moisture content of about 12% is reasonable. These soil properties

were used as input in RAECOM computer modeling of radon release from the cover impoundment. With 10 to 15 feet of sand tailings covering the slimes, less than one foot of soil, compacted to 90% Standard Proctor density (104 pcf) with about 37% porosity and at least 12% moisture, will satisfy NRC radon release rate limits.

To satisfy regulatory requirements that this soil cover thickness be maintained for 1,000 years, some extra soil thickness is needed to compensate for loss by erosion. Despite rock cover protection on the 5:1 slopes, some soil loss is assumed to occur. Prediction of soil loss by water erosion was made by the Universal Soil Loss Equation (USDA, 1978). This soil loss analysis is included in Appendix C of this plan. The calculated 1,000-year soil losses due to water erosion from top and side slopes are 1.1 inch and 0.7 inch, respectively. Wind erosion soil losses, calculated in accordance with USDA, 1980, are predicted to be 2.1 inches in 1,000 years from the top of the impoundment, where the surface will be revegetated rather than rock-covered. Therefore, the total cover thickness required for protection against radon emanation and erosion is less than 1.5 feet. However, for conceptual design and cost estimating purposes, HMC has selected 2.0 feet of soil cover. This greater-than-required thickness provides extra conservatism and also recognizes the practical constraints of large-scale earthwork; it is not feasible to control the depth and properties of a soil cover thinner than about 1.0 to 1.5 feet.

To construct a soil cover of 2.0 feet over the entire impoundment, a total of about 600,000 cubic yards is required. The borrow pit has been designed to yield enough soil for the impoundment cover, as well as extra for

stripping/grubbing losses and for fill to restore ground surface, to recontour around the mill, and to cover the evaporation pond if soils at that location are not suitable for cover.

The resultant volume of about 800,000 cubic yards will be obtained from the borrow area, illustrated in Figure 8. The borrow area can be enlarged to provide more soil if required. The borrow pit will have an initial upstream face slope of 100:1 and will be reclaimed after impoundment stabilization by grading side slopes to 50:1, followed by revegetation. The floor of the pit will be graded smooth and, because it will already slope downstream at a gradient of less than 1000:1, only revegetation will be required to stabilize the soil. As part of the site recontouring, the San Mateo Creek channel will be diverted through the reclaimed pit, which will subsequently divert all but the most extreme floods away from the impoundment. This recontouring and channelization is illustrated in Figure 9.

The soils will be excavated, hauled, and placed by standard earthwork equipment and methods. The pit will be stripped of vegetation and organic debris, which will be stockpiled for later use in reclamation or burned. Dozers and graders will make initial cuts to delineate clay lenses and sand zones. Scrapers will excavate and haul the soils to the impoundment (average of 0.8 miles one way), where graders will mix soil as necessary. The clay/sand mixtures will be moisture conditioned to wet-of-optimum (usually 14% or higher) and compacted by sheepsfoot rollers to 90% of maximum density.

5.3.5 Rock Cover

In conformance with the requirements of 10 CFR 40, Appendix A, Criterion 4, all relatively steep slopes will be protected against erosion by a cover of broken rock. In this plan, all 5:1 slopes will be covered. In addition, rock will be used at other selected locations to control channel erosion or to armor the toe of the impoundment slopes against Probable Maximum Flood (PMF) erosion. Surfaces flatter than 50:1 will be revegetated. The exception to this will be the drainage swales on the pond covers which, although sloped at about 200:1 (H:V), will be armored with graded rock cover up to one foot thick. Locations of rock cover are shown in Figures 6 and 7.

The rock for this cover is the Todilto Limestone, a Jurassic age formation which outcrops at several locations near the Grants mill (D'Appolonia, 1982, Appendix B). The most likely source is located on private land north of the mill at a haul distance of 7.5 miles one way. Alternate sources of this limestone and of malpais lava might also be considered.

Several rock samples were tested for sodium sulfate soundness, specific gravity, and absorption. The test results, attached to Appendix B of this plan, show that sample Nos. 1, 2, and 5 (all Todilto Limestone) meet the acceptability standards described in Nelson et al., 1986, Table 6.2.

The rock cover will be a minimum of six inches thick, consisting of broken rock up to six-inch size. The rock will be quarried by drill-and-blast methods, crushed and screened as necessary, loaded onto bottom-dump trucks, and hauled directly to the placement location. The rock will be spread in a

manner that allows the finer fractions to work to the bottom of the rock layer and form a filter zone in contact with the soil.

5.4 FLOOD PROTECTION

As part of the requirement to provide "reasonable assurance" of control of radiological hazards for 1,000 years (Criterion 4, Appendix A of 10 CFR 40), HMC will protect the stabilized impoundment against disruption by floods. Although no specific recurrence interval or design flood discharge is stated in the regulations, HMC will design against the Probable Maximum Flood (PMF) event.

5.4.1 Hydrologic Setting

The HMC uranium mill site is located east of the Continental Divide in the Rio Grande Drainage System of west-central New Mexico. The mill site is in the San Mateo drainage. North of the mill, the San Mateo is an ephemeral stream and flows only in direct response to large precipitation or snow melt events. There is no distinct channel near the mill, although there may have been one in formerly more pluvial times. A very large precipitation event could result in flow from the San Mateo drainage entering the Rio San Jose drainage. The Rio San Jose is itself ephemeral and flows only in direct response to local rain storms or snow melt. The Rio San Jose discharges to the Rio Puerco, which is a tributary of the Rio Grande.

The U.S. Geological Survey (USGS) has maintained stream flow measurement gages on several streams in this region. From the USGS records it is evident that most flow in this region is ephemeral or intermittent (D'Appolonia, 1982). No definite relationship between the size of the

drainage basins and the mean flow or the maximum recorded flow is evident. Variations in watershed characteristics such as vegetation, slope, soil, channel material and differences in water use apparently are great enough that they cancel or overpower a simple relationship between basin size and flow. These differences indicate that it is difficult to predict flow regimes using regional characteristics and that each watershed must be investigated separately.

The climatic characteristics of the area affect the hydrology of the region in many ways. The low annual precipitation, most of which occurs during brief, intense storms, supports only ephemeral stream flow. Even those drainages in higher elevations with increased precipitation and spring snowmelt are predominantly ephemeral since much of the flow is lost to the alluvium. Flows occur primarily as a result of the fairly common summer thunderstorms. These intense storms cause local flash flooding and erosion. The low precipitation and the high evaporation cause vegetation in some places to be sparse with large amounts of open ground between shrubs or forbs. The open ground, where present, contributes to surface runoff and sheet erosion during the thunderstorms.

The San Mateo drainage basin above the HMC mill site has a drainage area of approximately 291 square miles (Figure 10). Its shape is roughly circular and contains a dendritic (tree-branch style) drainage pattern. Maximum relief is 4,725 feet, with elevations ranging from 6,575 feet at the outlet to 11,300 feet at Mount Taylor, as illustrated in Figure 11.

Channel slopes in the basin range from nearly zero in the valley floor near the site to almost 50 percent at the higher peaks. The slopes on the flanks of the mesas and volcanic cones can vary from 5 to over 100 percent. The steeply sloping upper reaches of the drainage and its tributaries are commonly incised from 10 to 30 feet into the valley alluvium. Where slopes are low, such as near the mill site, flow follows shallow, poorly-defined, braided channels.

5.4.2 PMP and PMF

The peak discharge, velocity, and elevations of the flood produced by a Probable Maximum Precipitation (PMP) event in the San Mateo Creek watershed were determined for that portion of the San Mateo Creek adjacent to HMC's mill and tailings impoundment. This determination required three steps:

- Estimation of the PMP
- Generation of the PMP runoff hydrograph
- Flood routing

Previous surface hydrologic analyses were used as much as possible in these activities, described in detail in the following sections.

PMP Estimation - Hydrometeorological Report No. 55 (Miller et al., 1984) was used to estimate both general (frontal) storm and local (thunderstorm) storm PMP amounts for the San Mateo Creek watershed. Table 1 lists the results of these estimates. The general storm produces larger PMP amounts for the longer (greater than six hour) events.

Runoff Hydrograph - The runoff hydrographs derived from the 6.0 and 24 hour PMP events were estimated with the use of a computerized version of the U.S.

Soil Conservation Service's (SCS) synthetic triangular hydrograph method. This method uses basin soil and vegetative cover characteristics to derive a curve number (CN) that represents the basin's runoff-producing potential. Parameters of basin geometry, such as maximum relief and longest drainage path, are used to calculate a synthetic triangular hydrograph. The computer program distributes precipitation over time according to the graph shown in Figure 21-2 of the U.S. SCS National Engineering Handbook, Section 4, Hydrology (U.S. SCS, 1972). This precipitation distribution is then applied to the synthetic hydrograph to calculate the runoff hydrograph.

Input values for this method, described in the 1982 Environmental Report, include the basin area of 291 square miles, maximum relief of 4,725 feet, longest drainage path of 26.0 miles, and a CN of 70. The 6.0 hour PMP amount of 8.6 inches and the 24 hour PMP amount of 12.2 inches were used in the runoff hydrograph generation.

The results of the hydrograph generation are shown in Table 1. The 6.0 hour PMP produced a peak discharge of 180,250 cubic feet per second (cfs), and the 24 hour PMP produced a peak discharge of 169,800 cfs. The larger peak discharge was used in the flood routing.

Flood Routing - The U.S. Army Corps of Engineers water surface profile computer program, HEC-2, was used to calculate the surface width, elevation and flow velocities of the Probable Maximum Flood (PMF) near the mill site. The HEC-2 program solves backwater curves for both subcritical and supercritical flows. Input requirements include digitized channel and overbank area cross sections, channel and overbank area roughness coefficients, distances

between cross sections, and the stream flow (Hydrologic Engineering Center, 1976). Figure 12 shows the area of the San Mateo floodplain around the HMC mill site. In general, the floodplain is a complex area of berms, abandoned ditches, closed drainage areas and natural flow braids. However, recontouring of the site, especially the borrow area and the vicinity of the impoundment, will remove most irregularities and leave deeper, more uniform flow channels. Expected conditions were represented in the flood routing (HEC-2) model by five cross sections, as shown in Figure 12. Sections A-A', B-B', and C-C' were developed from the expected surfaces after recontouring, shown in Figure 9. Cross sections D-D' and E-E' in Figure 12 depict surfaces upstream of the recontoured area that will have little change. These latter sections were surveyed in October of 1980 and in November of 1981.

The resistance to flow of water provided by channel materials, vegetation, bends and meanders, and channel bottom configuration is characterized by the Manning coefficient "n". An "n" value of 0.05 was chosen for both the overbank and channel areas of cross sections D-D' and E-E' because the channels are quite small compared to, and nearly indiscernible from, the overbank areas. The forbs and shrubs of the overbank areas provide the most resistance to flow. The channel within the soil borrow area was assigned an "n" value of 0.035 because it will be relatively smooth.

The PMF of 180,250 cfs, resulting from the 6.0 hour PMP event, was used in the HEC-2 program to route the flood past the Homestake property. Figure 12 shows the PMF floodplain boundary at the site as calculated by the HEC-2 program. The maximum flow velocity would reach 5.7 feet per second (fps) and the elevation of the water in the overbank areas near the tailings

impoundment could reach 6,592 feet. The flood water elevations are shown in Figure 12 for each of the five sections analyzed. These elevations are high enough to submerge the toe of the impoundment by up to about 10 feet. Therefore, flood protection of the stabilized impoundment is required and will be achieved by placing oversized quarry rock (riprap) of one to two feet diameter along that portion of the toe of the impoundment that will be below PMP peak elevations and adjacent to high velocity flows (not in slack water).

5.4.3 Protection Measures

The crest elevation of the PMF at the tailings impoundment will exceed the elevation of the recontoured, revegetated ground surface around the toe of the impoundment and in some of the reclaimed area of the mill. Consequently, these areas would be inundated during a PMF. Those portions of the embankment toe which might be subject to erosive flow velocities, the north and west sides, will be armored with large rock (riprap) of about 12-24 inches.

In addition to these protective measures, flood flows will be substantially diverted away from the impoundment by the rechannelization of San Mateo Creek through the reclaimed borrow pit. The borrow pit for soil cover materials, described previously in Section 5.3.4, will be initially located and excavated, and later reclaimed, to provide a controlled connection between the ill-defined creek channel north of the impoundment and the broad floodplain to the southwest. The borrow pit will be 600-1300 feet wide and up to eight feet deep. The deeper, wider portion to the north will divert flow away from the impoundment and direct it southwestward. The pit floor will

slope to the southwest and merge with natural ground surface west of the impoundment. This diversion channel should force the higher velocities and most of the discharge volume away from the impoundment, leaving most of the toe areas in relatively slack water conditions.

PMF flood waters will be prevented from flowing around the east and south sides of the impoundment by placing an earthfill levee from the northeast corner of the impoundment to the highway right-of-way to the east. The levee will be constructed of soil excavated from the diversion ditch south of the impoundment and from local soil grading. The levee will keep the east and south impoundment toes in slack water during a PMF.

The toe protection measures and diversion channelization are illustrated in Figures 7 and 9, respectively.

5.5 WATER AND WIND EROSION

5.5.1 Water-Induced Erosion

The water-induced erosion that would occur at the reclaimed tailings impoundment was calculated using the Universal Soil Loss Equation (USLE) (USDA, 1978) for three distinct areas of the tailings impoundment. These areas include:

- Top of the impoundment, with slopes of 200-250:1 (H:V), an average slope length of 1000 feet, and 2.0 feet of cover material.
- East area of impoundment slope, with slopes of 5:1 (H:V), average slope length of 580 feet. Slopes will be covered with 2.0 feet of soil and six inches of rock material.

- West area of impoundment slope, with slopes of 5:1 (H:V), average slope length of 480 feet, 2.0 feet of soil cover and six inches of rock cover.

The soil loss equation is:

$$A = R\ k\ LS\ C\ P$$

where

A = the computed soil loss per unit area, expressed for the units selected for k and the period selected for R. These units selected compute A in tons per acre per year.

R = the rainfall and runoff factor. R = 20

k = the soil erodability factor. This is the soil loss rate per erosion index unit for a specific soil as measured on a unit plot. k = 0.34

L, S = the slope-length factor and slope steepness.

- Impoundment top with average slope length of 1000 feet and 200:1 (H:V) slopes (0.5%); LS factor = 0.152.
- East slope area with 5:1 (H:V) slope (20%) and average slope length of 580 feet; LS factor = 9.82.
- West slope area with 5:1 (H:V) slope (20%) and average slope length of 480 feet; LS factor = 8.93.

C = the cover and management factor. The cover factor for the three areas is as follows:

- Impoundment top with vegetation cover. C = 0.20
- East and West slope areas will be covered with six inches of durable rock cover. C = 0.002

P = Support practice factor. P = 1.0

Calculations for the three areas to determine the tons per acre per year and inches per year of soil loss are contained in Appendix C. For the three areas, the following soil loss can be expected:

- Impoundment top: 0.2067 tons/acre/year
- East pond slope: 0.134 tons/acre/year
- West pond slope: 0.1214 tons/acre/year

Converting these volumes to depths, the amount of soil loss over a 1000-year period will be:

- Impoundment top: 0.0011 in/yr or
  1.1 inches in 1000 years
- East pond slope: 0.0007 in/yr or
  0.7 inches in 1000 years
- West pond slope: 0.0006 in/yr or
  0.6 inches in 1000 years

From the above calculations, the cover as designed will protect against the release of radioactive material for a period in excess of 1,000 years.

5.5.2 Wind-Induced Erosion

Wind-induced erosion at the HMC impoundment is not expected to be a problem because the side slopes of 5:1 (H:V) will be covered with at least six inches of rock material. Over time and with some weathering, there will be the formation of an erosion blanket, and practically no material from these slopes will be wind-transported.

Wind soil loss was determined for the revegetated impoundment top using the following data from USDA Technical Note 27, 1980. Calculations for the Soil Loss Equation are contained in Appendix C. The Soil Loss Equation, where E is potential annual soil loss in tons/acre/year, is:

$$E = f\ (I\ K\ C\ L\ V)$$

where

f = A function of

I = Soil erodability factor. I = 86

K = Soil ridge roughness. K = 0.5

C = Wind erosion climatic factor. C = 50

L = Unsheltered field length, measured to be average of 1,000 feet.

V = Vegetation cover, 1,400 pounds/acre of flat small grain residue.

From Table 5, USDA Technical Note 27, 1980, it is estimated that there will be a loss of 0.4 tons/acre/year, which equates to a soil loss over 1,000 years of 2.1 inches. Adequate soil material will be placed on the impoundment top to prevent the release of radioactive material during the 1,000-year time period, as discussed in previous sections of this chapter.

6.0 REVEGETATION AND FINAL SITE CONFIGURATION

6.1 REVEGETATION

6.1.1 Contour Plan for Affected Areas

Upon completion of mill decommissioning and tailings impoundment stabilization, the site will be graded to the final site configuration, as shown in Figure 9. As explained in Chapter 8 of this plan, the ground water protection system will continue to operate for some time after mill closure. The reclamation of this system (wells, IX plant, and evaporation pond) will occur later (probably 15 years or more) than the reclamation of the rest of the mill site. HMC has taken care to blend the areas that have been affected into the existing landscape contours. The site will be graded to provide natural drainage and to protect against the development of depressions.

As shown in Figures 6 and 7, the tailings disposal area will be contoured with side slopes at 5:1 (H:V) and stabilized with 2.0 feet of soil cover and 0.5 of rock cover. The top of the tailings disposal area has slopes from 200:1 to 250:1 (H:V). A drainage system has also been designed to direct the runoff from the top of the reclaimed tailings, as shown in Figures 6 and 9.

6.1.2 Revegetation

About 1160 acres will require revegetation. The areas to be revegetated include the following:

- Top of tailings impoundment (70 acres)
- Mill area (49 acres)

- Borrow area(s) (139 acres)
- Contaminated soil removal areas (644 acres)
- Mine IX Plant (5 acres)
- Other, including diversions and evaporation pond (250 acres)

The revegetation requirements have been developed based on species currently on-site, on the ability to provide species diversity, and on adaptability of the species to the site. Both sod and bunchgrass species have been selected to help provide soil stability and minimize erosion. The seed mixture will be planted between mid-June and mid-September. This time period has the most favorable moisture and temperature conditions for germination. In some cases, if seedbed preparation is conducted prior to or after this time period, a preparatory crop may be planted. Table 2 provides the permanent seed mixture selected and seeding rates. Table 3 provides the data on rapid-growing preparatory crops, if required.

The soil in the affected areas is of the Penistaja-Prewitt-Moriarty association. This soil is rated good to poor depending on depth (Marker et al., 1974). A new soil survey, just completed by the Soil Conservation Service, has changed the Moriarty Series to the Venadito and the Prewitt Series to the Aparejo (USDA, 1986a). The report on this survey is expected to be published in 1987.

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

- Mill area -- The mill area will be prepared for revegetation upon completion of demolition and building/equipment removal. Areas where foundations have been cut two to three feet below ground surface will be filled with soil material through grading and recontouring. Contaminated soil will be removed to the depth indicated by radiological survey. The area 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 area(s) and contaminated soil removal area(s) -- Areas that have been compacted through the use of heavy equipment in the removal of soil 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. The seedbed preparation will commence as soon as the required amount of soil material has been removed.

- Top of tailings impoundment -- It is anticipated that several years of surcharge with tailings material will be required before the soil cover can safely be placed over the top of the east and west pond areas. Section 5.3.4 discusses the procedures that will be utilized for the placement of the cover material. Upon completion of soil material placement, the area will be disked or harrowed on the contour to provide a surface for drill or broadcast seeding.

- Mine IX Plant -- The foundation area and parking area as well as the evaporation ponds, up to five acres total, will be revegetated.

- Evaporation Pond -- Revegetation will be the same as used for the mill area.

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

Two methods of effectively seeding the area to be revegetated include drill and broadcast seeding. For HMC's site, drill seeding will be the primary method of seeding. Broadcast seeding is not considered as effective as drill seeding because of uneven seed distribution and seed desiccation if proper depth placement is not accomplished. Drill seeding offers uniform

placement of seeds, requires fewer seeds per acre seeded, can be drilled directly into preparatory crop stubble, and provides a uniform stand of seeded plants. With seedbed preparation as discussed above, drill seeding will be well suited for HMC's affected areas. 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.

It can be anticipated that during some years the revegetation program's success may not achieve desired levels. 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 2. If revegetation is not successful, for whatever reasons, undersize waste rock (minus three inches) will be hauled from the rock quarry (see Section 5.3.5) and mixed with the top lift of soil to raise the volume of 0.84 mm particles to increase wind erosion resistance.

6.2 MULCHING AND FERTILIZATION

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 as 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 soil investigation will be conducted to determine soil fertility. Results of the analysis will allow determination of the amount of nutrients contained in the plant growth medium. Parameters for determining fertility include nitrate-nitrogen, phosphorus, organic matter and potassium.

6.3 FENCING

Fencing will be used to control access into the revegetated area. The fencing will serve to control livestock grazing on the revegetated areas. The fencing will remain as long as HMC is responsible for monitoring and maintenance. To enclose the property and separate it from public road rights-of-way, about 58,000 feet of three-strand barbed wire will be used.

7.0 NON-RADIOLOGICAL PROTECTION

7.1 CURRENT PROTECTION MEASURES

The only non-radiological hazards identified as resulting from the HMC mill are those related to ground water quality. As the result of a 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 (EID) to restore water quality outside the restricted area to background concentrations, or better, and to prevent the future migration of tailings seepage from the property. This agreement with the EID 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 dilute and disperse elevated concentrations of selenium, uranium and sulfate in 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 further 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 towards the pump-back system of collection wells located around the downstream periphery of the tailings impoundment. The fresh water injection rate for each of these systems has averaged approximately 300 gallons per minute for the last several years. The locations of these wells are shown in Figure 13.

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 their tailings impoundment. This system was installed in 1978 and was designed to intercept all seepage from the tailings pile. 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 tailings 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 300 gallons per minute over the last several years.

7.2 EFFECTIVENESS OF CURRENT MEASURES

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 to 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 tailings impoundment are presently intercepting all seepage from the facility and, in fact, are drawing water far out in the aquifer back towards 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.

Injection of fresh water has been found to be a very effective solution for the reduction of the elevated chemical concentrations in the alluvial aquifer near Homestake's mill. The hydrologic mound of fresh water at the south property boundary is also a very effective hydrologic barrier which is forcing a reversal of flow direction, driving the elevated constituents between the property boundary and the tailings impoundment northward back to the system of collection wells. Dilution, dispersion and absorption have been very effective in reducing the elevated concentrations observed in the alluvial aquifer without significantly increasing concentrations downgradient. Collection of seepage adjacent to the tailings impoundment and the injection of fresh water have been successful remedial measures to reduce elevated concentrations which had migrated over a large area of the alluvial aquifer.

7.3 POST-CLOSURE PROTECTION MEASURES

In its Ground Water Protection Discharge Plan submitted to the State of New Mexico, HMC has committed to continuing its ground water protection programs until it can be demonstrated that, when the systems are turned off, any future seepage from the tailings facility will not cause the State's Ground Water Protection Standards to be exceeded at the property line. The collection system (which includes the collection wells, IX plant, and evaporation pond) will require operation for a considerable period of time

(possibly 15 years) after the shut-down of the tailings facility. This is because seepage will continue for a time after termination of operation until storage of water in the tailings is down to, or nearly at, its specific retention. However, as the tailings are gradually dewatered, the collection system discharge rate is expected to decline to 200-250 gpm.

This seepage water will be piped through the IX plant for removal of uranium, and the discharged water will be used for interim stabilization during post-closure grading and reclamation of the impoundment. After the impoundment reclamation has been completed and interim stabilization is no longer required, the IX discharge water will be placed in an evaporation pond as discussed below.

7.4 EVAPORATION POND

After mill closure, the tailings impoundment will be dewatered and no longer available for evaporation of water from the collection wells. Consequently, a 66-acre evaporation pond will be constructed to receive collection well discharge during the post-closure period of active ground water protection. This pond will provide storage for about 26 million gallons of water per year in excess of evaporation for about the five years when the collection system will operate at 250 gpm. Subsequently, as discharge declines to 200 gpm and lower, the stored water (about 131 million gallons) will evaporate until the pond is dry.

This pond will be constructed by excavating sufficient soil to create a rectangular retention dike system, then placing a liner across the bottom and sides of the pond. The liner will be Derry Oil Membrane No. 6, a felt

material coated with a thick petroleum rubber compound. The liner will be 250 mils and 125 mils thick on the bottom and sides of the pond, respectively. Leak detection will be provided by existing monitoring wells. The pond, illustrated in Figure 14, will be located as shown in Figure 13 and will incorporate the existing brine pond. It will be reclaimed after cessation of ground water protection measures using the dike soils and clays, excavated previously from the borrow pit before reclamation, to construct a soil cap with the necessary structural and hydrologic properties. This soil cap will be revegetated with the seed mixture discussed in Chapter 6.

8.0 POST-CLOSURE CARE AND MONITORING

Upon completion of the reclamation activities at HMC's site, it is anticipated that a modified ground water and subsidence monitoring program will be required. The following provides a brief description of the monitoring programs that will be implemented.

8.1 GROUND WATER MONITORING PROGRAM

During and after reclamation of the mill and tailings impoundment, HMC will perform ground water monitoring in conjunction with its Ground Water Discharge Plan. Ground water samples will be taken from selected wells downgradient of the reclaimed tailings impoundment and from three wells upgradient. As indicated in Chapter 7, HMC will continue to operate their injection/collection well system to further clean up ground water in the San Mateo alluvium. This system will operate until it can be demonstrated 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.

8.2 MONITORING AND INSPECTION

HMC will place 15 or more feet of tailings sands over the slimes areas in the west and east ponds. When the sands have been placed and the tailings impoundment graded to final contours, HMC will place two feet of soil over the entire impoundment area. Because the buildout of the impoundment placed only coarse sands in the embankments enclosing the ponds, the only potential for settlement due to consolidation of slimes will be in the pond areas on

top of the tailings impoundment. To determine if settlement has occurred, HMC will install settlement monitoring points at locations similar to those shown in Figure 6.

The monitoring points will be surveyed annually to determine the amount of settlement during the year. The revegetated soil cover over the pond areas will be inspected annually for signs of cracking, 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.

8.3 REMEDIAL CARE

The monitor point surveys and inspections described above will detect any conditions requiring maintenance or remediation. The most likely condition will be excessive or non-uniform settlements of the soil cover. During soil cover placement, some extra thickness of soil (included in the nominal two feet thickness) will provide the soil necessary for redistribution and regrading to fill in settlement depressions, reestablish positive gradients, or fill cracks in the cover. Extra soil and rock will be placed at several locations on the stabilized impoundment for these purposes, precluding the need to bring in additional material, a very difficult task after reclamation.

For areas of the site not on the impoundment, remedial measures or maintenance will involve relatively simple repairs using hand tools or light equipment. This work can be accomplished by the staff running the ground water collection system.

9.0 ESTIMATED COSTS

The preceding chapters of this plan have described the conceptual design for long-term stabilization and reclamation of the Homestake-Grants mill site. Some of the stabilization measures (e.g., soil cover placement and contaminated soil cleanup) are based on estimated quantities or dimensions, the accuracy of which can be determined only after additional surveys. Actual mill production in the future will also significantly influence the volumes and dimensions of the impoundment stabilization plan. Consequently, in developing the estimates of costs for stabilization, conservatively high estimates of quantities were used.

The pricing in this estimate is based primarily on independent quotes or unit prices provided by outside sources. The exceptions are those activities or items for which Homestake has cost data from previous requisitions, such as piping and snow fence. The following discussions refer to the items and costs enumerated in Table 4.

9.1 INTERIM STABILIZATION

The items that are specific to interim stabilization are the water spray system and snow fence, and the labor associated with them. Piping already exists to bring water from the mill (slurry line), so the only additional piping needed for the spray system will be that to distribute water along the beach areas. Using one foot of pipe per foot of beach length, a total of 9400 feet of pipe, plus one sprinkler head per 80 feet (or 118 heads) will be required. The unit price of pipe and heads is $1.54 per foot and $12.00 per head, respectively. To maintain pressure and flow, two pumps

(300 gpm at 20 psi) at $1,040 per pump were included in the system. Adding all these costs, the system will cost about $1.91 per foot, or about $18,000 total.

Snow fence will be used on the crests and slopes of the impoundment and will be moved from place to place as required. Using snow fence on half the surface at any time, and placing one line of fence (210 feet) per acre, a total of 11,550 feet of fence at $0.74 per foot will cost about $8,550.

The interim stabilization efforts will gradually give way to long-term stabilization. Consequently, labor will be most intense early in the program and decrease with time. Labor will be required to place and maintain fencing, pipes, sprinklers and pumps over a target period of about three years. Assuming an average of two man-years per year and a total labor cost of $20/man-hour, the estimated total labor cost is $249,600. The total estimated cost of interim stabilization is about $275,000.

9.2 IMPOUNDMENT RECONTOURING

Recontouring of the impoundment will consist of two activities: excavation of the embankment crests and upper slopes to 5:1 (H:V) and placement of this material as fill in the pond areas, and placement of contaminated soil as fill at the embankment toe. Excavation of the crest is expected to be performed first by dozers making relatively short pushes of tailings sands across the beach areas. Once the dozers have cut away the crests and created beaches on the slopes, scrapers will flatten the slopes by longitudinal cuts, hauling the sand tailings up to 1,000 yards to fill locations in the pond areas, where dozers and graders will spread and compact the tailings.

The total volume of 1,850,000 is divided equally between dozers and scrapers for estimating purposes. The entire relocation of tailings (excavate, move, fill, and compact) is a continuous operation and is estimated by a unit price of $1.00 per cubic yard for dozer yardage and $1.62 per cubic yard for scraper yardage, for totals of $925,000 and $1,498,500, respectively.

Fill placed at the toe, consisting of the contaminated soil excavated around the site, is priced as if the soil will be drawn from a stockpile near the fill location, dozed into place, and compacted. Excavation of this soil is priced separately as contaminated soil excavation in Section 9.7. About 310,000 cubic yards are required to create a 5:1 slope toe fill, and about 50,000 cubic yards additional soil will be used to bury the mill debris under a slope of about 10:1. A unit price of $1.80 per cubic yard for dozing and compaction results in a cost of $648,000 for placing the toe fill.

Total costs for recontouring the impoundment are estimated at slightly over $3 million.

9.3 IMPOUNDMENT SOIL COVER

The work items to construct the soil cover on the tailings impoundment consist of borrow pit development (stripping and grubbing); borrow excavation, haulage, and dumping; and spreading and compacting. The borrow area covers about 139 acres. An independent local contractor provided an estimated unit price of $400 per acre, or a total of $55,600 for borrow pit preparation.

The borrow material will be excavated, hauled and dumped by scrapers. The average haul distance, estimated at 0.8 miles, was used to determine the

unit price of $1.62 per cubic yard. Dumped in windrows across the impoundment, the borrow will be spread and compacted by graders, dozers and sheepsfoot rollers after moisture conditioning by water trucks. An estimated unit price of $1.80 per cubic yard covers these activities. With 600,000 cubic yards required for a two-foot cover, the total costs for excavate/haul/dump and spread/compact are $972,000 and $1,080,000, respectively. Combined with borrow area preparation, the total soil cover estimated cost is $2,107,600.

9.4 IMPOUNDMENT ROCK COVER

Rock will be required to cover the impoundment side slopes, to line the drainage swales against all erosion, and to protect the diversion ditches and impoundment toe against flood erosion. The impoundment slope rock cover, 0.5 foot thick, will require about 103,000 cubic yards. Toe protection using oversized rock (one- to two-foot diameter riprap) will require about 16,000 cubic yards. The total for other rock protection is about 5,000 cubic yards, bringing the total to about 124,000 cubic yards.

The cost of rock was separated into six categories. Purchase of rock from the owner was estimated at $0.25 per cubic yard, or $31,000. The rock will be quarried by drill-and-blast methods, crushed and screened, loaded and hauled to dump locations on site, then spread and graded or placed. Each of these tasks has been priced separately based on estimated unit prices supplied by contractors or industry cost data publications. Drill-and-blast is estimated at $1.58 per cubic yard and crushing and screening at $3.50 per cubic yard. To load, haul about 7.5 miles, and dump is priced at $2.00 per cubic yard. Spreading is priced at $1.00 per cubic yard and riprap placement is expected to be $21.00 per cubic yard.

If vegetation cannot dependably protect the top of the impoundment from wind erosion, the undersize waste rock (minus three inches) will be hauled to the site and mixed in the top lift of soil to raise the volume percentage of 0.84 mm particles to increase resistance to wind erosion. No additional costs except load/haul/dump will be involved in this measure, which would call for 25,000 to 30,000 cubic yards of material. The cost of moving this undersize rock to the site has not been included in the estimate in Table 4.

Excluding the undersize rock haulage, the total cost for rock protection is about $1,352,900.

9.5 RADIOLOGICAL SURVEY

The survey to be conducted after site cleanup, to locate residual contamination, has been estimated in two parts, mill area survey and vicinity survey, as lump sum items. Estimates of these costs by an independent contractor are $9,000 and $23,000, respectively, for a total of $32,000.

9.6 MILL DEMOLITION

A detailed estimate of mill demolition costs could not be obtained in the time period available for preparing this plan. Therefore, as a basis for estimating, HMC used the award cost of a contract placed in 1986 for demolition of a uranium mill near Grants. The total estimated cost of mill demolition is $1.5 million, about double the cost of the aforementioned demolition contract.

9.7 CONTAMINATED SOIL EXCAVATION

Cleanup of contaminated soil is expected to be performed in the same manner as borrow pit preparation and excavation, and with comparable haul distances. Therefore, the same unit prices apply. Clearing of 644 acres at $400 per acre will cost $257,600, and excavation of about 80,000 cubic yards in the mill area and 520,000 cubic yards around the site at $1.62 per cubic yard will cost $129,600 and $842,000, respectively. This gives a total cost of $1,229,600 for contaminated soil cleanup. Note that soil disposal is included in impoundment toe fill costs elsewhere in the estimate and that no clearing of the 49-acre mill area is included (included elsewhere as part of demolition).

9.8 SITE RECONTOURING

The earthwork to recontour the site will be accomplished by graders with some minor earthmoving by dozer and scraper. For estimating purposes, the work has been divided into four tasks: general grading (930 acres); borrow pit grading (139 acres); San Mateo diversion (4 acres); and impoundment diversion ditch grading (28 acres). However, the same unit price of $200 per acre applies to all recontouring except the diversion ditch grading, which is estimated by cost per cubic yard ($1.62) to excavate soil and place it in the levee northeast of the impoundment. The estimated cost for recontouring is $360,400.

9.9 REVEGETATION

After recontouring is completed, all site areas not covered by rock will be revegetated. These areas include the top of the impoundment, the contaminated soil removal areas, the mill site, the evaporation pond, and the bor-

row and flood diversion areas. A total of about 1,160 acres will be revegetated. The included tasks, priced separately, are soil preparation/fertilizer/mulch, seeding, and fencing. According to an estimate from an independent revegetation contractor, the costs per acre for the first two are $420 and $80, respectively. Triple-strand barbed wire fencing is priced at $0.89 per foot.

The item totals to revegetate 1,160 acres are $487,200 for soil preparation fertilizer/mulch and $92,800 for seeding. Adding $51,620 for fencing, the total estimated cost is $631,620 for revegetation.

9.10 GROUND WATER RESTORATION AND MONITORING

Two major costs are identified in the ground water protection program. The first--collection, injection, and monitor well operations--is priced at $250,000 per year and includes replacement and repair costs based on actual system operating costs over a 5 to 10 year period. Operating for 15 years, this task will cost $3,750,000.

An evaporation pond, the second major cost item, will be constructed to support the ground water program. The existing five-acre brine pond will be incorporated into this new pond. The cost of the 66-acre pond includes earthwork (excavation of pond area and fill placement to build dikes) at $1.90 per cubic yard, based on costs actually incurred to construct the present brine evaporation ponds. The 85,800 cubic yards of earthwork will cost $163,000. Later earthwork, priced at $1.47 per cubic yard, will be required for reclaiming (filling and covering) this pond. This reclamation earthwork will cost $141,700.

The pond will be lined with Derry Oil Membrane No. 6, the same liner used to create the existing brine evaporation ponds. Homestake paid $4.05 per square yard for this liner. Using the same unit price for the evaporation pond liner, the 306,200 square yards of liner will cost $1,240,110.

The total ground water restoration and monitoring costs are estimated to be about $5,295,000.

9.11 COST ESTIMATE SUMMARY

The total estimated cost for long-term stabilization and reclamation is about $15,855,400. This cost results from conservative estimates of quantities and actual or realistically conservative unit prices based either on independent contractor/vendor estimates, industry cost data, or Homestake procurement records.

These costs will be reviewed annually and revised as necessary.

10.0 SCHEDULE

A schedule for tailings stabilization and site reclamation has been developed on a conceptual basis, relating all activities to the closure date, year 0 in Figure 15. This figure illustrates the schedule and relationship of the activities outlined in this plan. No calendar date for closure of the mill has been set by HMC, so the schedule is based on years from closure, not specific dates.

The ground water protection measures, already in place except for the evaporation pond, start before closure and last for about 15 years after closure, followed by a year of pond reclamation and well plugging. All other activities start at or after closure and will be completed by the end of year six.

At closure, the plan will begin in the first year with interim stabilization, mill demolition, and initial recontouring. In the second year, a radiological survey will define areas for soil cleanup, which will also start that year. Impoundment recontouring will continue through the second year, as well, with sand tailings being pushed progressively farther over the pond areas to fill and surcharge them. The top of the impoundment should be recontoured by the end of the fifth year.

In the third year and through the fourth, the impoundment toe areas will be filled and the side slopes cut to required grade. Site recontouring will be completed, allowing revegetation to start as early as the fourth year.

In the fourth year the soil cover placement will start, followed as closely as possible by rock cover on the outside slopes. Both these activities will continue through the fifth year and should be completed by the end of the sixth year.

This schedule is conceptual only. The actual schedule will be strongly influenced by the rate of dewatering and consolidation of tailings slimes.

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TABLE 1
PMP AND PMF DATA

A. PMP Amounts for San Mateo Creek Watershed

Duration (hrs.)	1/2	1	3	6	24	72
General Storm	NA	3.4	NA	8.6	12.2	15.9
Local Storm	2.2	3.4	5.3	6.7	NA	NA

B. Hydrograph Generation Results

PMP Duration (hrs.)	6	24
PMP Amount (inches)	8.6	12.2
PMF Peak Discharge (cfs)	180,250	169,800
Time to Peak (hrs.)	5.75	5.75
Hydrograph Length (hrs.)	13.5	31.5

TABLE 2
STABILIZATION SEED MIXTURE

SCIENTIFIC NAME	COMMON NAME	GROWTH HABIT[(1)]	SEEDING RATE (DRILL SEEDING) LBS PURE LIVE SEED/ACRE	SEEDING RATE (DRILL SEEDING) NUMBER OF SEEDS/FT^2
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 3

PREPARATORY CROP SEEDING RATES

SCIENTIFIC NAME	COMMON NAME	SEEDING RATE[1] LBS PURE LIVE SEED/ACRE
Hordium vulgare	Barley	25.0
or	or	
Triticum aestivum	Wheat	25.0
or	or	
Avena sativa	Oats	25.0

(1) Seeding rate is for drill seeding. If broadcast seeding is used, the rate will be doubled.

TABLE 4

ESTIMATED COSTS
LONG-TERM STABILIZATION AND RECLAMATION
HOMESTAKE MINING COMPANY, GRANTS, NEW MEXICO

CATEGORY OR ITEM/UNITS	UNIT PRICE	QUANTITY	ITEM COST*	CATEGORY COST
1.0 INTERIM STABILIZATION DURING CLOSURE				
1.1 Water Spray System/Ft	$1.91	9,400	$18,000	
1.2 Snow Fence/Ft	$.74	11,550	$8,500	
1.3 Labor/Hr	$20.00	12,480	$249,600	
				$277,100
2.0 IMPOUNDMENT RECONTOURING, TAILINGS EXCAVATION, FILL				
2.1 Dozer (Crest)/Cu Yd	$1.00	925,000	$925,000	
2.2 Scraper (Slope)/Cu Yd	$1.62	925,000	$1,498,500	
2.3 Toe Fill/Cu Yd	$1.80	360,000	$648,000	
				$3,071,500
3.0 IMPOUNDMENT SOIL COVER				
3.1 Borrow Pit Prep./Acre	$400	139	$55,600	
3.2 Excavate, Haul, Dump/Cu Yd	$1.62	600,000	$972,000	
3.3 Spread and Compact/Cu Yd	$1.80	600,000	$1,080,000	
				$2,107,600
4.0 IMPOUNDMENT ROCK COVER				
4.1 Purchase Rock/Cu Yd	$0.25	124,000	$31,000	
4.2 Drill and Blast/Cu Yd	$1.58	124,000	$195,900	
4.3 Crush and Screen/Cu Yd	$3.50	124,000	$434,000	
4.4 Load, Haul, Dump/Cu Yd	$2.00	124,000	$248,000	
4.5 Spread, Grade/Cu Yd	$1.00	108,000	$108,000	
4.6 Place Riprap/Cu Yd	$21.00	16,000	$336,000	
				$1,352,900
5.0 RADIOLOGICAL SURVEY				
5.1 Mill Area Survey, Sampling	L.S.	1	$9,000	
5.2 Vicinity Survey, Sampling	L.S.	1	$23,000	
				$32,000
6.0 MILL DEMOLITION				$1,500,000
7.0 CONTAMINATED SOIL CLEAN-UP				
7.1 Clear Vegetation/Acre	$400	644	$257,600	
7.2 Mill Area/Cu Yd	$1.62	80,000	$129,600	
7.3 Site/Cu Yd	$1.62	520,000	$842,400	
				$1,229,600
8.0 SITE RECONTOURING				
8.1 General Grading/Acre	$200	930	$186,000	
8.2 Borrow Pit Grading/Acre	$200	139	$27,800	
8.3 San Mateo Diversion/Acre	$200	4	$800	
8.4 Impoundment Diversion Ditch/Cu Yd	$1.62	90,000	$145,800	
				$360,400

*Costs rounded to nearest $100.

TABLE 4

ESTIMATED COSTS
LONG-TERM STABILIZATION AND RECLAMATION
HOMESTAKE MINING COMPANY, GRANTS, NEW MEXICO
(Continued)

CATEGORY OR ITEM/UNITS	UNIT PRICE	QUANTITY	ITEM COST*	CATEGORY COST
9.0 REVEGETATION				
9.1 Soil Prep., Fertilizer, Mulch/Acre	$420	1,160	$487,200	
9.2 Seeding/Acre	$80	1,160	$92,800	
9.3 Fencing/Ft	$.89	58,000	$51,600	
				$631,600
10.0 GROUND WATER RESTORATION AND MONITORING				
10.1 Collection, Injection, Monitor Well Opns/Yr	$250,000	15	$3,750,000	
10.2 Evaporation Pond				
10.21 Earthwork/Cu Yd	$1.90	85,800	$163,000	
10.22 Liner/Sq Yd	$4.05	306,200	$1,240,100	
10.23 Reclamation Fill/Cu Yd	$1.47	96,400	$141,700	
				$5,294,800
TOTAL COST				$15,855,400

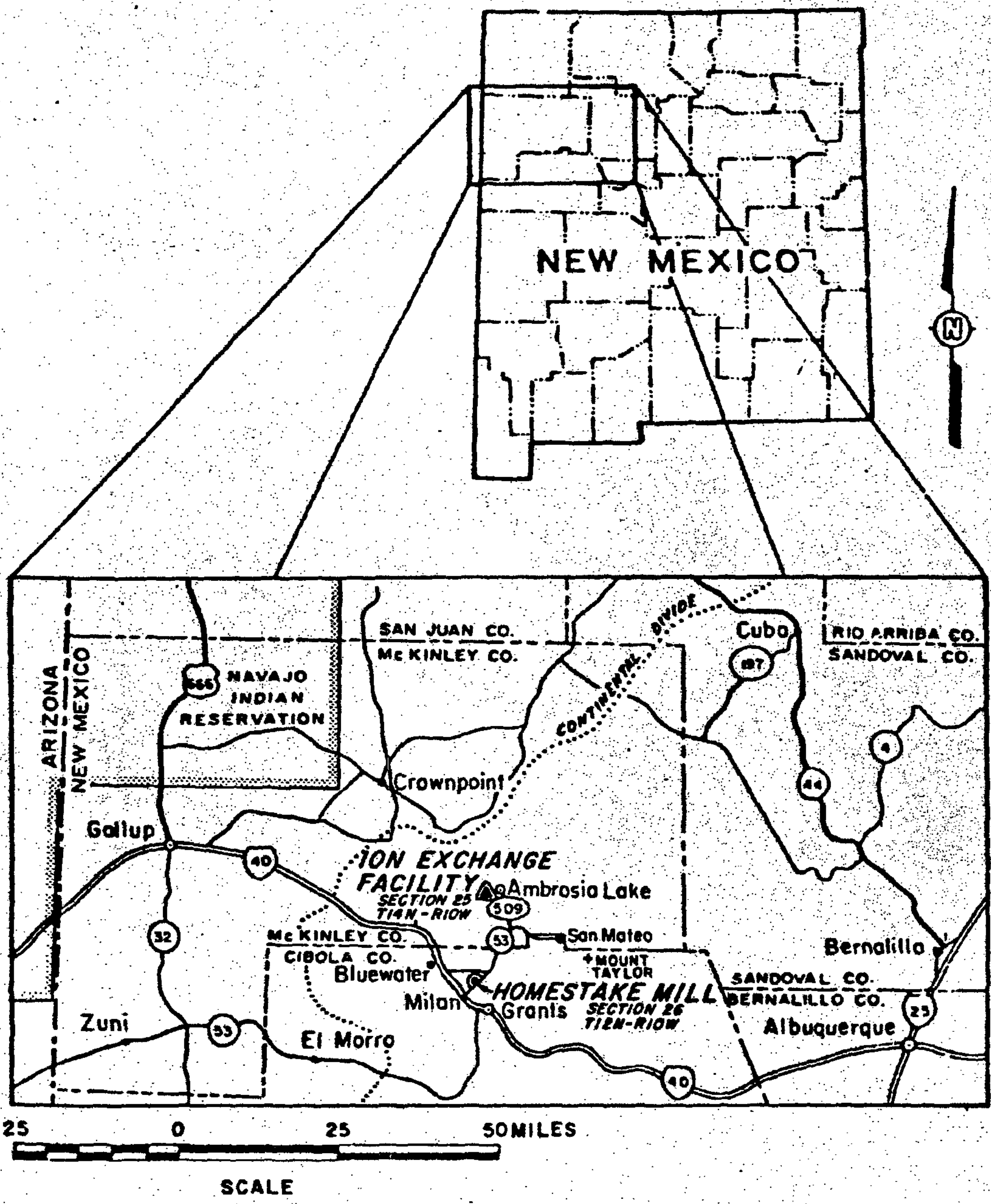


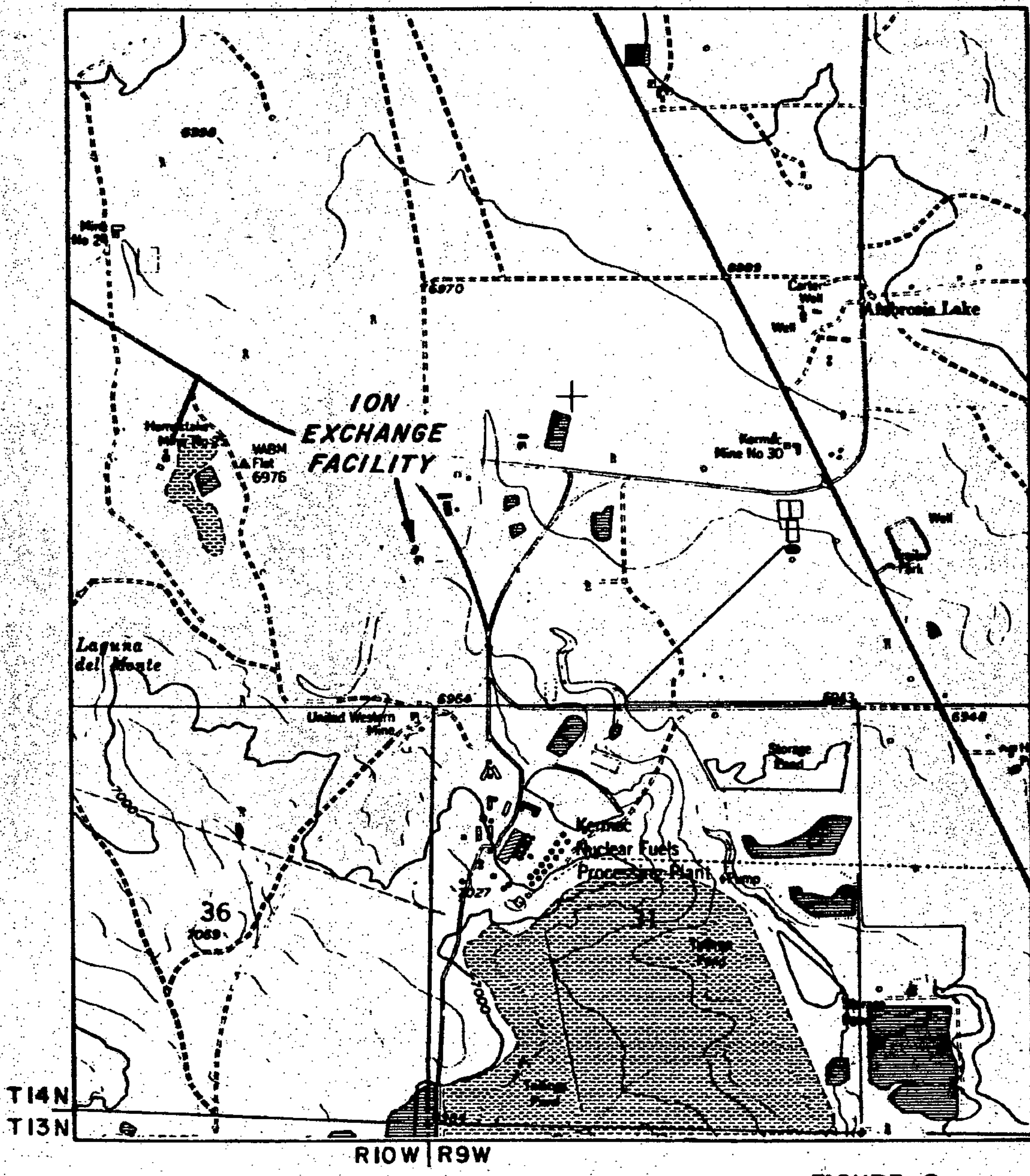
FIGURE I

SITE LOCATION MAP

REFERENCE

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

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO



2000 0 2000 4000 FEET

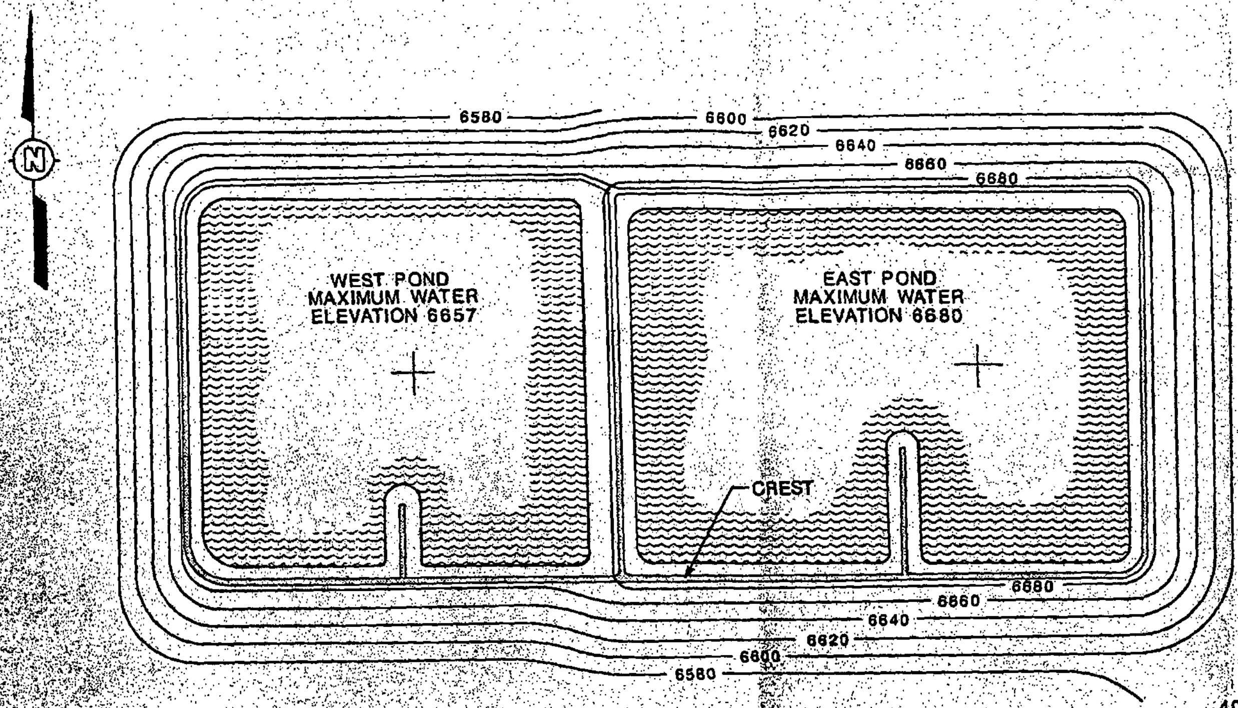
SCALE

FIGURE 2

SITE LOCATION
MINE WATER DISCHARGE
ION EXCHANGE FACILITY

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

REFERENCE
USGS 7.5 MINUTE TOPOGRAPHIC MAP
OF AMBROSIA LAKE, NEW MEXICO,
DATED 1957, PHOTOREVISED 1980.



NOTES

1. MINIMUM BEACH WIDTH 50 FT.
2. MINIMUM FREEBOARD 5 FT.
3. MAXIMUM CREST ELEVATIONS:
   6687 – EAST POND
   6675 – WEST POND

400 0 400 800 FEET

SCALE

CONTOUR INTERVAL: 20'

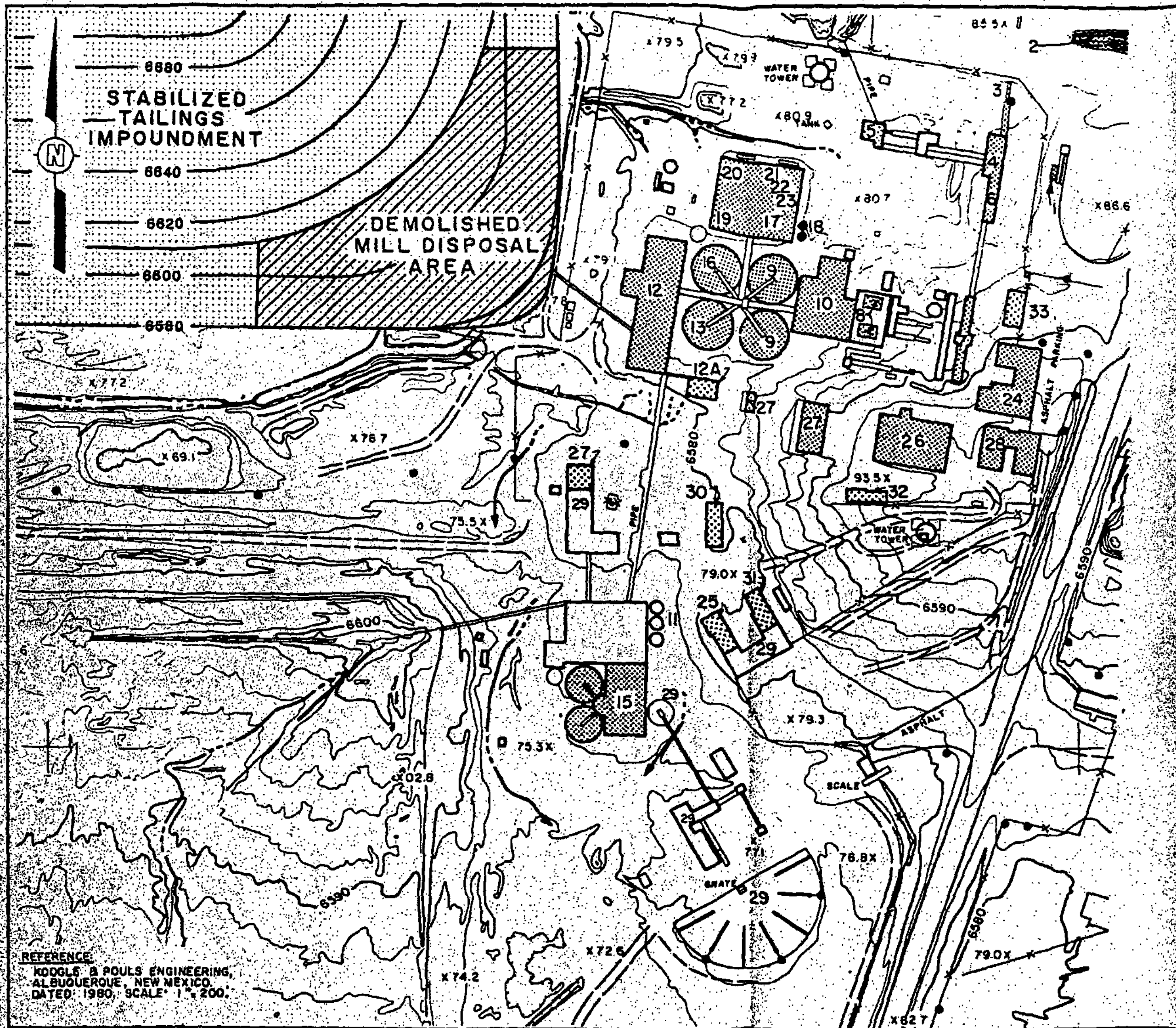
FIGURE 3

TAILINGS IMPOUNDMENT
AT END OF FIVE YEARS
OF 2000 TPD PRODUCTION

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

REV. 0 10/24/86

DESIGNED BY: A.K. KUHN
DRAWN BY: T.M. BOND



CURRENT OPERATING FACILITIES LOCATION IDENTIFICATION

- ORE RECEIVING SECTION
  1. ORE RECEIVING SCALE
  2. ORE STORAGE PAD
- CRUSHING AND SAMPLING SECTION
  3. GRIZZLY
  4. IMPACT BREAKER
  5. ROTARY DRYER
  6. RECIPROCATING SAMPLERS
- FINE ORE STORAGE SECTION
  7. FINE ORE BINS
- GRINDING SECTION
  8. BALL MILL
  9. THICKENER TANKS
- URANIUM LEACHING SECTION
  10. PRESSURE LEACHING AUTOCLAVES
  11. ATMOSPHERIC LEACHING PACHUCA TANKS
  12. FILTERS
  12 A. VACUUM PUMPS
  13. SOLUTION STORAGE TANK
  14. TAILINGS DISPOSAL POND
  15. TAILINGS POND ION EXCHANGE
- PRECIPITATION SECTION
  16. PREGNANT SOLUTION
  17. PRECIPITATION TANKS
  18. PRECIPITATION TANKS
  19. PRECIPITATE THICKENER TANK
- 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

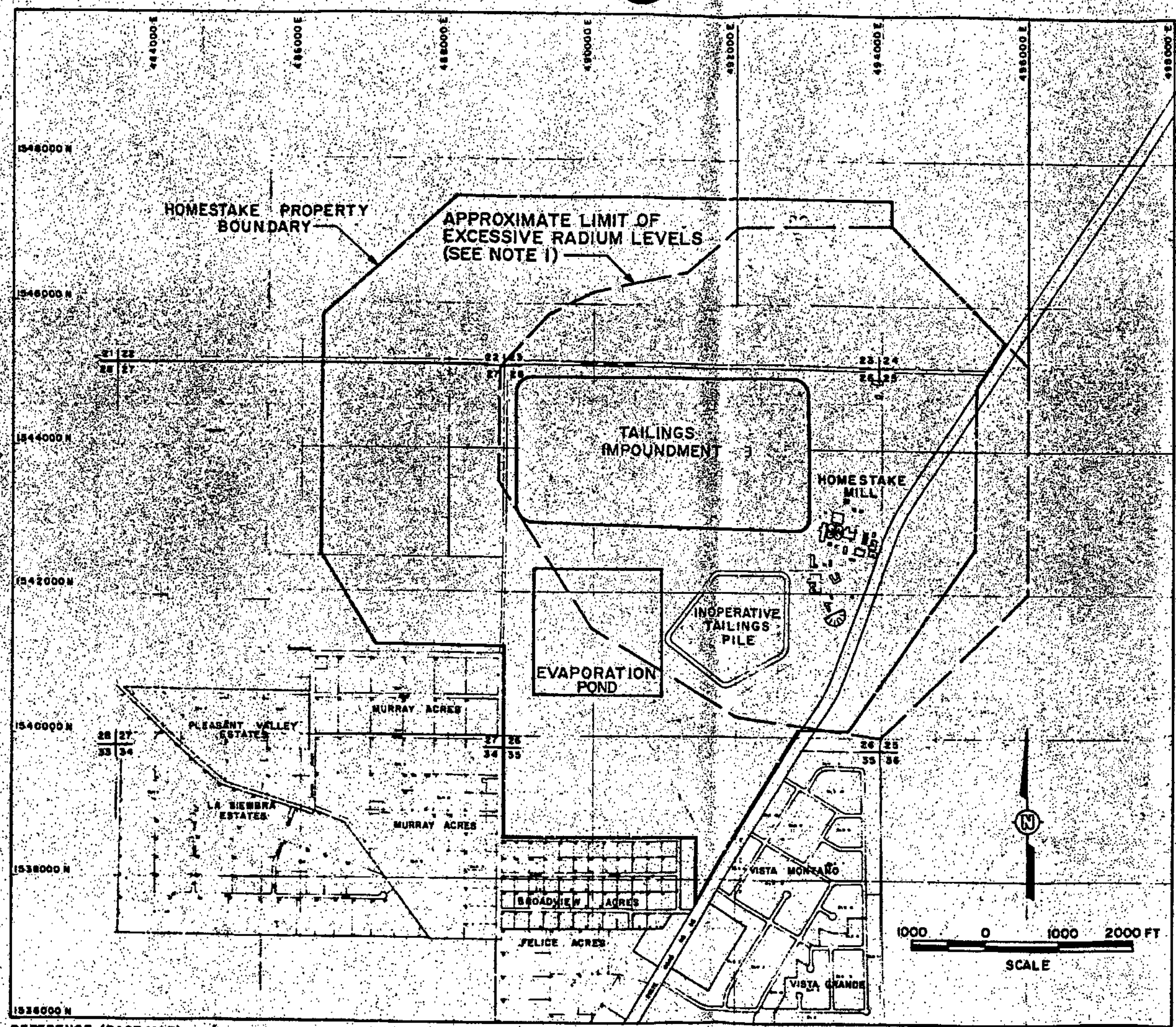
200 0 200 FEET
SCALE

FIGURE 4

MILL FACILITIES MAP

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

HMCSL024646



REFERENCE (BASE MAP)
HOMESTAKE MINING COMPANY, 1981b.

NOTES

1. APPROXIMATE LIMIT IS OUTER BOUNDARY OF THE AREA OF 25+µR/HR GAMMA READINGS FROM 1980 HMC SURVEY. THE ACTUAL IRREGULAR BOUNDARY HAS BEEN EXTENDED OUTWARD IN SOME PLACES AND SIMPLIFIED ON THIS FIGURE BY STRAIGHT LINE SEGMENTS FOR CONSERVATISM.
2. AREA OF TAILINGS IMPOUNDMENT, 179 ACRES, REPRESENTS CONFIGURATION AT END OF 5-YEAR BUILDOUT.

FIGURE 5

AREA OF SUSPECTED EXCESSIVE RADIUM LEVELS IN SOIL

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

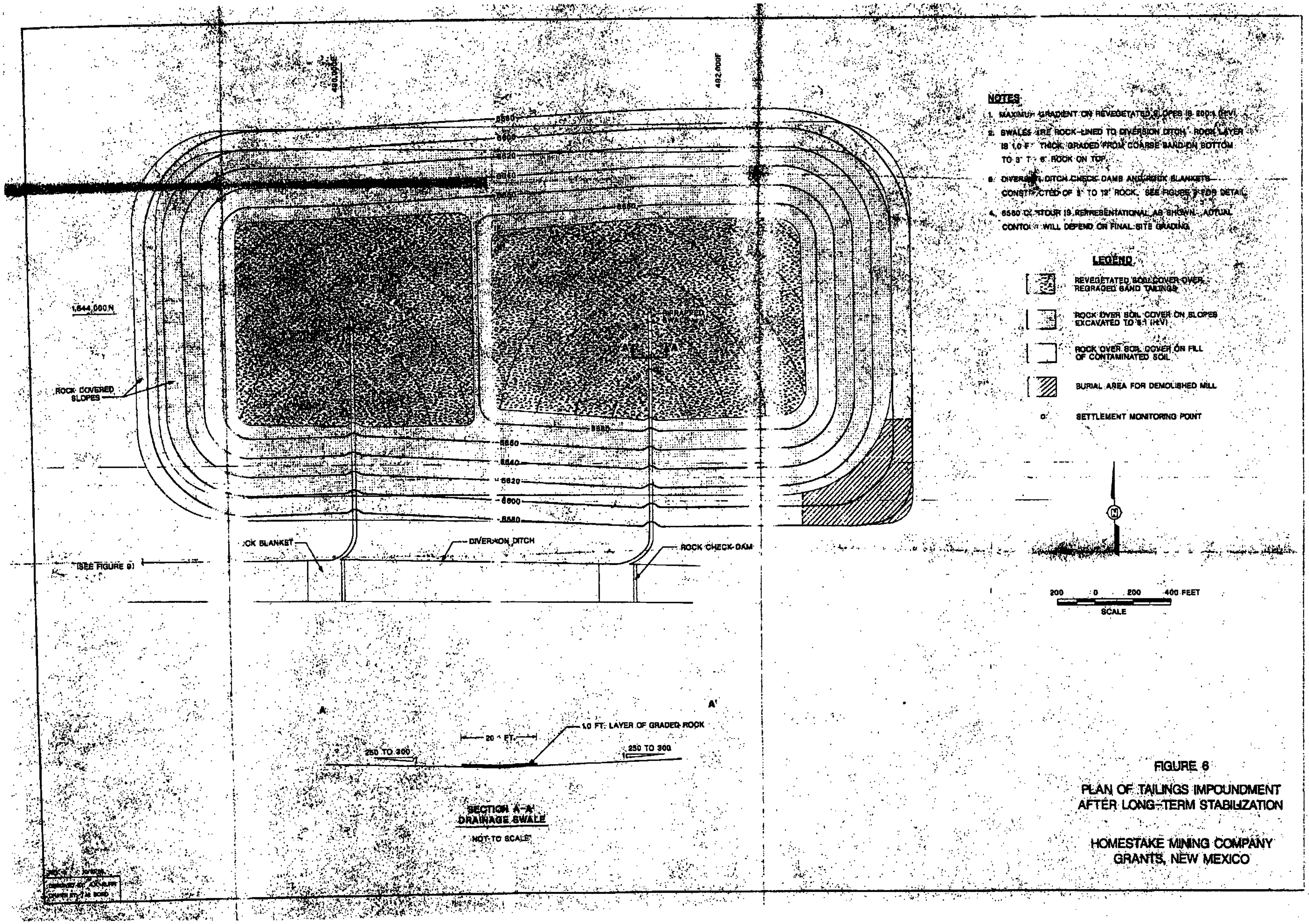


FIGURE 6

PLAN OF TAILINGS IMPOUNDMENT AFTER LONG-TERM STABILIZATION

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

HMCSL024648

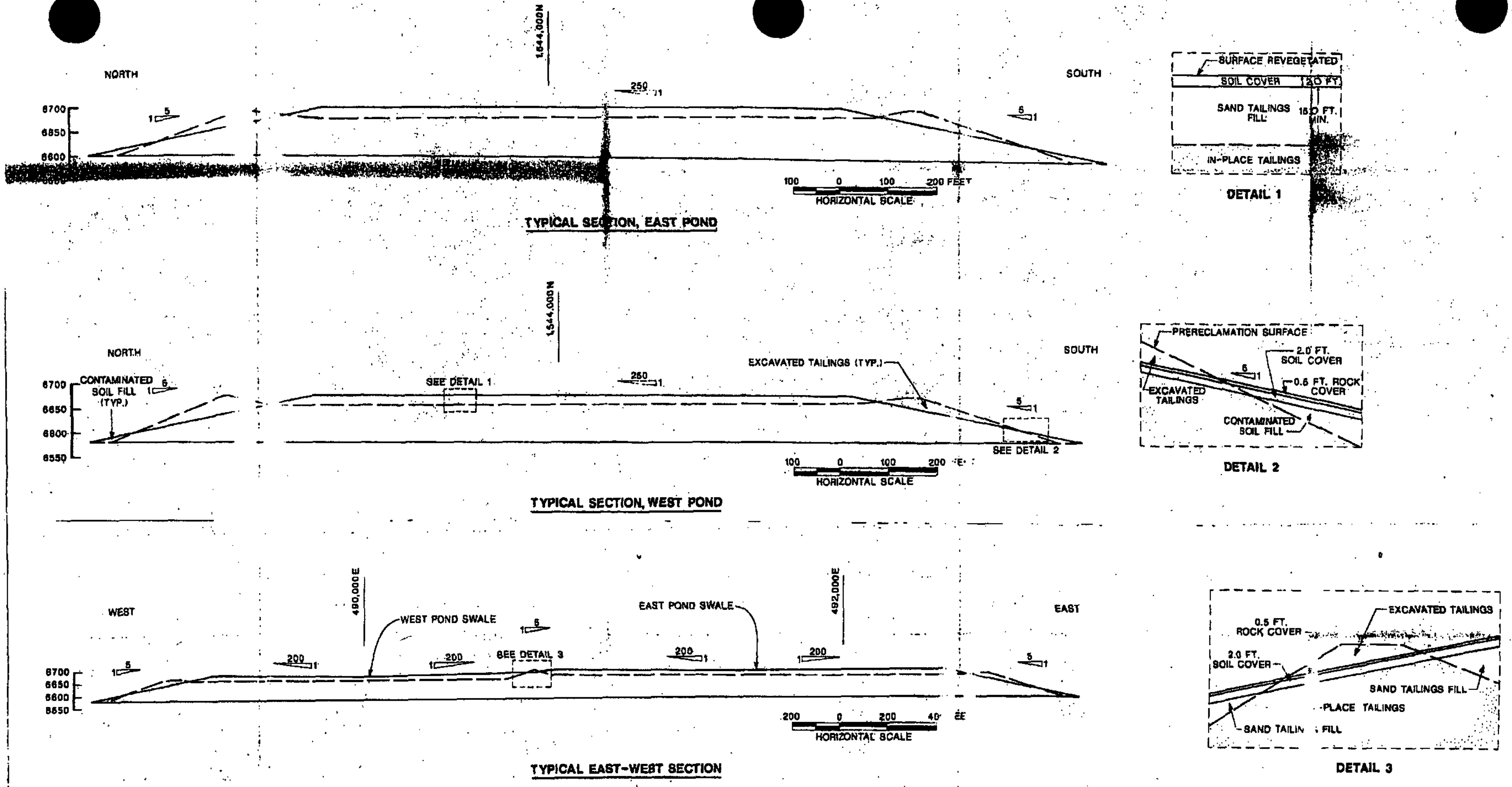


FIGURE 7
CROSS SECTIONS OF TAILINGS IMPOUNDMENT AFTER LONG-TERM STABILIZATION

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

REV 0 10/10/88
DESIGNED BY: A.K. KUHN
DRAWN BY: T.M. BOND

HMCSL024649

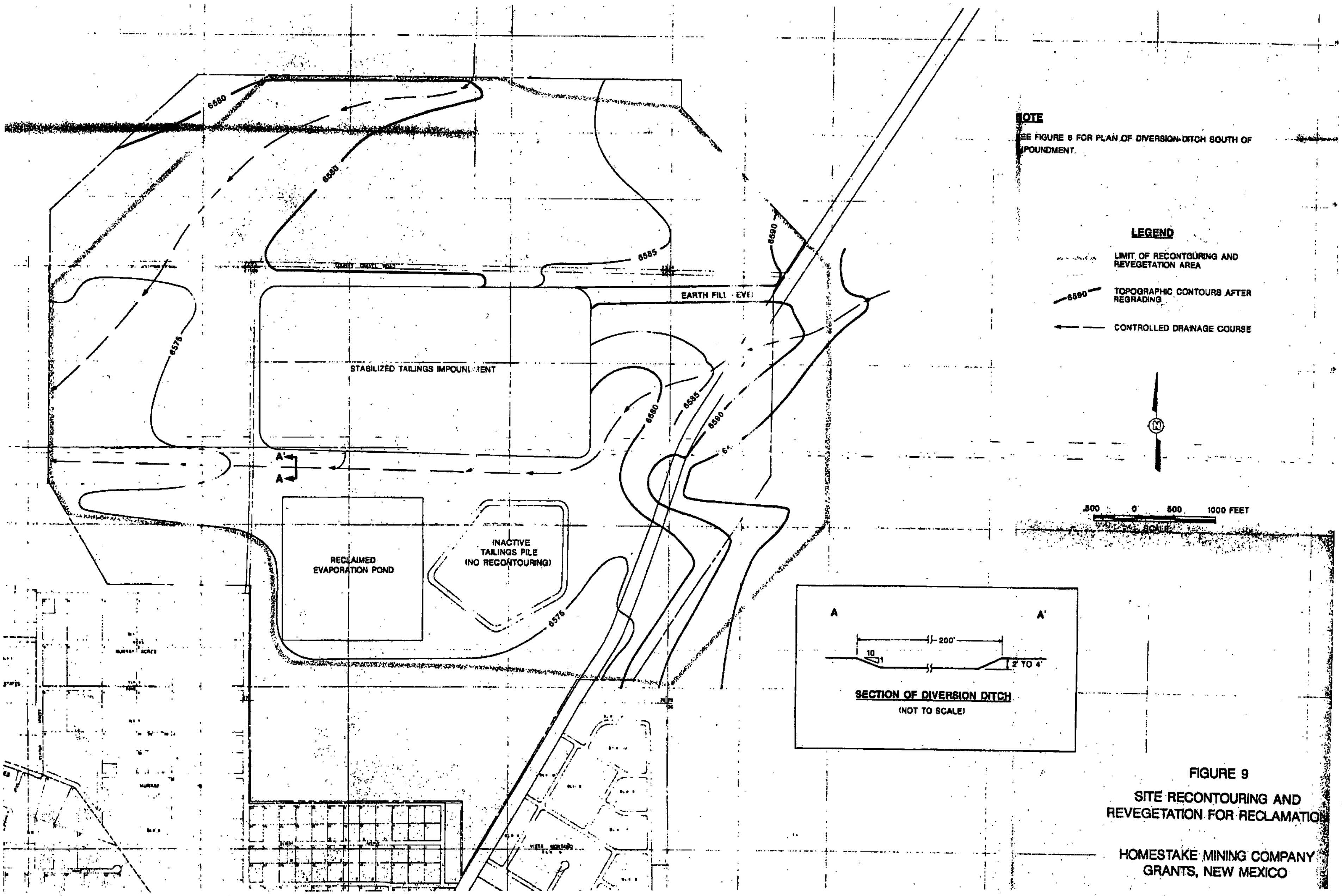
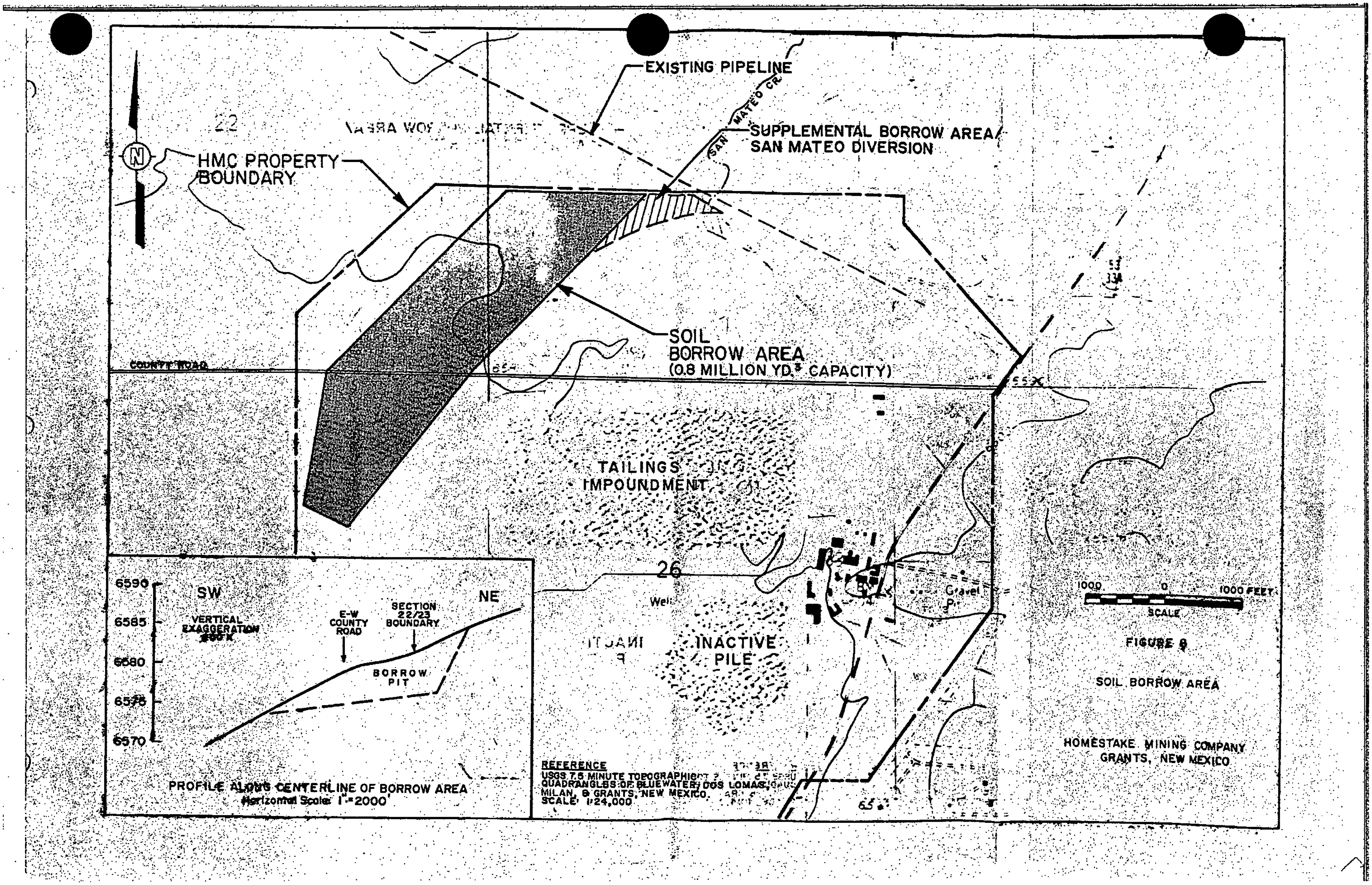


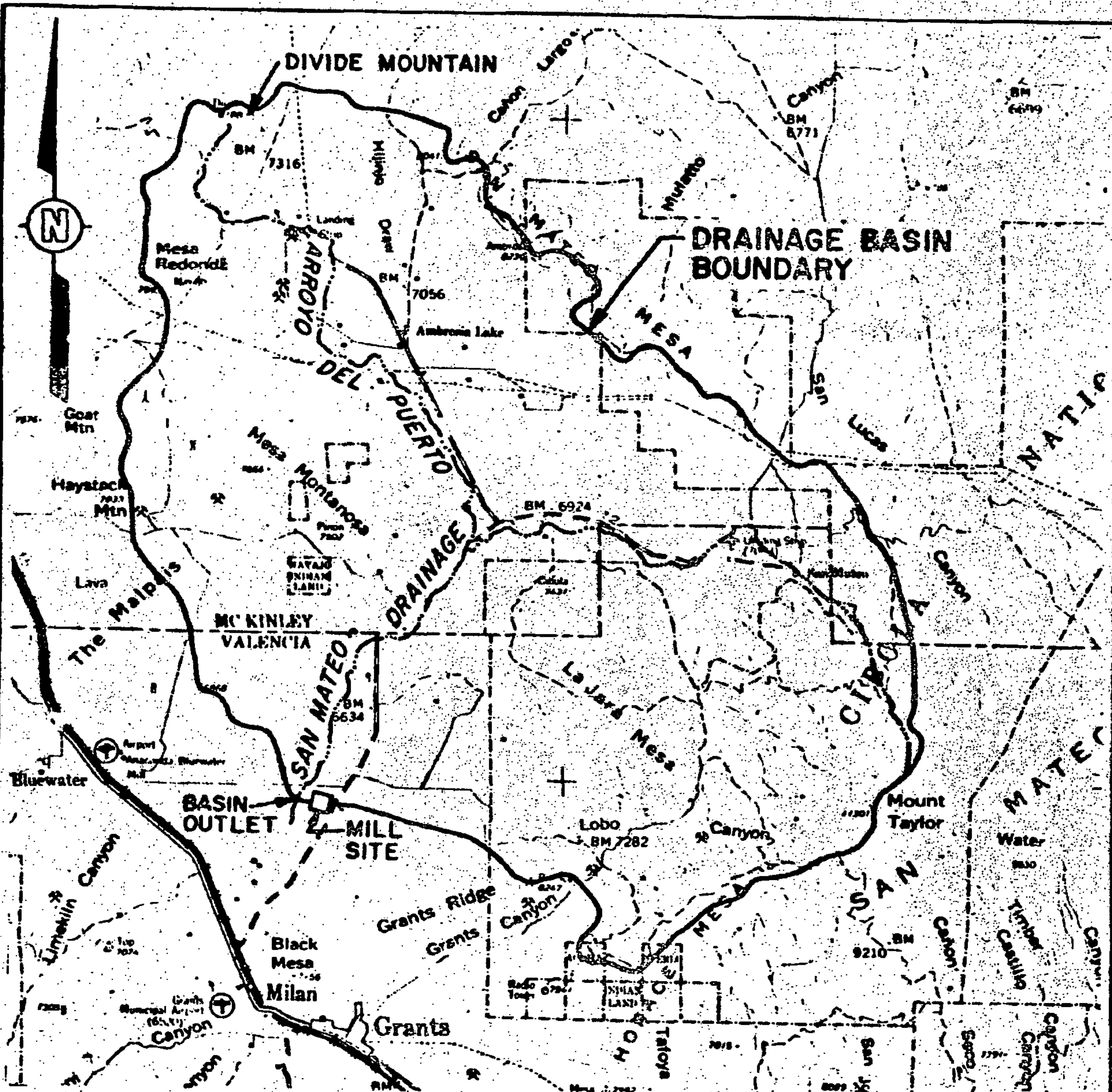
FIGURE 9

SITE RECONTOURING AND REVEGETATION FOR RECLAMATION

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO



EXISTING PIPELINE
SAN MATEO CR.
SUPPLEMENTAL BORROW AREA/
SAN MATEO DIVERSION
HMC PROPERTY
BOUNDARY
22
SOIL
BORROW AREA
(0.8 MILLION YD.3 CAPACITY)
COUNTY ROAD
TAILINGS
IMPOUNDMENT
26
INACTIVE
PILE
Gravel
6590
6585
6580
6575
6570
SW
NE
VERTICAL
EXAGGERATION
E-W
COUNTY
ROAD
SECTION
22/23
BOUNDARY
BORROW
PIT
PROFILE ALONG CENTERLINE OF BORROW AREA
Horizontal Scale: 1"=2000'
REFERENCE
USGS 7.5 MINUTE TOPOGRAPHIC
QUADRANGLES OF BLUEWATER, DOS LOMAS,
MILAN, & GRANTS, NEW MEXICO.
SCALE: 1:24,000
1000
0
1000 FEET
SCALE
FIGURE 8
SOIL BORROW AREA
HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO



4 0 4 8 MILES
SCALE

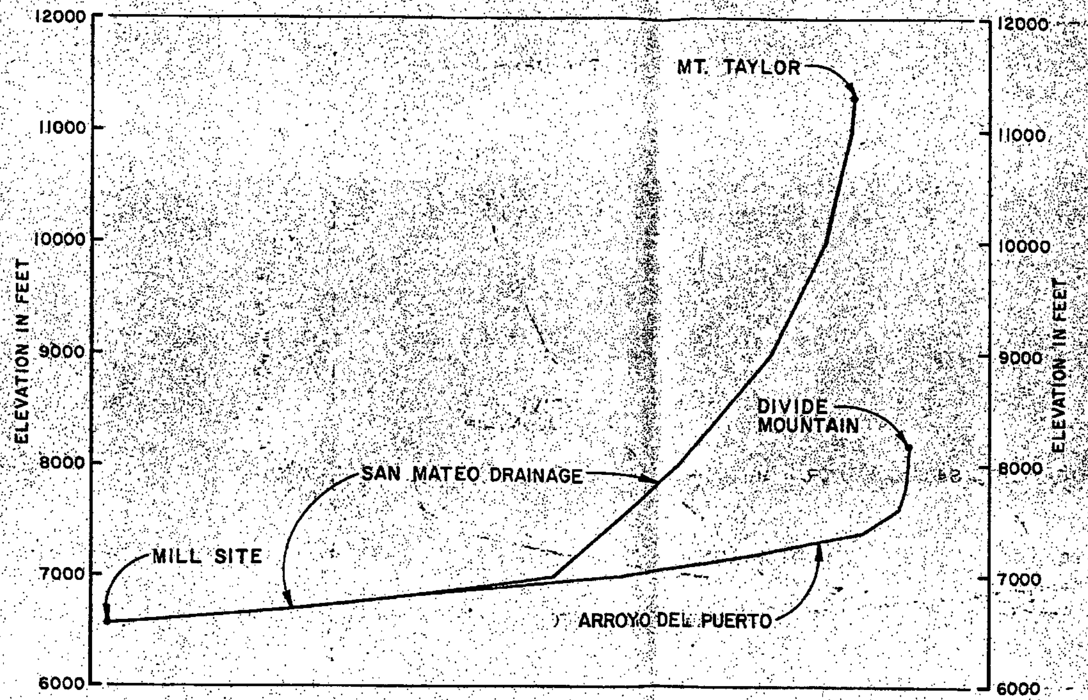
FIGURE 10

SAN MATEO
DRAINAGE BASIN

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

REFERENCE:
U.S.G.S. TOPOGRAPHIC MAP OF ALBUQUERQUE, NEW MEXICO.
SCALE: 1:250,000 DATED: 1963.

HMCSL024652



SAN MATEO DRAINAGE AND
ARROYO DEL PUERTO PROFILES

NOTE:
FOR PROFILE LOCATIONS SEE FIGURE 10.

1000 0 1000 2000 FEET
VERTICAL SCALE

20000 0 20000 40000 FEET
HORIZONTAL SCALE

FIGURE 11

SAN MATEO DRAINAGE AND ARROYO DEL PUERTO PROFILES

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

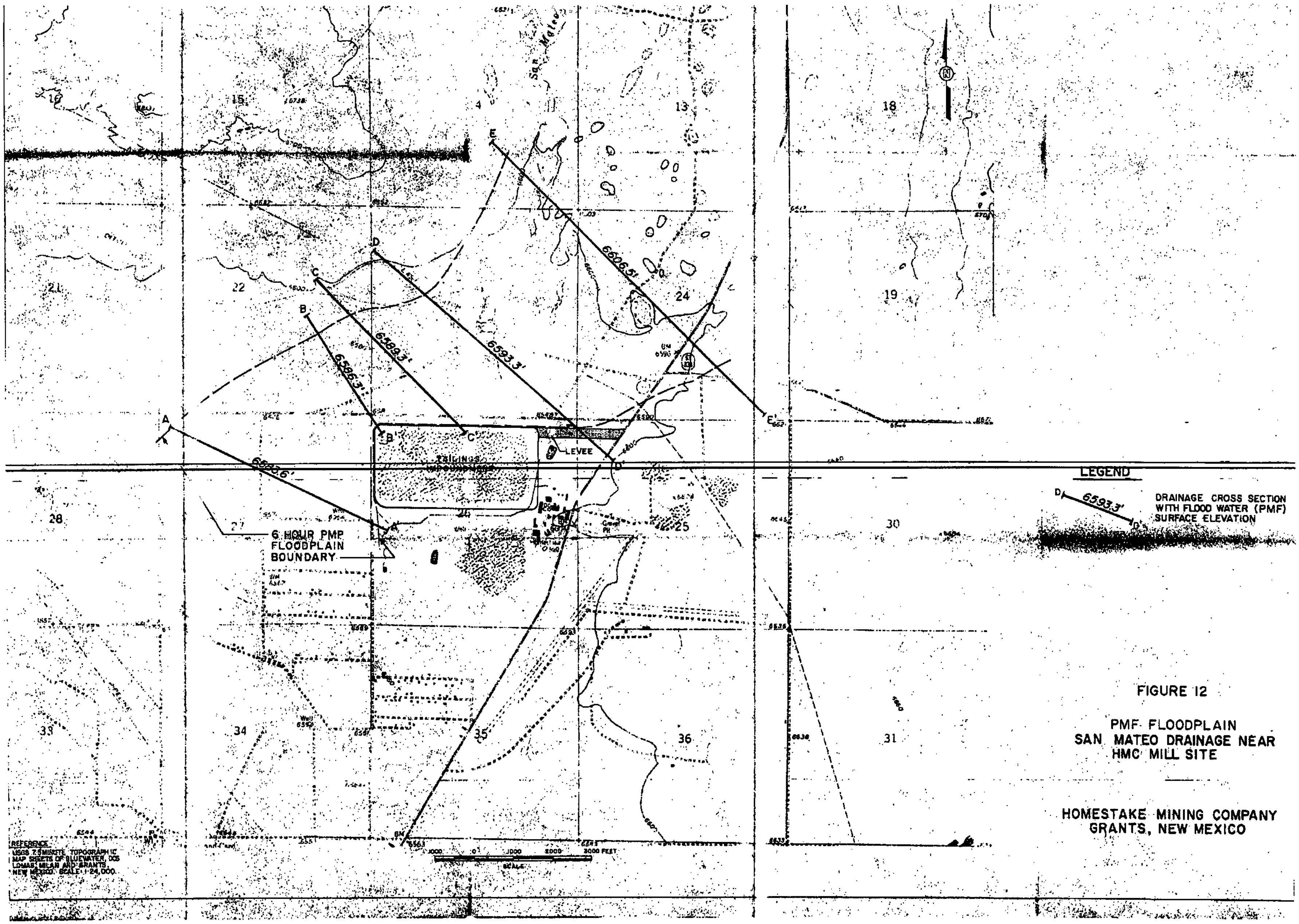


FIGURE 12

PMF FLOODPLAIN
SAN MATEO DRAINAGE NEAR
HMC MILL SITE

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

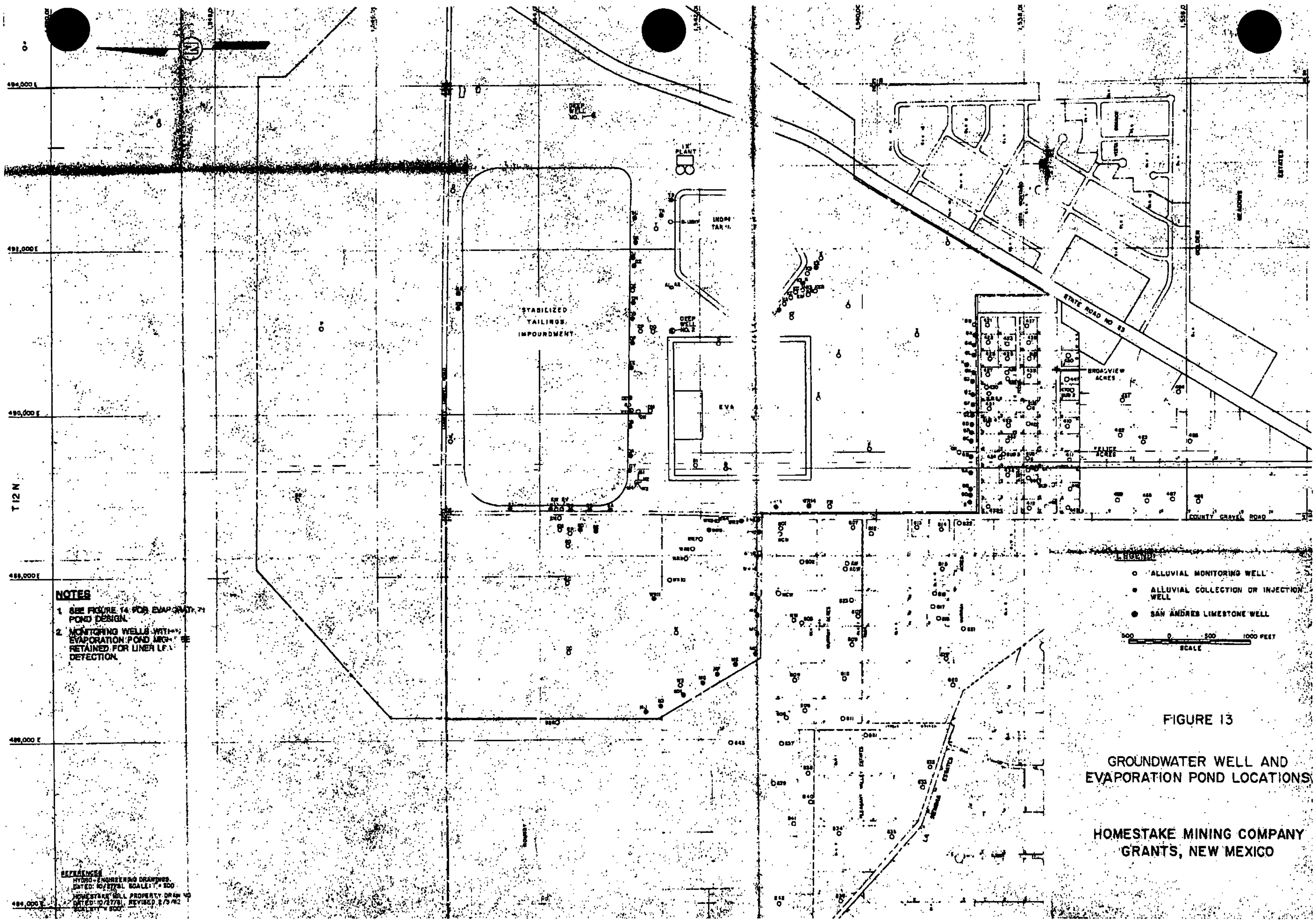
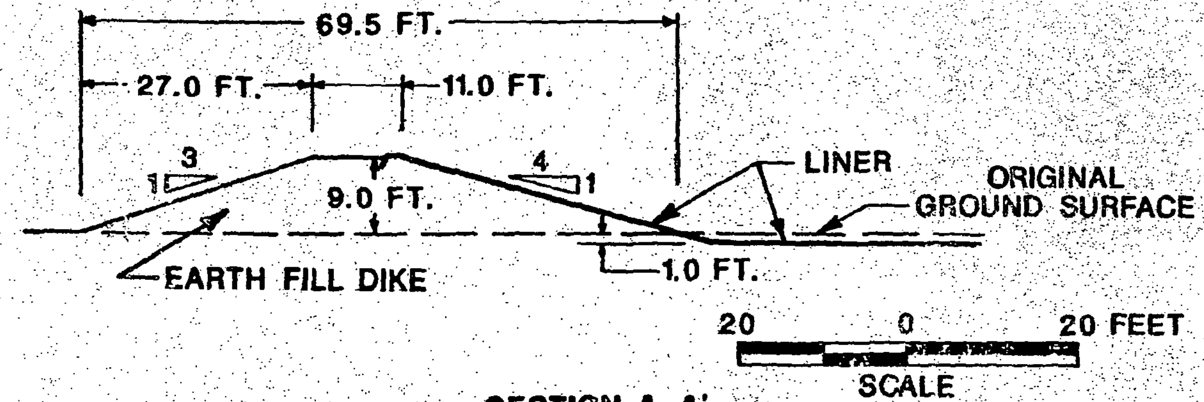


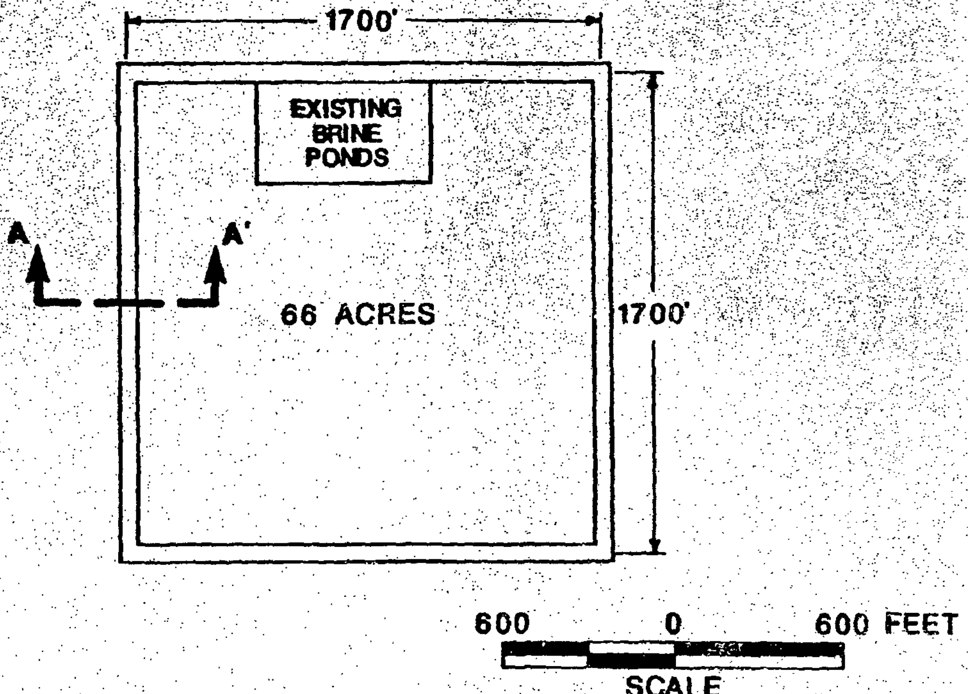
FIGURE 13

GROUNDWATER WELL AND EVAPORATION POND LOCATIONS

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO



SECTION A-A'



PLAN VIEW

NOTE

FOR POND LOCATION, SEE FIGURE 13.

REV. 0 10/23/80

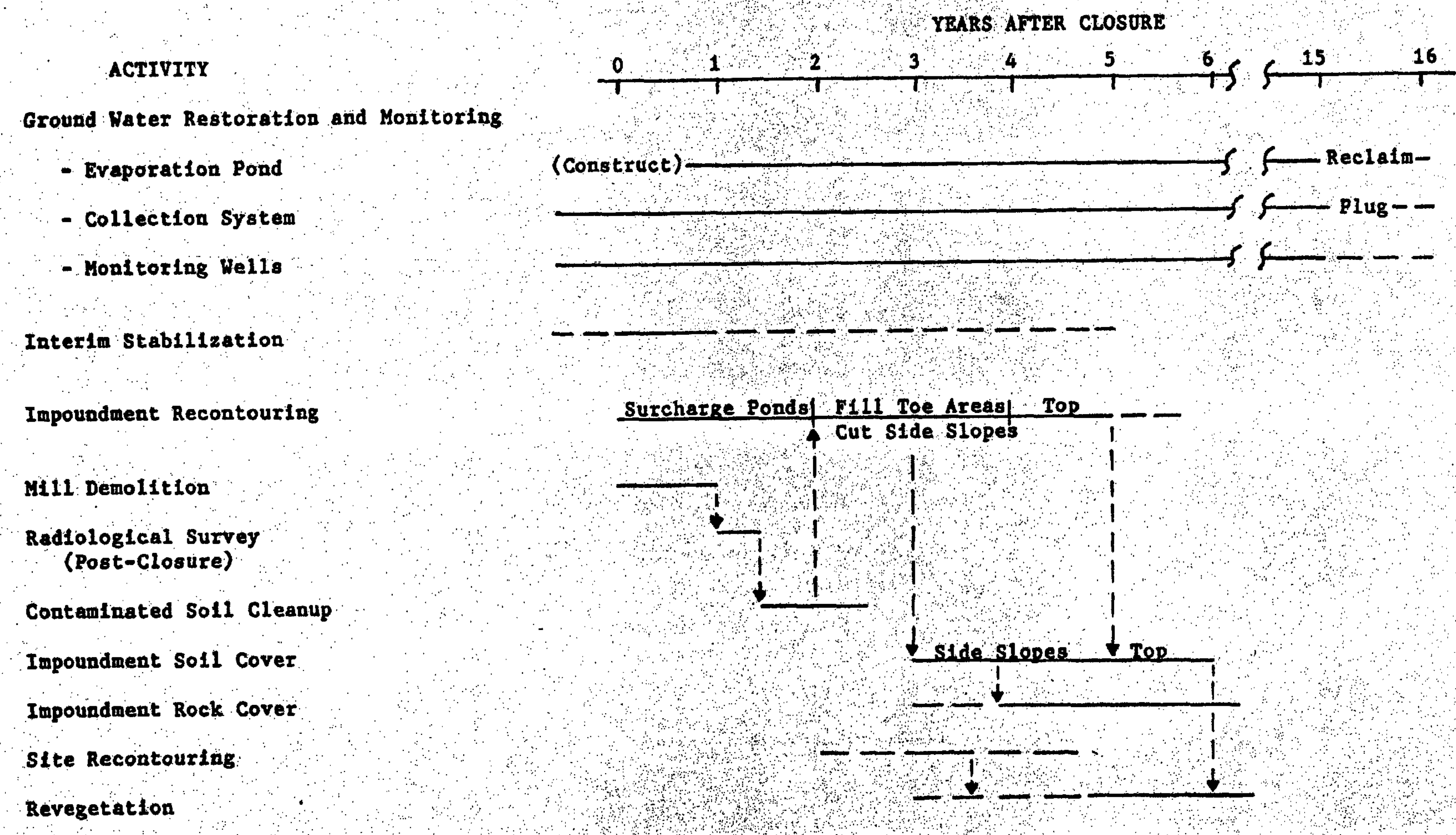
DESIGNED BY:	A.K. KUHN
DRAWN BY:	T.M. BOND

FIGURE 14

EVAPORATION POND
PLAN AND SECTION

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

FIGURE 15. STABILIZATION AND RECLAMATION SCHEDULE



Note: Dashed horizontal line indicates uncertain start or duration time, or intermittent activity.

APPENDIX A

RADON EMANATION MODELING

Condensed from the Report,
"Radon Emanation and Dispersion Modeling"
By Triad Inc., Albuquerque, New Mexico
October 1976
For Homestake Mining Company

APPENDIX A

TABLE OF CONTENTS

ABSTRACT
RADON EMANATION MODELING
OCTOBER 1986

This report is part of the results of work accomplished under Contract Number 152772, conducted for Homestake Mining Company, Grants, New Mexico for the determination of radon emanation and dispersion. The modeling was performed to determine the cover requirements for the Homestake Mill Tailings Pile.

The results show that if the tailings sands are pushed over the slimes, they would reduce the emissions from the slimes. This, in turn, reduces the soil cover requirements to slightly less than one foot of cover required to meet the radon emission requirements of the NRC. This result is conservative.

The computer programs that were used for this work are documented and verified utilizing numeric calculations and comparative analysis. The programs consisted of RAECOM (Ref. 1), an NRC-approved program for determination of cover requirements; HAZMAT (Ref. 2), a proprietary Triad program for statistical analysis and numeric modeling; and AIRDOSE (Ref. 3), a DOE program for the determination of plume dispersion in various meteorological conditions.

RADON EMANATION MODELING

1.0 INTRODUCTION

Homestake Mining Company, Grants, New Mexico came under the regulatory overview of the Nuclear Regulatory Commission (NRC) in 1986. The NRC requested that a plan be developed for the stabilization and reclamation of the facility. This plan includes a soil cover to reduce radon flux to meet the emission requirements in 10 CFR 40, Appendix A.

Triad Inc. (Triad) was contracted to perform the radon emanation modeling. Homestake also requested that Triad review their data, determine its statistical validity, and put it into a useful format. This was done using the program "STA-PRO" (Ref. 4). The initial findings were presented to the NRC at an informal meeting in September 1986. The concensus from the NRC at this meeting was that the methods utilized and results obtained met with their general approval. This report contains only information on the modeling of radon emanation related to soil cover requirements for Homestake's tailings facility.

2.0 COVER REQUIREMENTS

2.1 ASSUMPTIONS

Radon emanation is normally calculated assuming a blend of tailings sands and slimes. The total combined amount of radium is determined using the slimes and sands as percentages of the blend, which is used for calculation of the cover requirements. The Homestake plan for reclamation of the pile does not blend the sands and slimes, but calls for at least 15 feet of

tailings sands to be pushed over the slimes (Ref. 6). This configuration uses the sands to reduce the emission rate from the slimes.

2.1.1 Parameters

The calculations used the following parameters. The sands were assumed to have a radium content of 100 pCi/g and the slimes of 1,000 pCi/g (Ref. 7). The sands were assumed to have a diffusion coefficient of .021 cm^2/s and the slimes of 4.3×10^{-5} cm^2/s (Ref. 8). The radon flux rates for the sands were assumed to be .71 $pCi/m^2/s$ and for the saturated slimes, .032 $pCi/m^2/s$ (Ref. 8). These are conservative numbers. The porosity of the tailings sands is estimated at 37% with a moisture content of 11%. The cover material was assumed to have a porosity of 37% with a moisture content of 12% (Ref. 6).

2.2 COMPUTATIONS OF SANDS OVER SLIMES

It was necessary to determine the optimized amount of tailings sands over slimes to reduce the radon emissions from slimes. The RAECOM code was used with the following assumptions:

1. Sands have no radium.
2. Sands have porosity of 37% with 11% moisture.
3. Slimes have a diffusion coefficient of 4.3×10^{-5} cm^2/s.
4. The flux rate for the saturated slimes is .032 $pCi/m^2/s$.
5. Saturated slimes have a porosity of 37% with a 24.8% moisture content.
6. Slimes have 1,000 pCi/g radium concentration.
7. Slimes are assumed to be infinitely thick.

The results of these computations are:

AMOUNT (feet)	EMISSION RATE ($pCi/m^2/s$)
01	97
02	93
03	82
04	62
05	48
06	36
07	27
08	22
09	17
10	16
11	15
12	14
13	13
14	11
15	10
16	09
17	09
18	08
19	08
20	08

These results indicate that when nine feet of sands are placed on the slimes, radon emissions are reduced to below the required limits of 10 CFR 40, Appendix A.

2.3 <u>SANDS WITH RADIUM</u>

A determination of the cover requirements was then necessary for the tailings sands. The RAECOM code was used with the following assumptions:

1. Sands have 100 pCi/g.
2. Sands have porosity of 37% with 11% moisture.
3. Sands have a diffusion coefficient of .021 cm^2/s.
4. The flux rates for the sands is .71 $pCi/m^2/s$.
5. Cover material has porosity of 37% with 12% moisture.

AMOUNT (feet)	EMISSION RATE ($pCi/m^2/s$)
01	11
02	09
03	08
04	04
05	01

The results indicate that one foot of the soil cover described will meet the 10 CFR 40 requirements for radon emanation limits of 20 $pCi/m^2/s$.

2.4 MODELING OF SLIMES, SANDS, AND COVER SECTION

The models described in 2.2 and 2.3 were combined in a subsequent RAECOM modeling run that combined the slimes, sands, and cover material in one section with all the following assumptions:

1. Slimes have 1,000 pCi/g, sands have 100 pCi/g.
2. Slimes have a porosity of 37% with a 24.8% moisture content.
3. Sands have 100 pCi/g, with a porosity of 37% and a moisture content of 11%.
4. Cover material has a porosity of 37% with a moisture content of 12%.
5. Sands have a diffusion coefficient of .021 cm^2/s, and slimes have 4.3×10^{-5} cm^2/s.
6. Sands have a radon flux rate of .71 $pCi/m^2/s$, and the saturated slimes of .032 $pCi/m^2/s$.
7. Slimes are assumed to be infinitely thick.

AMOUNT (feet)	EMISSION RATE ($pCi/m^2/s$)
01	12
02	10
03	09
04	05
05	02

These results indicate that less than one foot of cover material is required to be placed on the tailings pile to comply with the NRC radon emission release limits.

3.0 CONCLUSION

3.1 COVER REQUIREMENTS

The cover requirements for the Homestake Mill Tailings Pile are based on the results of the radon emanation model (Attachment 1). Input to the model requires at least 15 feet of sands being placed on slimes. The result is that the emissions from the slimes become negligible. The sands have an order of magnitude less radium than the slimes. This allows for a significantly reduced amount of soil cover material thickness. Specifically, less than one foot is required for radon release protection.

3.2 METEOROLOGICAL EFFECTS

Barometric pressure affects the radon emissions from the Homestake facility and influences the area's background significantly. The barometric pressure causes measured changes in background concentrations from 0.98 pCi/l to 6.83 pCi/l Rn-222. All other meteorological conditions combined produce less than a 1% difference in emissions (Ref. 9).

3.3 BACKGROUND RADON

Background radon concentrations for the Ambrosia Lake area are significantly higher than normal. The readings taken at the Homestake facility are greatly influenced by this background. The background radon subtraction

shows that over the past three years there is normally less than 1 pCi/l of Rn-222 present at the mill site (Ref. 9).

3.4 CONSERVATISMS

The following conservatisms are included for information and are not used in any of the calculations:

1. The radium content of the sands is assumed to be 100 pCi/g; the actual amount is approximately 90 pCi/g (Ref. 7).

2. The radium content of the slimes is assumed to be 1,000 pCi/g; the actual amount is approximately 900 pCi/g (Ref. 7).

3. The depth of sands over slimes will be at least 15 feet; there will be more in some locations (Ref. 6).

4. The actual cover requirement is 0.6 feet, whereas 1.0 feet is actually recommended.

5. The small size of the tailings particles is not accurately modeled in RAECOM; consequently, the tortuosity of radon gas flow paths and resultant flow retardation is underestimated by RAECOM.

6. The influence of background is not considered.

These conservatisms clearly indicate with a great deal of certainty that one foot of cover material is adequate with a significant margin of conservatism.

APPENDIX A - REFERENCES

Ref. 1 - "Radiation Attenuation Effectiveness and Cover Optimization with Moisture Effects," RAECOM, The RAECOM Code. NUREG/CR-3533, PNL 4878, RAE-18-5, RU.

Ref. 2 - "HAZMAT", A Proprietary 2-D and 3-D Modeling Code Developed by Triad Incorporated. Prepared by G.S. Mihalovich, December 1985.

Ref. 3 - "AIRDOSE", An airborne release program for determination of plume dispersion integrating meteorological conditions. Resident at the Westinghouse Computing Center, Advanced Systems Technology, Pittsburgh, PA.

Ref. 4 - "STAT-PRO", A Proprietary Statistical and Data Base Management System Developed by Mass. Institute of Computer Technologies. ISBN #0-534-02831-4, September 1984.

Ref. 5 - "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design," NUREG/CR-3533, PNL-4878, RAE-18-5, RU, prepared by V.C. Rogers et al., by Rogers and Associates Engineering Corporation, April 1984.

Ref. 6 - Telecom, Alan K. Kuhn, Consulting Engineer, September 1986, for data input to RAECOM model and other information. Telecom #HMC-86-045.

Ref. 7 - Meeting Minutes, Homestake Mining Company, Edward Kennedy, Meeting Minutes #HMC-86-023. Data obtained for calculations of both forward and backfit model, August 1986.

Ref. 8 - "Radon-222 Emissions and Control Practices for Licensed Uranium Mills and Their Associated Tailings Piles," by PEI Associates, June 1985.

Ref. 9 - "Computer Modeling and Data Analysis of Uranium Mill Tailings Cover," TRIAD:086:HMC:002, prepared by G.S. Mihalovich and S.W. Woolfolk, November 1986.

ATTACHMENT 1
TO APPENDIX A

RUN ONE

********** I N P U T P A R A M E T E R S **********

NUMBER OF LAYERS : 3
RADON FLUX INTO LAYER 1 : 0.032 pCi/m2/sec
SURFACE RADON CONCENTRATION : 9.800 pCi/liter

LAYER 1 ADJUSTED TO MEET Jcrit: 20.0 +/- 0.100E-02 pCi/m2/sec

BARE SOURCE FLUX (Jo) FROM LAYER 1 : 0.000 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/sec)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	30.	2.1000E-02	37.0000	0.0000E-01	12.00
2	457.	2.1000E-02	37.0000	4.3100E-02	11.00
3	00.	4.3000E-05	37.0000	7.1000E-02	24.80

*****R E S U L T S O F R A D O N D I F F U S I O N C A L C****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONN. (pCi/liter)	MIC
1	30.	1.2350E+02	2.8734E+01	0.7125

RUN TWO

********** I N P U T P A R A M E T E R S **********

NUMBER OF LAYERS : 3
RADON FLUX INTO LAYER 1 : 0.032 pCi/m2/sec
SURFACE RADON CONCENTRATION : 9.800 pCi/liter

LAYER 1 ADJUSTED TO MEET Jcrit: 20.0 +/- 0.100E-02 pCi/m2/sec

BARE SOURCE FLUX (Jo) FROM LAYER 1 : 0.000 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/sec)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	61.	2.1000E-02	37.0000	0.0000E-01	12.00
2	457.	2.1000E-02	37.0000	4.3100E-02	11.00
3	00.	4.3000E-05	37.0000	7.1000E-02	24.80

*****R E S U L T S O F R A D O N D I F F U S I O N C A L C****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONN. (pCi/liter)	MIC
1	61.	1.3121E+02	2.2354E+01	0.7125

TRIAD INCORPORATED

ATTACHMENT 1
TO APPENDIX A
(Continued)

RUN THREE

********** I N P U T   P A R A M E T E R S **********

NUMBER OF LAYERS : 3
RADON FLUX INTO LAYER 1 : 0.032 pCi/m2/sec
SURFACE RADON CONCENTRATION : 9.800 pCi/liter

LAYER 1 ADJUSTED TO MEET Jcrit: 20.0 +/- 0.100E-02 pCi/m2/sec

BARE SOURCE FLUX (Jo) FROM LAYER 1 : 0.000 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/sec)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	91.	2.1000E-02	37.0000	0.0000E-01	12.00
2	457.	2.1000E-02	37.0000	4.3100E-02	11.00
3	00.	4.3000E-05	37.0000	7.1000E-02	24.80

*****R E S U L T S O F R A D O N D I F F U S I O N C A L C*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONN. (pCi/liter)	M1C
1	91.	9.7232E+03	1.8635E+01	0.7125

RUN FOUR

********** I N P U T   P A R A M E T E R S **********

NUMBER OF LAYERS : 3
RADON FLUX INTO LAYER 1 : 0.032 pCi/m2/sec
SURFACE RADON CONCENTRATION : 9.800 pCi/liter

LAYER 1 ADJUSTED TO MEET Jcrit: 20.0 +/- 0.100E-02 pCi/m2/sec

BARE SOURCE FLUX (Jo) FROM LAYER 1 : 0.000 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/sec)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	122.	2.1000E-02	37.0000	0.0000E-01	12.00
2	457.	2.1000E-02	37.0000	4.3100E-02	11.00
3	00.	4.3000E-05	37.0000	7.1000E-02	24.80

*****R E S U L T S O F R A D O N D I F F U S I O N C A L C*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONN. (pCi/liter)	M1C
1	122.	5.2873E+03	1.4231E+01	0.7125

TRIAD INCORPORATED

HMCSL024669

ATTACHMENT 1
TO APPENDIX A
(Continued)

RUN FIVE

********** I N P U T P A R A M E T E R S **********

NUMBER OF LAYERS : 3
RADON FLUX INTO LAYER 1 : 0.032 pCi/m2/sec
SURFACE RADON CONCENTRATION : 9.800 pCi/liter

LAYER 1 ADJUSTED TO MEET Jcrit: 20.0 +/- 0.100E-02 pCi/m2/sec

BARE SOURCE FLUX (Jc) FROM LAYER 1 : 0.000 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/sec)	POROSITY	SOURCE * (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	152.	2.1000E-02	37.0000	0.0000E-01	12.00
2	457.	2.1000E-02	37.0000	4.3100E-02	11.00
3	90.	4.3000E-05	37.0000	7.1000E-02	24.80

*****R E S U L T S O F R A D O N D I F F U S I O N C A L C*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONN. (pCi/liter)	MIC
1	152.	2.3622E+03	1.0221E+01	0.7125

TRIAD INCORPORATED

HMCSL024670

APPENDIX B

REPORT OF BORROW SOIL INVESTIGATIONS
HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

B.1.0 INTRODUCTION

Upon closure of the Grants mill, Homestake Mining Company (HMC) will place a soil cover over the tailings impoundment in accordance with 10 CFR 40, Appendix A, Criterion 6. The reclamation plan developed in 1982 (D'Appolonia, 1982) identified two borrow areas on HMC property from which cover soil could be obtained. However, no detailed investigations had been performed on these areas. In order to determine specifically the properties and quantities of potential borrow materials, information needed in part to support radon emanation modeling and cover design, HMC conducted investigations of the potential borrow areas.

The potential borrow sources are those portions of HMC property to the north and west of the tailings impoundment. Auger test borings and test pits were used to explore these areas and obtain samples for identification and testing. Laboratory tests were conducted on selected samples to determine soil classification and properties important in cover design.

The field and laboratory investigations show that the potential borrow areas contain mostly fine to medium grained alluvial sands. However, significant amounts of clay also exist at shallow depths. When used separately or mixed with the sands, the clays will be easily workable and will provide a suitable cover material for the tailings impoundment. Available quantities of

clay, sand, or a sand/clay mixture are sufficient for the impoundment cover as well as any other possible use in site reclamation.

This report describes the investigations that were performed and the rationale behind them (B.2.0) and the results of the investigations (B.3.0). Supporting data, including logs and test reports, are included as attachments to this report.

B.2.0 METHODS OF INVESTIGATION

The objectives of the investigation were to:

- Identify the types and volumes of soils available in the potential borrow areas.
- Determine those physical properties which would affect placement and performance of the soils as cover on the impoundment.
- Delineate a borrow pit in appropriate soils to be included in the stabilization and reclamation plan.

To accomplish these objectives, a two-phase field exploration program and a laboratory testing program were used. The first phase of the exploration program consisted of drilling and sampling 20 test holes. After initial laboratory testing and evaluation of samples from these test holes, the second exploratory phase was performed. In this second phase, nine test pits were dug at selected locations between test borings. Additional laboratory testing was performed on selected bulk samples of test pit material.

B.2.1 TEST BORINGS AND SAMPLING

In the first phase of exploration during July 15-17, 1986, twenty test

borings were drilled at locations shown in Figure B1. All but three borings were drilled to 21.5 feet. Two, BA17 and BA18, were drilled to 26.5 feet, and BA11 was drilled to 36.5 feet. Each boring was advanced by 4.0 inch I.D. hollow stem auger with Standard Penetration Tests (SPT) performed at five-foot intervals, starting at five feet depth. SPT samples were used for visual soil classification in the field and then preserved in glass jars with airtight lids.

Grab samples of auger cuttings were also obtained at irregular intervals from each boring. A sample of 10 to 20 pounds was usually collected whenever a change of soil was encountered or when clay was penetrated. The mixing of clay and sand soils on the auger flights provided a reasonable analog of the soil mixture that could be used for the impoundment cover.

The locations of the borings were chosen to provide coverage of all HMC property north and west of the impoundment from which borrow soil, if suitable, could be obtained. Other locations on the property were not considered because of proximity to the highway, residences, or mill facilities. The location of each boring was selected by a field engineer and later surveyed by HMC.

All test borings encountered relatively uniform fine to medium sand, and most borings encountered clay as well. Two distinct areas of clay exist, one to the north and west of the impoundment and the other off the northeast corner of the impoundment. The latter occurs at the bottom of BA11 and BA18, below 21 feet, and is the clay of the Chinle shale. The major area of clay, north and west of the impoundment, contains stiff to very stiff

alluvial clays interbedded with sands. The clay which occurs at relatively shallow depth, less than 10 feet, is most accessible and, therefore, of most interest in this investigation. A significant volume of shallow clay, estimated to be about 580,000 cubic yards, was found in the area outlined in Figure B1.

B.2.2 TEST PITS

After the test borings were completed and results were obtained from the initial laboratory tests, nine test pits were dug by backhoe. The test pits were located between borings and beyond the boring pattern to confirm the continuity and extent of the clay deposits. The pits were dug to a maximum depth of 10 feet. Bulk samples were obtained of individual soil strata for additional testing.

The test pits were located by a field engineer relative to the test boring locations and nearby reference points. The locations of the pits were not surveyed.

B.2.3 LABORATORY TESTING

Standard soil testings using ASTM procedures were used to characterize the properties important to the evaluation of the soils for the impoundment cover. In the reduction of radon emanation, the long-term retained moisture and density/porosity of the soil is most important. Grain size distribution and plasticity characteristics affect the workability, compaction characteristics, and erodability of the soil.

Moisture Content - All SPT samples were tested for natural moisture content. Most of this testing was performed by HMC in its mill lab, but Sergent, Hauskins and Beckwith (SHB) tested moisture contents in samples from four borings. The natural moisture ranged from less than 8% in sands to between 8 and 16% in clays.

Grain Size Distribution - Because most soils were clearly either sands or fines (minus No. 200 mesh) based on visual classification, grain size analysis was run only on those 11 bulk samples of mixed soils taken from the augers. These analyses made it possible to relate compaction test results to the grain size distribution.

Atterberg Limits - A total of 22 Atterberg limits (liquid and plastic limits and plasticity index) were run in accordance with ASTD D4318 to properly classify and predict behavior of the fine grained soils. Fifteen of the samples were from SPT tests and provided an initial assessment of the occurrence and distribution of clays. The seven test pit samples tested later confirmed continuity of clays and provided a broader data base for evaluating the properties of the clays.

Compaction Tests - Moisture-density relationships for compacted soils were determined for 18 samples of borrow soil using the Standard Proctor Test Method A of ASTM D698. This test, used to determine the relationship between moisture content and compacted density, yields the optimum values of both. Eleven tests were performed on auger-mixed sand-and-clay grab samples and seven tests were performed on bulk samples of clays taken from the test pits.

Permeability Tests - Four constant-head hydraulic conductivity tests were performed to determine the intrinsic permeability of compacted soil covers. The samples tested were four auger-mixed sand-and-clay samples that represented a reasonable range of cover soil mixtures, based on visual inspections. The samples were first compacted to about 95% maximum dry density at moisture contents slightly wet-of-optimum amounts, similar to the expected field compaction specifications. Each was then saturated and placed under a constant head of 11.5 feet of water, and the amount of flow through time was measured.

B.3.0 RESULTS OF THE INVESTIGATION

B.3.1 DESCRIPTION OF SOILS PRESENT

The designated borrow area contains alluvial soils to depths of at least 21 feet, all above the ground water table. These soils are primarily fine to medium sands, but in the portion of the area west of about departure coordinate 400,000E (see Figure B1), a large amount of clay exists at shallow depth within the alluvium. The natural moisture contents and Atterberg limits of the clays indicate that there may be two distinct clays present in this area. Clay A has medium to low plasticity and natural moisture content below 9%. Clay B is medium to high plasticity with natural moisture content of 10% or higher. The two clays are also distinguishable in Standard Proctor testing, where optimum moisture content of Clay B is higher than Clay A (19 to 22% versus 13 to 18%) and the maximum dry density of B is lower than A (100 to 102 pcf versus 109 to 112 pcf). The distinction between the two clays is readily apparent based on the properties tested but might not be statistically supportable.

The distribution of shallow clay is shown in Figure B1. Deeper clays exist south and east of the clay area shown, but are not being considered at this time for use as borrow material. The area of clay is irregular but appears to be continuous. The A and B clays occur together in this area without apparent spatial separation, although there is some indication that the B clay is concentrated in the deeper, more central parts of the clay deposit, while the A clay is more common toward the edges of the deposit. It is not possible to delineate the separation of A from B clay with confidence at this time.

The sand soils appear to be relatively clean, containing little fines (silts and clays). The size range is narrow and consistently fine to medium sand. Natural moisture contents are usually up to 8% and seem unrelated to depth.

B.3.2 SUITABILITY FOR COVER SOIL

The evaluation of the borrow soil for cover suitability must refer to the performance requirements of the cover. The cover must: (1) reduce radon flux to not more than 20 pCi/m^2s; and (2) resist erosion and infiltration and otherwise remain stable for 1,000 years.

For the first requirement the lowest possible effective porosity and a long-term retained moisture content of at least 10% are desired. For the second requirement, maximum density and cohesion and minimum permeability are desired. The clays soils have more of these desirable properties than the sands. However, sand compacts to higher densities and is generally more

workable than clay. Consequently, a mixture of clay and sand is best for the cover soil, although either the A or B clay alone would be satisfactory.

The mixed soil obtained from the auger, which effectively blended the clay and sand that it penetrated, has been evaluated as the design soil mix for the impoundment cover. This clay/sand mix contains up to 40% clay and is classified as a clayey sand (SC) according to the Unified Soil Classification System. Maximum dry density should be 111 to 117 pcf with optimum moisture contents of 12 to about 15%. Placed at 90-95% density, initial moisture contents can be raised to 14-18% so that long-term retained moisture of about 12% is reasonable. With a mean maximum dry density of about 115 pcf, 90% compaction will produce about 104 pcf dry density and total porosity of about 37%. With a significant clay content, the effective porosity should be significantly less. At 95% compaction, the hydraulic conductivity (intrinsic permeability) of this mixed soil should be 10^{-6} to 10^{-8} cm/sec, while at 90% compaction the value will probably increase about an order of magnitude.

Achieving these properties is well within both the characteristics of the mixed soil and the capabilities of standard earthwork practice. Natural moisture contents of 9 to 15% indicate that it is reasonable to expect 12% retained moisture over the long term if the soil is moisture conditioned to 14-18% during compaction. With that moisture content the soil should be compactable to at least 100 pcf, a dry density sufficient to make the cover durable over a long period of time. Should further analysis indicate that increased clay content (above 40%) would improve cover performance, the soil

mixture can be easily enriched with clay, which will decrease dry density but also increase retained moisture and reduce effective porosity.

B.3.3 DELINEATION OF BORROW PIT

The design cover soil, a sand/clay mixture, can be obtained from relatively shallow excavation in the area in the clay deposit, shown in Figure B1. For a nominal two-foot thick cover, about 570,000 to 600,000 cubic yards of soil will be needed. Conceivably, then, the estimated 580,000 cubic yards of shallow clay could provide all the cover soil needed. However, some borrow soil might be required for site recontouring, evaporation pond reclamation, or other purposes, so a borrow pit of larger capacity is desirable. In addition, because the pit will be located in the San Mateo Creek floodplain, its location, shape, and reclamation should enhance flood diversion and protection to the extent possible.

The location, size, and configuration of the borrow pit delineated in Figure B1 take into account the considerations discussed above. The pit will be located west and north of the areas of suspected excessive radium contamination of soil, so no borrow soils should be contaminated. The borrow pit is defined by straight boundaries, for simplicity in conceptual design, and follows the general pattern of the clay deposit. It starts at the northeast end with a 1% grade sloping to a cut up to 10 feet deep. The pit trends southwestward for about 3,000 feet to the county road, then south-southwestward for another 2,000 feet, becoming progressively more shallow until it merges with existing grade. The width north of the county road is about 1,300 feet, narrowing south of the road to 600 feet at the south end of the pit.

This configuration will yield about 800,000 cubic yards and will require very little reclamation. The capacity includes allowance for losses due to clearing and spoil of soil with too much organic content, for impoundment cover design thickness changes, and for borrow soil requirements elsewhere on site. The layout and gradient of the pit create a large diversion channel which can redirect flood waters around the impoundment. Only small amounts of regrading and then revegetation will be required to reclaim the pit to its post-closure function as a flood channel.

B.4.0 CONCLUSION

This investigation has established that the northwest portion of the HMC property contains clay and sand soils in sufficient quantity and with suitable properties to provide good cover soil for the impoundment and other possible uses. These soils will have the necessary moisture and density to effectively control radon emanation with relatively modest compacted thicknesses (about two feet). Standard earthwork methods and equipment will be adequate to excavate these soils from shallow depths and to place and compact them to required density and moisture. The volumes of available soil are more than enough to satisfy required quantities.

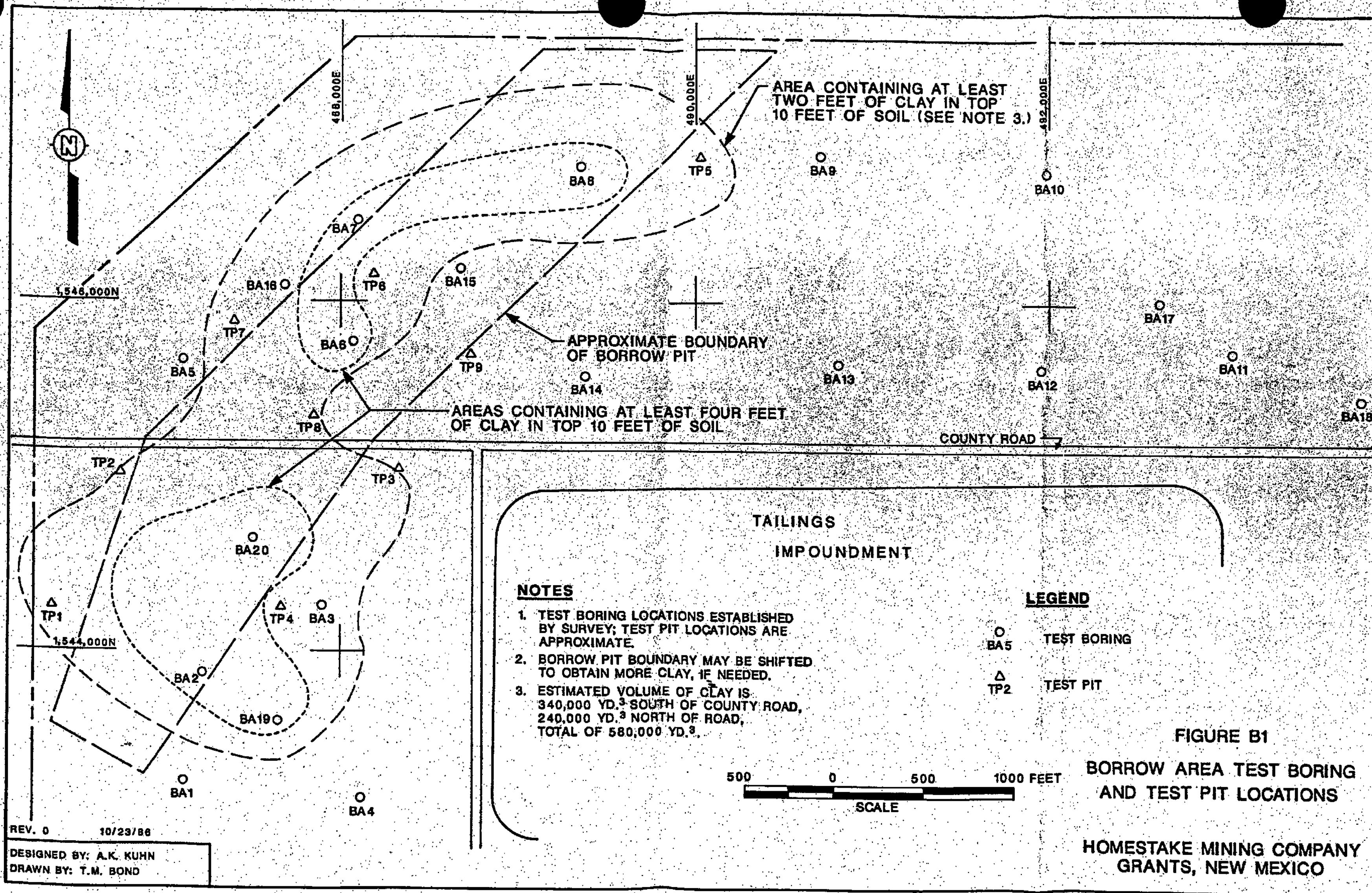


FIGURE B1
BORROW AREA TEST BORING AND TEST PIT LOCATIONS

HOMESTAKE MINING COMPANY
GRANTS, NEW MEXICO

HMCSL024681

SERGENT, HAUSKINS & BECKWITH CONSULTING GEOTECHNICAL ENGINEERS

APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING • HYDROLOGY

Date July 25, 1986

To: Alan Kuhn PhD., PE
13212 Manitoba Dr. N.E.
Albuquerque, N.M. 87111

SHB Job No. E86-1113

Attn: Alan Kuhn

Re: Contract Drilling & Lab Tests
Homestake Mining Company
Grants, New Mexico

We are sending ☐ As requested ☒ For your use ☐ For comment

☐ Enclosed ☐ Under separate cover via ____

Description Moisture content data & calculations on samples recieved today from Homestake Mine.

Remarks Homestake added one more sample to determine Atterberg Limits, BA 11-54

By Gregory M. Smith
Title Staff Engineer

REPLY TO: 4700 LINCOLN ROAD, N.E., ALBUQUERQUE, NEW MEXICO 87109

HMCSL024682

12-21-86

Samples

PAN #		Wet	Dry	Tare
	BA-16			
1	S-1 CL	840	827	665
2	S-2	906	902	636
3	S-3	858	852	630
4	S-4	926	920	674
	BA-17			
5	S-1	962	958	673
6	S-2	881	872	669
7	S-3	909	895	623
8	S-4	926	922	666
9	S-5	905	894	671
	BA-18			
10	S-1	941	921	709
11	S-2	863	857	627
12	S-3	811	799	595
13	S-4 (A)	874	857	635
14	S-4 (B) CL	909	876	668
15	S-5	799	789	604
	BA-19			
16	S-1	878	851	679
17	S-2	947	943	665
18	S-3	966	961	683
19	S-4	915	913	604
	BA-20			
20	S-1	851	831	656
21	S-2	933	930	683
22	S-3	936	928	692
23	S-4	890	884	669

HMCSL024683

7-22-86

Calculations

BA-16	Wet	Dry	Diff	% moisture $\frac{Wet-Dry}{Wet} \times 100$
S-1	175	162	13	7.43
S-2	270	266	4	1.48
S-3	228	222	6	2.63
S-4	252	246	6	2.38
BA-17				
S-1	289	285	4	1.38
S-2	212	203	9	4.25
S-3	286	272	14	4.90
S-4	260	256	4	1.54
S-5	234	223	11	4.70
BA-18				
S-1	232	212	20	8.62
S-2	236	230	6	2.54
S-3	216	204	12	5.56
S-4(A)	239	222	17	7.11
S-4(B)	241	208	33	13.69
S-5	195	185	10	5.13
BA-19				
S-1	199	172	27	13.5[illegible]
S-2	282	278	4	1.42
S-3	283	278	5	1.77
S-4	311	309	2	0.6[illegible]
BA-20				
S-1	195	175	20	10.26
S-2	250	247	3	1.20

SUMMARY OF NATURAL MOISTURE CONTENTS
OF BORROW SOIL SAMPLES
FROM TESTS BY HMC MILL LAB, 7/17/86

BORING NO., BA-	SAMPLE NO., S-	MOISTURE %	SOIL TYPE
1	1	2.55	
1	2	8.94	CL
1	3	2.22	
1	4	1.67	
2	1	13.27	CH
2	2	13.71	CL
2	3	2.67	
2	4	2.07	
3	1	2.36	
3	2	1.84	
3	3	0.94	
3	4	1.16	
4	1	4.48	
4	2	14.20	CL
4	3	11.03	
4	4	2.02	
5	1	5.57	
5	2	3.10	
5	3	2.21	
5	4	2.09	
6	1	12.04	CL
6	2	2.42	
6	3	2.08	
6	4	2.17	
7	1	9.96	CL
7	2	12.22	CL-CH
7	3	2.34	
7	4	1.67	
8	1	13.81	CH
8	2	2.26	
8	3	1.59	
9	1	4.00	
9	2	1.42	
9	3	0.48	
9	4	1.16	
10	1	2.21	
10	2	3.10	
10	3	1.57	
10	4	1.17	
11	1	3.26	
11	2	6.31	
11	3	3.96	
11	4	14.64	CH
11	5	14.14	CL
11	6	16.93	CH
11	7	4.79	
12	1	0.76	
12	2	3.17	
12	3	0.79	
12	4	2.53	
13	1	2.02	
13	2	5.70	
13	3	1.77	
13	4	0.96	
14	1	1.18	
14	2	1.78	
14	3	0.58	
14	4	0.80	
15	1	3.40	
15	2	2.91	
15	3	0.29	
15	4	1.45	

84-102

SERGENT, HAUSKINS & BECKWITH

CONSULTING GEOTECHNICAL ENGINEERS

APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING • HYDROLOGY

July 28, 1986

SHB Job No. E86-1113

Alan K. Kuhn, PhD, P.E.
13212 Manitoba Drive, N.E.
Albuquerque, New Mexico 87111

Re: Contract Drilling & Laboratory Testing
Homestake Mining Company
Grants, New Mexico

Dr. Kuhn:

The following table lists results of moisture-density relationships, ASTM D698, on samples requested in your letter to this firm dated July 21, 1986. Results of sieve analyses and compaction curves are attached.

Sample	Optimum Moisture Content (%)	Maximum Dry Density (pcf)
BA1-A1	7.8	118.4
BA2-A1	13.6	117.2
BA3-A1	12.1	115.4
BA5-A1	12.3	117.4
BA5-A3	13.6	116.6
BA6-A1	12.4	114.8
BA7-A2	13.4	115.8
BA8-A1	14.8	114.4
BA10-A1	12.0	117.2
BA14-A1	13.3	111.0
BA19-A1	12.8	116.2

Respectfully submitted,
Sergent, Hauskins & Beckwith Engineers

By [signature]
Gregory M. Smith, Staff Engineer

REPLY TO: 4700 LINCOLN ROAD, N.E., ALBUQUERQUE, NEW MEXICO 87109

PHOENIX (602) 272-6848 · ALBUQUERQUE (505) 884-0950 · SANTA FE (505) 471-7836 · SALT LAKE CITY (801) 266-0720 · EL PASO (915) 778-3369

TABULATION OF TEST RESULTS

Job No. E86-1113

Project Contract Drilling & Laboratory Testing
Homestake Mining Company, Grants, NM

Material

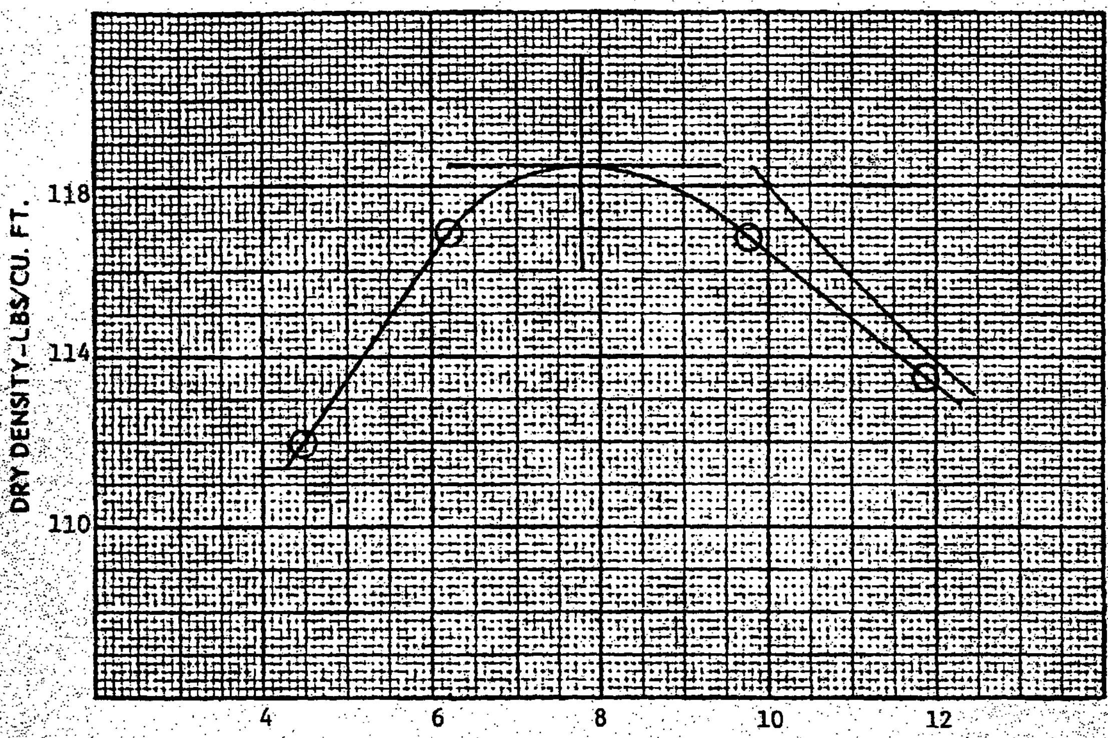
Source

HOLE NO.	LOCATION	DEPTH	UNIFIED CLASS.	LL	PI	SIEVE ANALYSIS – ACCUM. % PASSING 200	100	40	10	4	3/8	1/2	3/4	1	1-1/2	3	MOIST.	LAB. NO.
	BA1-A1					13	35	98	100								2	13-1
	BA2-A1					32	56	99	100								5	13-2
	BA3-A1					19	55	100									3	13-3
	BA5-A1					25	45	97	100								4	13-4
	BA5-A3					30	50	98	100								2	13-5
	BA6-A1					17	48	99	100								3	13-6
	BA7-A2					36	55	94	100								5	13-7
	BA8-A1					25	50	98	100								6	13-8
	BA10-A1					18	42	96	100								4	13-9
	BA14-A1					14	35	94	100								3	13-10
	BA19-A1					26	61	99	100								5	13-11

SERGENT, HAUSKINS & BECKWITH
CONSULTING GEOTECHNICAL ENGINEERS

SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS/CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA1-A1	7.9	118.4	ASTM D698	A	13-1

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
		DIAMETER	HEIGHT					
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
		DIAMETER	HEIGHT					
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
B	-#4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
C	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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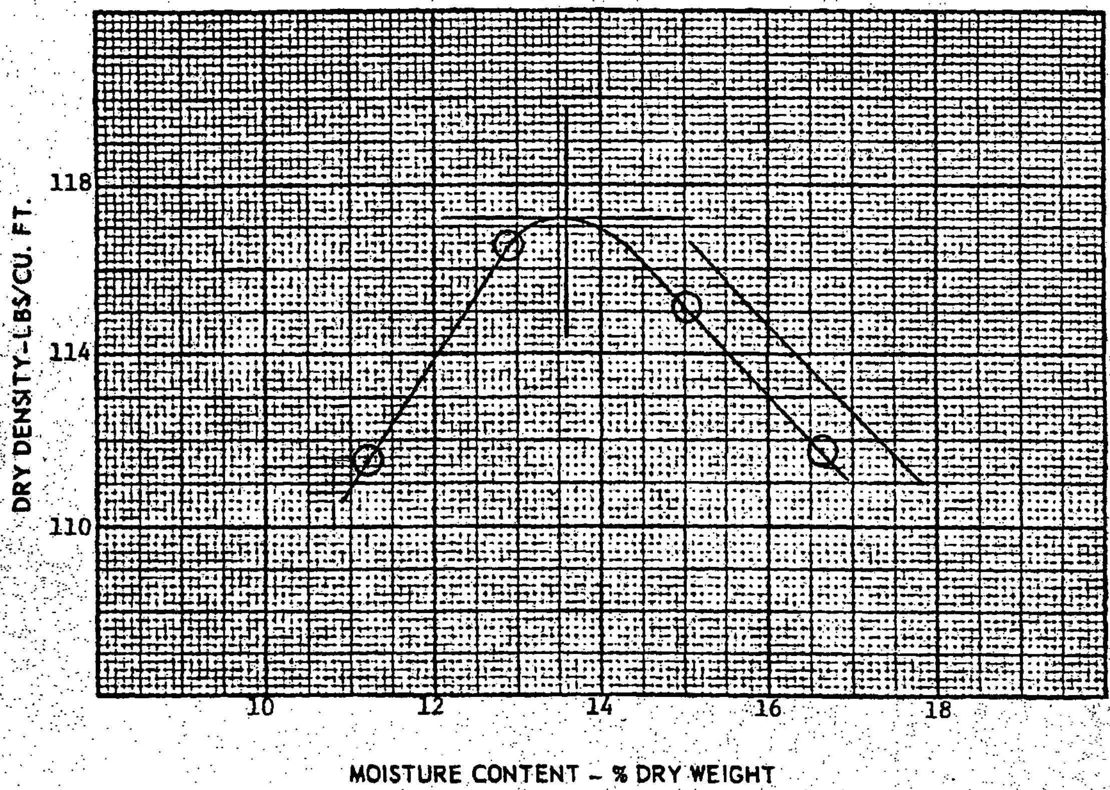
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA2-A1	13.6	117.2	ASTM D698	A	13-2

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
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D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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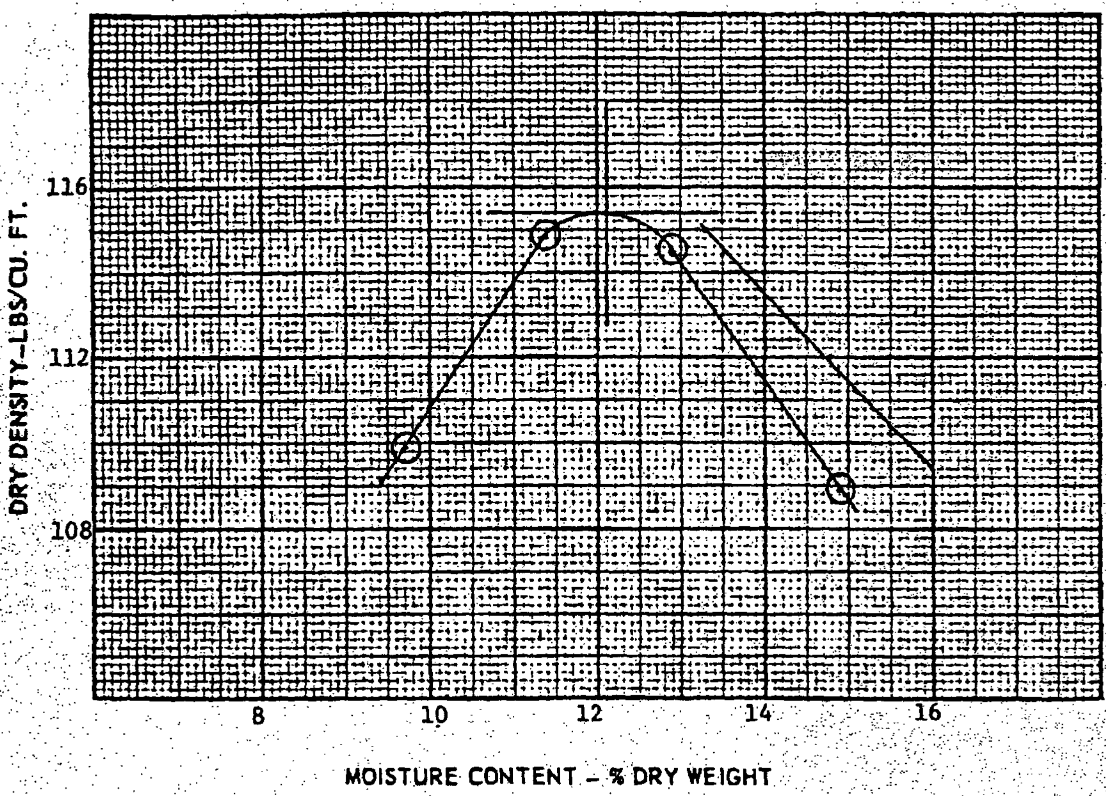
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS/CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA3-A1	12.1	115.4	ASTM D698	A	13-3

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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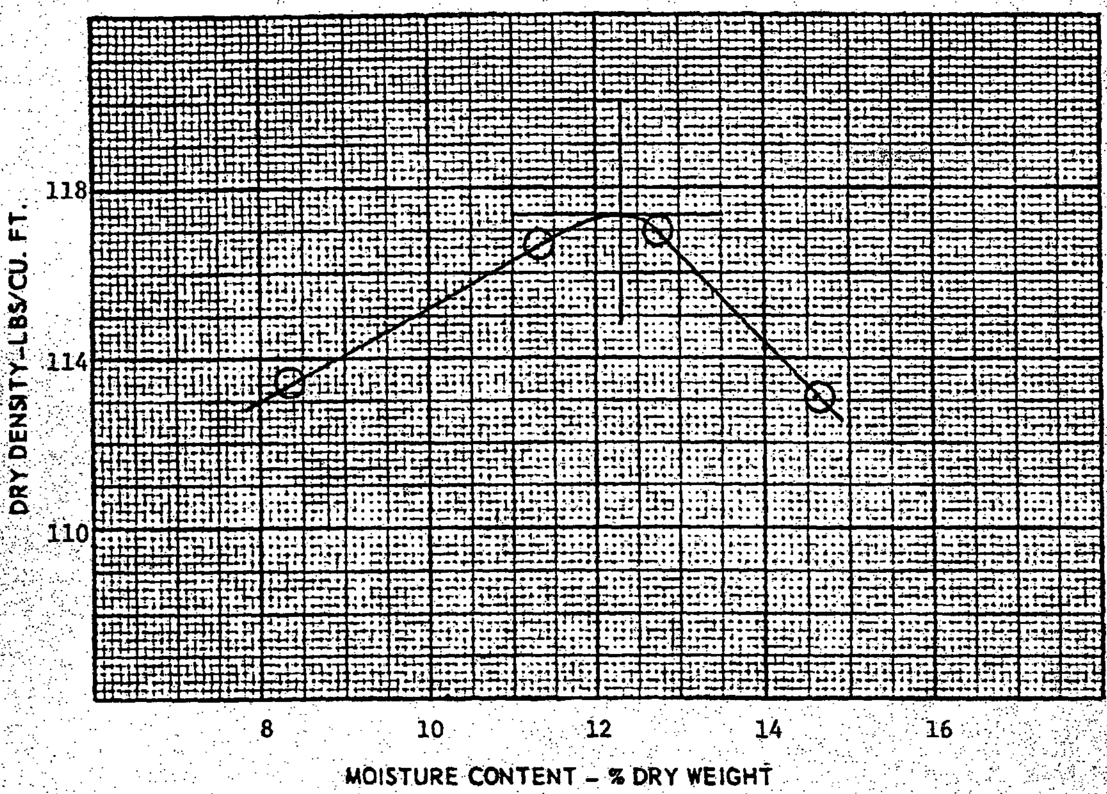
HMCSL024690

SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA5-A1	12.3	117.4	ASTM D698	A	13-4

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
		DIAMETER	HEIGHT					
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D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

SERGENT, HAUSKINS & BECKWITH
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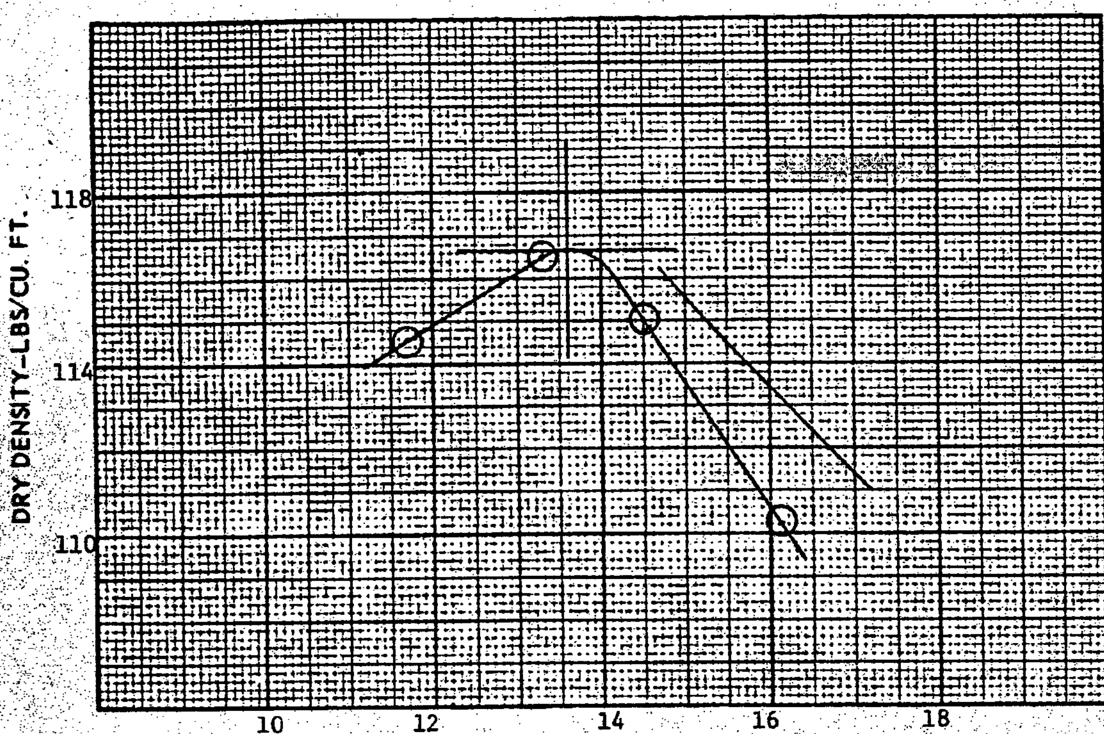
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



MOISTURE CONTENT – % DRY WEIGHT

CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA5-A3	13.6	116.6	ASTM D698	A	13-5

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
B	-#4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
C	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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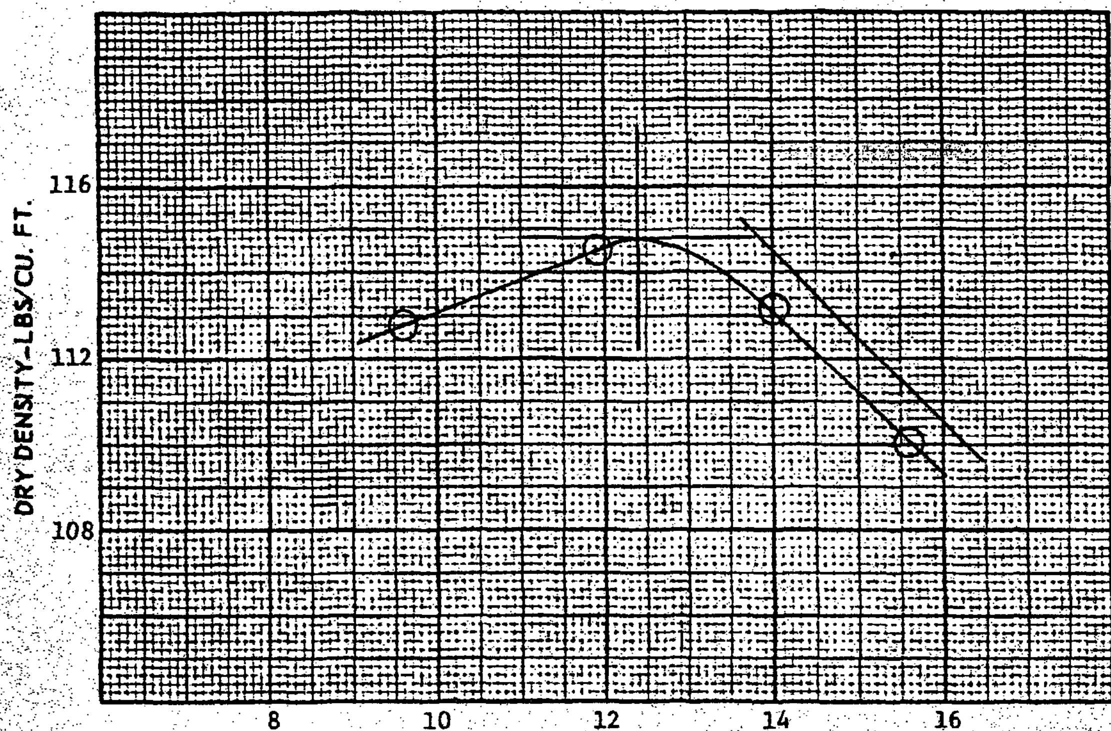
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA6-A1	12.4	114.8	ASTM D698	A	13-6

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
B	-#4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
C	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
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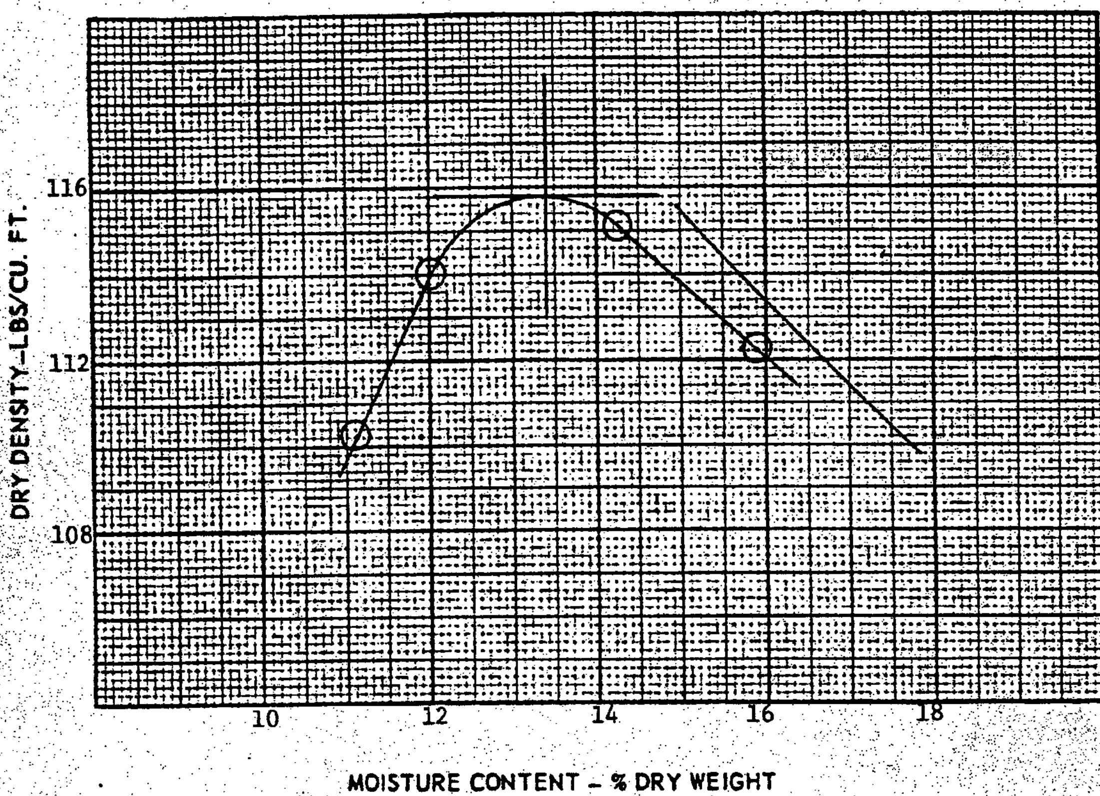
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA7-A2	13.4	115.8	ASTM D698	A	13-7

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
B	-#4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
C	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
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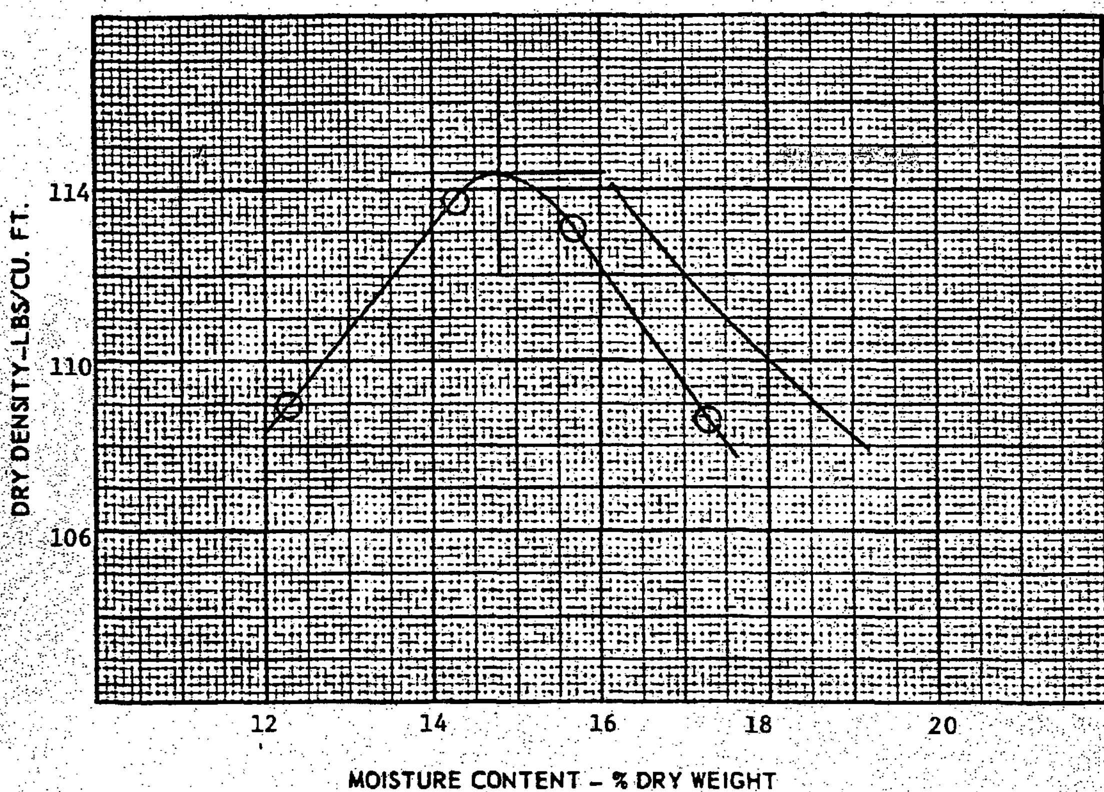
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA8-A1	14.8	114.4	ASTM D698	A	13-8

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
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C	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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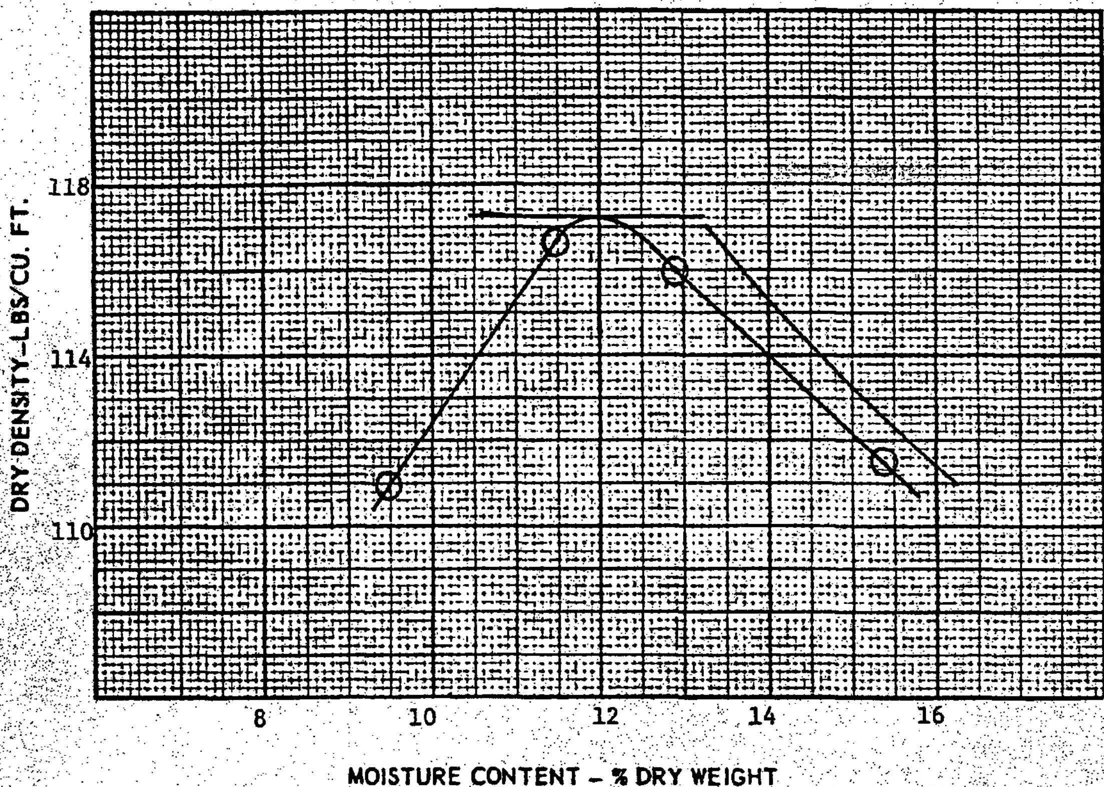
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA10-A1	12.0	117.2	ASTM D698	A	13-9

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
		DIAMETER	HEIGHT					
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD		NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
		DIAMETER	HEIGHT					
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
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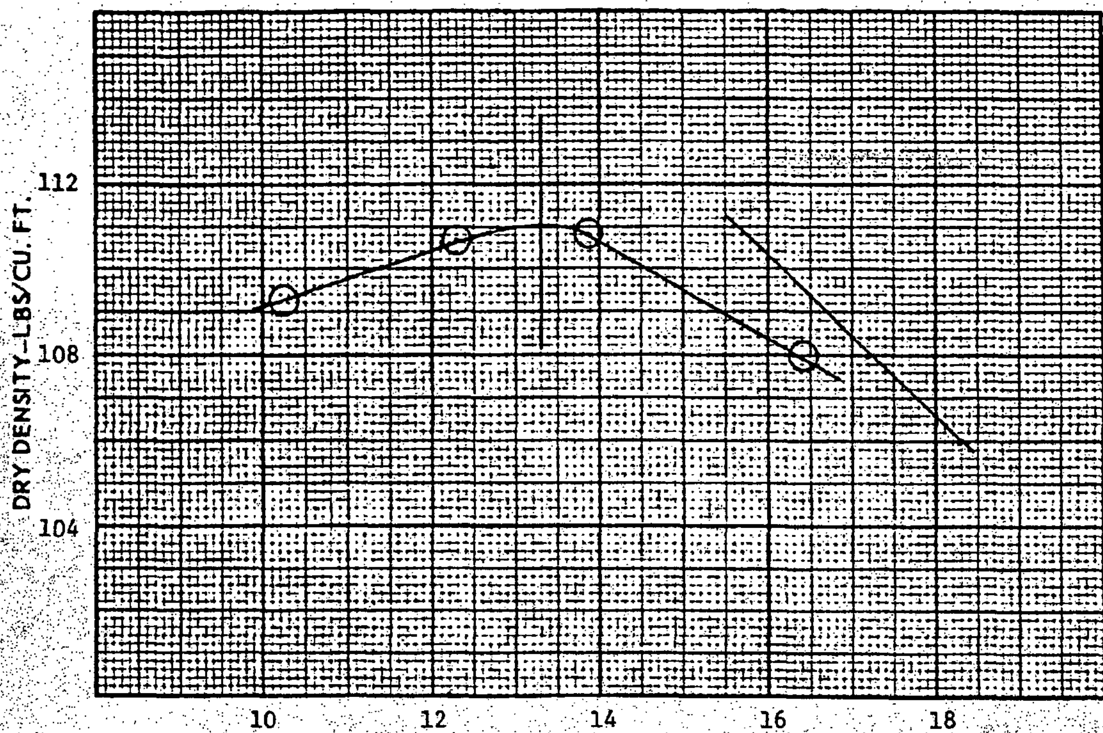
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA14-A1	13.3	111.0	ASTM D698	A	13-10

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
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D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
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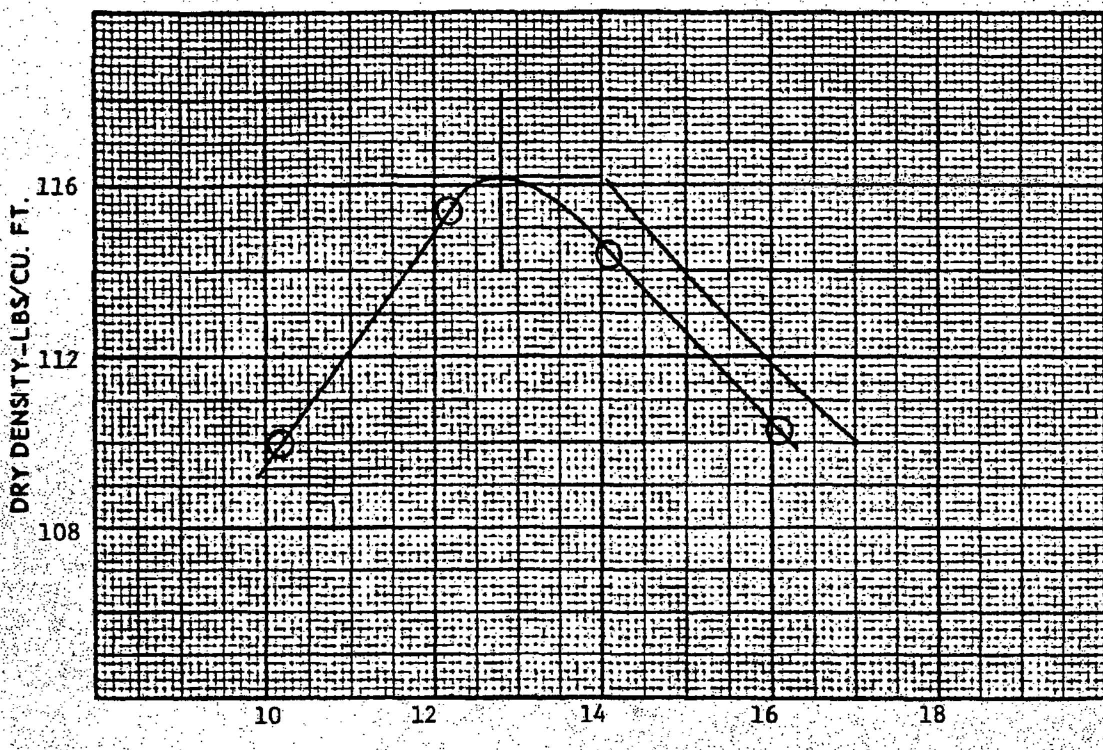
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS/CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	BA19-A1	12.8	116.2	ASTM D698	A	13-11

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
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D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
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APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING • HYDROLOGY

July 31, 1986

Alan K. Kuhn, Ph.D., P.E.
13212 Manitoba Drive, N.E.
Albuquerque, New Mexico 87111

SHB Job No. E86-1113

Re: Contract Drilling & Laboratory Testing
Homestake Mining Company
Grants, New Mexico

Dear Dr. Kuhn:

Transmitted herewith is a table listing results of liquid limit and plasticity index tests performed in accordance with ASTM D4318, as requested in your letter of July 21, 1986. Also shown are the soil types of the samples according to the Unified Soil Classification System.

If you have any questions regarding these test results or those transmitted in our letter of July 28, please do not hesitate to contact us.

Respectfully submitted
Sergent, Hauskins & Beckwith Engineers

By Gregory M. Smith
Gregory M. Smith, Staff Engineer

Copies: Addressee (2)

REPLY TO: 4700 LINCOLN ROAD, N.E., ALBUQUERQUE, NEW MEXICO 87109

PHOENIX (602) 272-6848 | ALBUQUERQUE (505) 884-0950 | SANTA FE (505) 471-7836 | SALT LAKE CITY (801) 266-0720 | EL PASO (915) 778-3369

Contract Drilling & Laboratory Testing
Homestake Mining Company
Grants, New Mexico
SHB Job No. E86-1113

Sample	Depth (feet)	U.S. Class.	Liquid Limit	Plasticity Index
BA1-S2	10-11.5	CL	32	11
BA2-S1	5-6.5	CH	52	31
BA2-S2	10-11.5	CL	48	28
BA4-S2	10-11.5	CL	48	26
BA6-S1	5-6.5	CL	47	27
BA7-S1	5-6.5	CL	42	22
BA7-S2	10-11.5	CL-CH	50	29
BA8-S1	5-6.5	CH	71	52
BA11-S4	20-21.5	CH	56	37
BA11-S5	25-26.5	CL	42	24
BA11-S6	30-31.5	CH	64	45
BA16-S1	5-6.5	CL	30	13
BA18-S4(B)	20-21.5	CL	33	14
BA19-S1	5-6.5	CH	52	32
BA20-S1	5-6.5	CL	39	20

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JOHN B. HAUSKINS, P.E. DALE V. BEDENKOP, P.E. DONALD L. CURRAN, P.E. J. DAVID DEATHERAGE, P.E.
GEORGE H. BECKWITH, P.E. ROBERT W. CROSSLEY, P.E. DONALD G. METZGER, P.G. JONATHAN A. CRYSTAL, P.E.
ROBERT D. BOOTH, P.E. NORMAN H. WETZ, P.E. ROBERT L. PREW ALLON C. OWEN, JR., P.E.

August 22, 1986

Alan K. Kuhn, Ph.D., P.E.
13212 Manitoba Drive, N.E.
Albuquerque, New Mexico 87111

SHB Job No. E86-1113

Re: Contract Drilling & Laboratory Testing
Homestake Mining Company
Grants, New Mexico

Dear Dr. Kuhn:

The table below presents results of moisture-density relationships, as determined by ASTM D698, on samples delivered by you to our lab August 15, 1986. Also listed are results of plastic and liquid limit tests, ASTM D4318. Moisture-density compaction curves are attached.

Sample	Optimum Moisture Content %	Maximum Dry Density (pcf)	Liquid Limit %	Plastic Limit %
TP1, B-1	19	102	40	20
TP2, B-1	13	110.5	23	19
TP4, B-1	16	112	24	19
TP4, B-2	22	102	37	18
TP5, B-1	21	102	45	18
TP7, B-1	16	109	25	18
TP8, B-1	21	100	35	19

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PHOENIX (602) 272-6848 ALBUQUERQUE (505) 884-0950 SANTA FE (505) 471-7836 SALT LAKE CITY (801) 266-0720 EL PASO (915) 778-3369

If you have any questions regarding these test results, please do not hesitate to contact us.

Respectfully submitted,

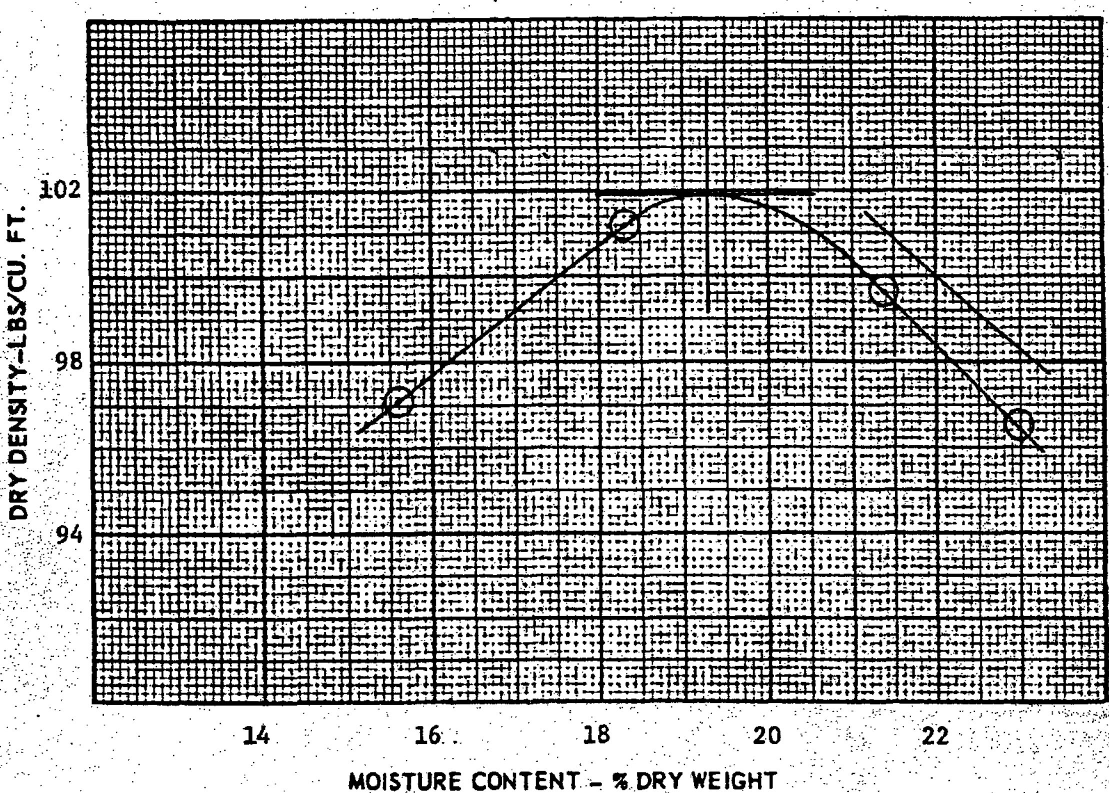
Sergent, Hauskins & Beckwith Engineers

By Gregory M. Smith
Gregory M. Smith, Staff Engineer

Copies: Addressee (2)

SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	TP1, B-1	19.3	101.9	D698	A	

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4''	4.58''	3	25	5.5 LBS.	12''	12,375
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AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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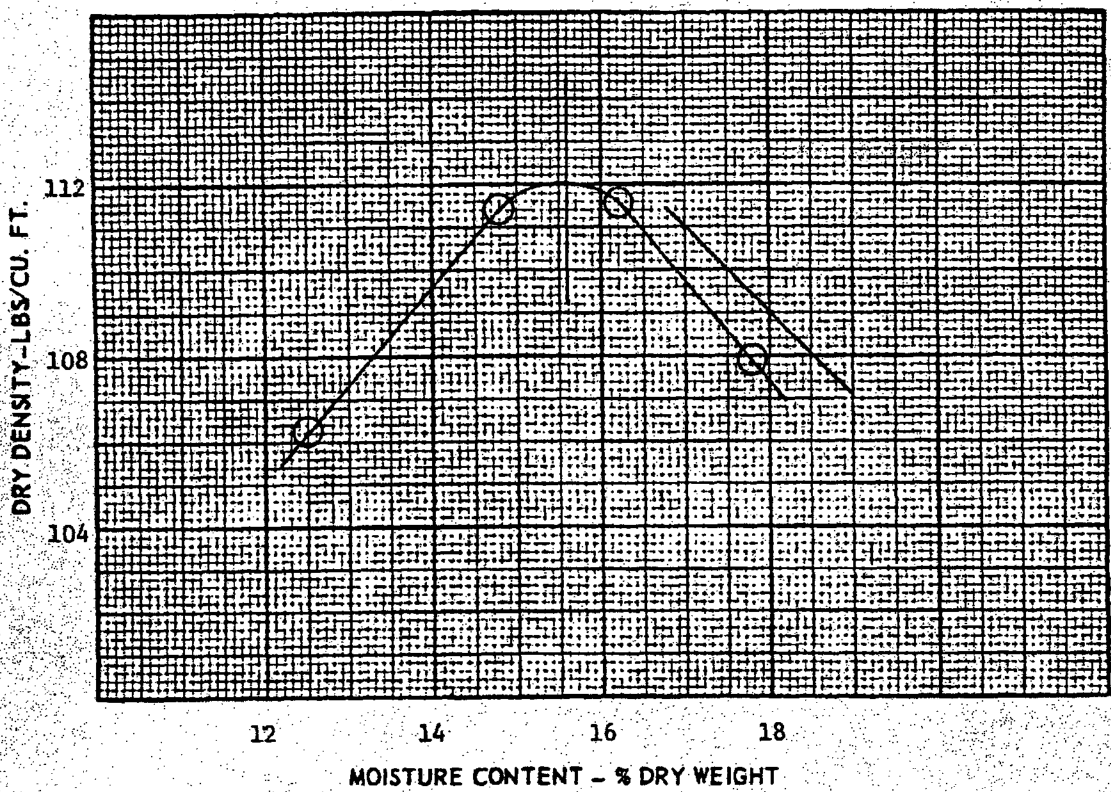
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS/CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	TP4, B-1	15.6	112.0	D698	A	

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
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AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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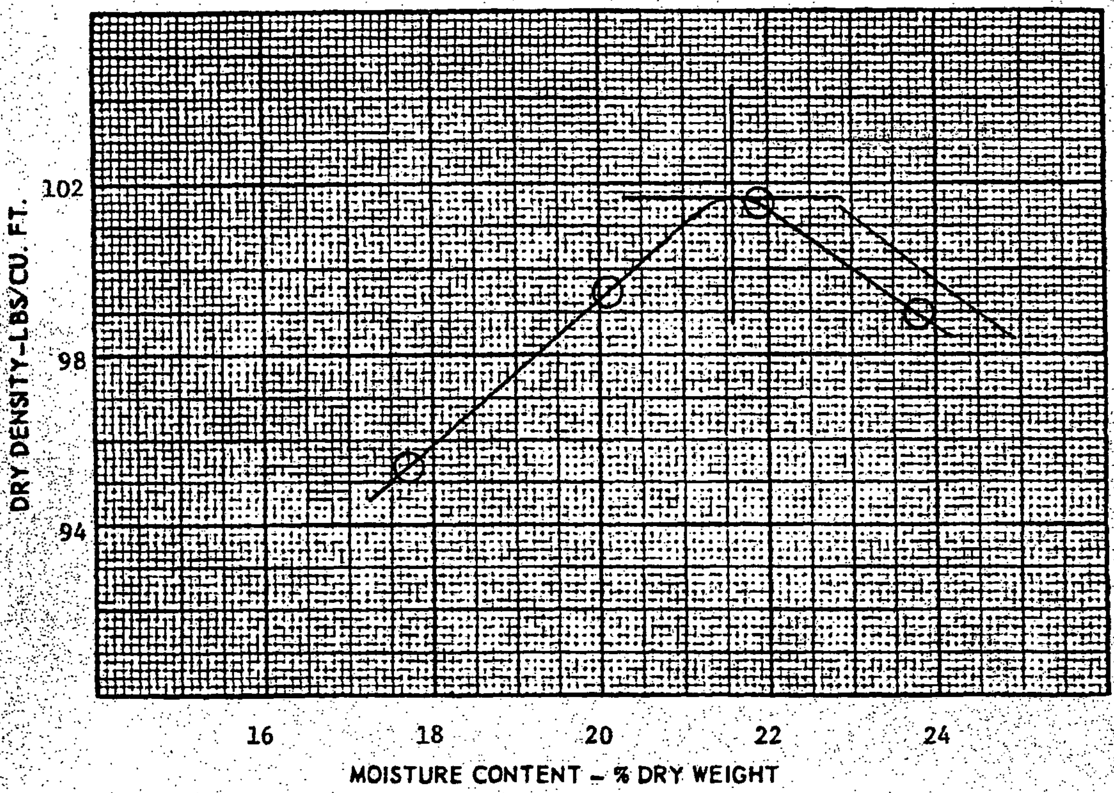
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	TP4, B-2	21.6	101.7	D698	A	

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
B	-#4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
C	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317
D	-3/4	6"	4.58"	3	56	5.5 LBS.	12"	12,317

AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	5	25	10.0 LBS.	18"	56,250
B	-#4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
C	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986
D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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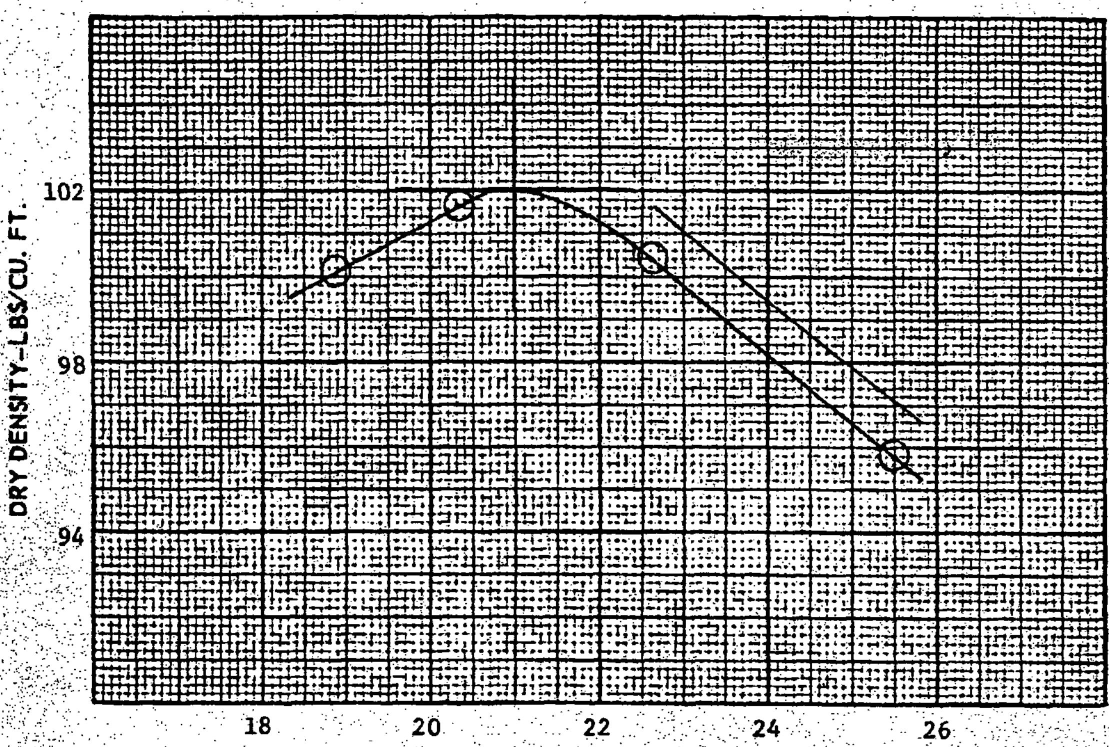
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



MOISTURE CONTENT – % DRY WEIGHT

CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	TP5, B-1	21.0	102.0	D698	A	

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4"	4.58"	3	25	5.5 LBS.	12"	12,375
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AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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D	-3/4	6"	4.58"	5	56	10.0 LBS.	18"	55,986

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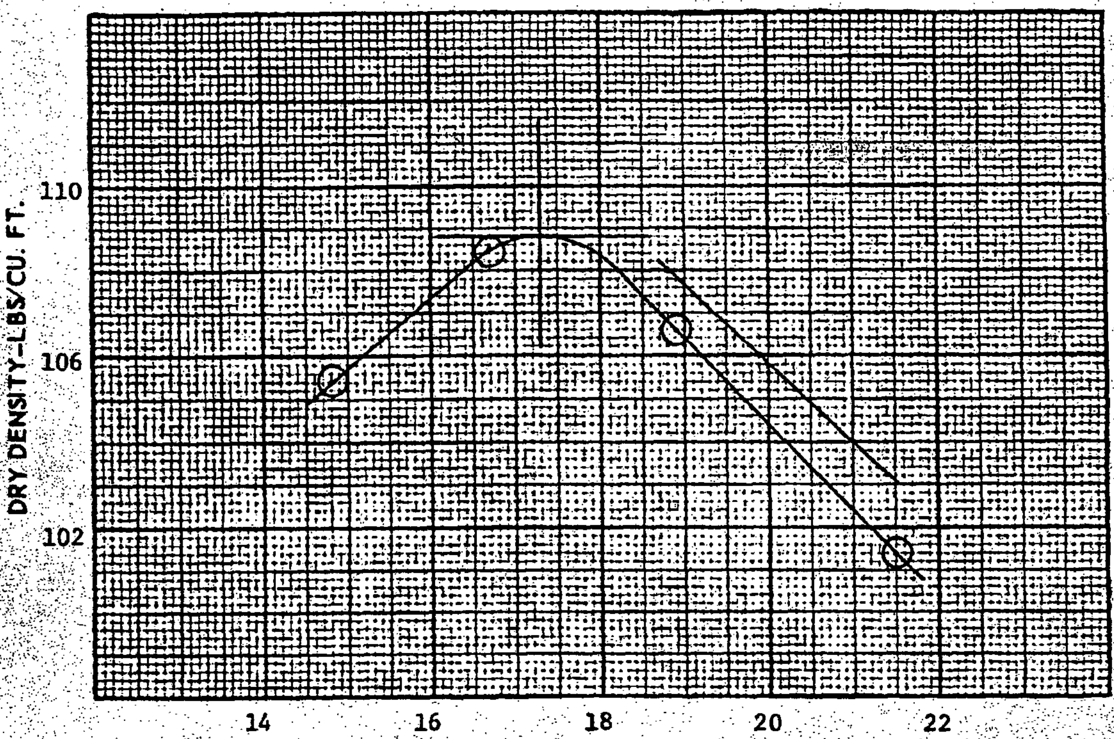
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



MOISTURE CONTENT – % DRY WEIGHT

CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS/CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	TP7, B-1	16.3	108.8	D698	A	

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
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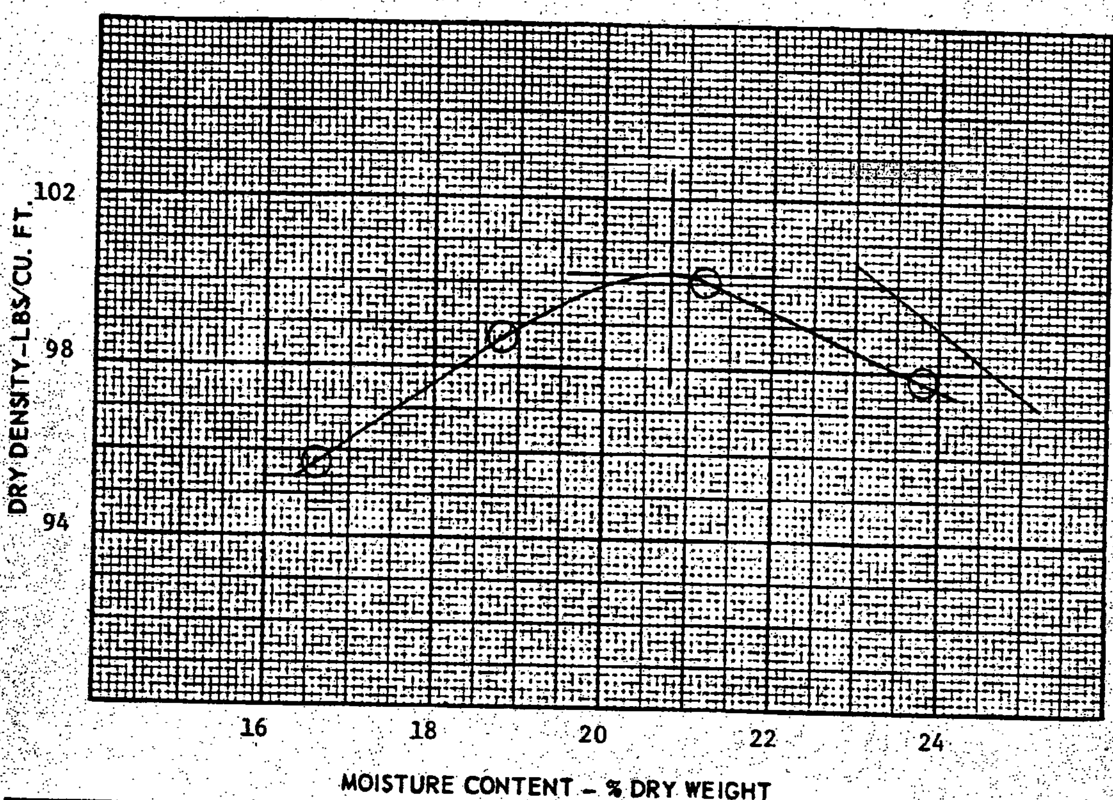
SUMMARY OF MOISTURE DENSITY RELATIONSHIP TESTS

PROJECT Homestake Mining Company **JOB NO.** E86-1113



CURVE	SOURCE	OPTIMUM MOISTURE CONTENT % DRY WT.	MAXIMUM DRY DENSITY LBS./CU. FT.	TEST DESIGNATION	TEST METHOD	LAB NO.
	TP8, B-1	20.8	100.2	D698	A	

MOISTURE-DENSITY RELATIONSHIP TEST METHOD DATA

AASHTO T99 and ASTM D698 (Standard Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4''	4.58''	3	25	5.5 LBS.	12''	12,375
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AASHTO T180 and ASTM D1557 (Modified Proctor)

METHOD	MATERIAL	MOLD DIAMETER	MOLD HEIGHT	NO. OF LAYERS	BLOWS PER LAYER	HAMMER WEIGHT	HEIGHT OF FALL	COMPACTIVE EFFORT FT. LBS/CU. FT.
A	-#4	4''	4.58''	5	25	10.0 LBS.	18''	56,250
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C	-3/4	6''	4.58''	5	56	10.0 LBS.	18''	55,986
D	-3/4	6''	4.58''	5	56	10.0 LBS.	18''	55,986

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APPLIED SOIL MECHANICS • ENGINEERING GEOLOGY • MATERIALS ENGINEERING • HYDROLOGY

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September 3, 1986

Alan K. Kuhn, Ph.D., P.E.
13212 Manitoba Drive, N.E.
Albuquerque, New Mexico 87111

SHB Job No. E86-1113

Re: Contract Drilling & Laboratory Testing
Homestake Mining Company
Grants, New Mexico

Dear Dr. Kuhn:

The table below lists results of constant-head permeability testing performed. A constant water head of 11.5 feet was used to determine the hydraulic conductivities. Also presented are dry densities and water contents achieved prior to testing.

Sample	Dry Density (pcf)	Moisture Content (%)	Compaction* (%)	Hydraulic Conductivity (cm/sec)
BA1-A1	112.5	11.9	95.0	5.4×10^{-5}
BA3-A1	109.0	14.2	94.5	4.4×10^{-6}
BA5-A3	110.8	14.0	95.0	7.6×10^{-6}
BA19-A1	112.5	13.0	96.8	4.7×10^{-8}

* Relative to maximum dry density as determined in accordance with ASTM D698.

REPLY TO: 4700 LINCOLN ROAD, N.E., ALBUQUERQUE, NEW MEXICO 87109

PHOENIX (602) 272-6848 ALBUQUERQUE (505) 884-0950 SANTA FE (505) 471-7836 SALT LAKE CITY (801) 266-0720 EL PASO (915) 778-3389

If you have any questions regarding these results, please do not hesitate to contact us.

Respectfully submitted,

Sergent, Hauskins & Beckwith Engineers

By Gregory M. Smith
Gregory M. Smith, Staff Engineer

Copies: Addressee (2)

SERGENT, HAUSKINS & BECKWITH CONSULTING GEOTECHNICAL ENGINEERS

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NICHOLAS T. KORECKI, P.E.
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SUANG CHENG, P.E.
JAMES R. FAHY, P.E.
MICHAEL HULPKE, P.G.
DAVID E. PETERSON, P.G.
ALBERT C. RUCKMAN, P.E.
PAUL KAPLAN, P.E.

November 6, 1986

Alan K. Kuhn, Ph.D., P.E.
13212 Manitoba Drive, N.E.
Albuquerque, New Mexico 87111

SHB Job No. E86-1113

Re: Laboratory Testing
Homestake Mining Company
Grants, New Mexico

Dear Dr. Kuhn:

Test results for specific gravity absorption, and sodium soundness are enclosed. These analysis were performed on the follwoing samples which were submitted on October 10, 1986.

Sample No. 1 - Massive Limestone, Surface
Sample No. 2 - Laminar Limestone, Surface
Sample No. 3 - Bluff Sandstone
Sample No. 4 - Red Sandstone, Recapture
Sample No. 5 - Limestone at 100 feet
Sample No. 6 - Sandstone at 100 feet

ASTM C-127

Specific Gravity & Absorption

Sample No.	Dry Bulk	SSD Bulk	Apparent	Absorption (%)
1	2.68	2.69	2.71	0.4
2	2.69	2.70	2.72	0.4
3	2.04	2.24	2.54	9.9

REPLY TO: 4700 LINCOLN ROAD, N.E., ALBUQUERQUE, NEW MEXICO 87109

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ASTM C-127

Specific Gravity & Absorption

Sample No.	Dry Bulk	SSD Bulk	Apparent	Absorption (%)
4	Sample very weathered, decomposed during preparation.			
5	2.64	2.66	2.70	0.9
6	2.11	2.28	2.55	8.1

ASTM C-88

Sodium Soundness (5 cycles)

Sample No.	Sieve Size	Individual Loss (%)	Average Loss (%)
1	-1.5" to +1.0"	0.2	0.2
	-1.0" to +0.75"	0.2	
2	-1.5" to +1.0"	0.1	0.2
	-1.0" to +0.75"	0.3	
3	-1.5" to +1.0"	38.4	44.2
	-1.0" to +0.75"	50.1	
4	Sample very weathered, decomposed during preparation.		
5	-1.5" to +1.0"	1.0	0.6
	-1.0" to +0.75"	0.3	
6	-1.5" to +1.0"	43.8	46.8
	-1.0" to +0.75"	49.8	

Qualitative Examination

Number of Particles

Sample No.	Before Test	Split	Crumbled	Cracked	Flaked	Sound
1	34	---	---	---	4	30
2	34	---	---	---	2	22

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Qualitative Examination

Sample No.	Before Test	Number of Particles: Split	Crumbled	Cracked	Flaked	Sound
3	31	---	13	3	2	5
4	Sample very weathered, decomposed during preparation.					
5	24	---	---	1	4	19
6	23	---	5	2	4	6

If you have any questions regarding these results, please do not hesitate to contact us.

Respectfully submitted,

Sergent, Hauskins & Beckwith Engineers

By Timothy R. Hyden
Timothy R. Hyden
Assistant Laboratory & Field Supervisor

Copies: Addressee (2)

APPENDIX C

SOIL LOSS BY WATER AND WIND-INDUCED EROSION

Calculations were made to determine the amount of soil loss on the impoundment cover that would occur over time (1,000 years) from both water and wind erosion. Calculations in Section C.1 contain the amount of water erosion soil loss that can be expected from the impoundment top with vegetative cover, gentle slopes (200H:1V) and slope lengths averaging 1,000 feet. In addition, calculations were made for side slopes at 5:1 (H:V), 580 and 480 slope lengths (east and west ponds, respectively) and six inches of rock cover.

Section C.2 contains the estimated amount of soil loss due to wind erosion that can be expected from the impoundment top with gentle slopes (200H:1V), ridge roughness, and vegetative cover converted to pounds of flat small-grain residue or equivalent.

It should be noted that the Universal Soil Loss Equation (USLE) and Wind Erosion Equation were developed for crop land and not range land. However, these are currently the only tools available to estimate soil loss over time.

C.1 WATER SOIL LOSS USING UNIVERSAL SOIL LOSS EQUATION (USLE)

C.1.1 Embankment Top

Soil loss from the top of the embankment was determined by the following:

Average slope = 200:1 (H:V)

Average slope length = 1,000 ft.

Soil Loss Equation: A = R k LS C P

where:

A = Computed soil loss per unit area.

R = Rainfall and runoff factor. For HMC = 20 (Figure 1, USDA Handbook No. 537, 1978).

k = Soil erodability factor. Soil material in the HMC site classified as follows, with assigned k factor:

- Penistaja: k = 0.32
- Prewitt: k = 0.32
- Moriarty: k = 0.37
- Average: k = 0.34

(Marker et al., 1974 and USDA, 1986a) (1)

L, S = Slope length factor and slope steepness factor.

Slope length = 1,000 feet
Slope steepness = 200:1 (H:V) = 0.5% slope

LS = 0.152 (Table 3, USDA Handbook No. 537, 1978).

C = Cover and management factor.
Tall weeds or short brush, 25% cover with 20% ground cover;
C = 0.20 (Table 10, USDA Handbook No. 537, 1978).

P = Support practice factor: P = 1.0
Conservative factor due to slope lengths; slopes will be contoured through disking or harrowing and seeding.

$$A = \underset{R}{20} \times \underset{k}{0.34} \times \underset{LS}{0.152} \times \underset{C}{0.20} \times \underset{P}{1} = 0.2067 \text{ tons/acre/year.}$$

West pond area = 1,250 x 1,080 = 1,350,000 sq ft
= 31 acres.

East pond area = 1,650 x 1,000 = 1,650,000 sq ft
= 38 acres.

---

(1) A recent soil survey has been conducted in the HMC area. The Penistaja series remains Penistaja. Moriarty has been changed to Venadito, and Prewitt changed to Aparejo. k factors remain essentially the same.

Soil Loss From West Pond

31 acres x 0.2067 ton/acre/year = 6.41 tons/year.

Soil Loss From East Pond

38 acres x 0.2067 ton/acre/year = 7.86 tons/year.

C.1.2 Embankment Sides

Soil loss from the sides of the embankment that have side slopes of 5:1 (H:V) and covered with six inches of rock material. Area divided into East area with average slope lengths of 580 feet, and West area with average slope lengths of 480 feet.

Soil Loss Equation: A = R k LS C P

where all factors are defined as in C.1.1, and R and k values are the same as those in C.1.1 above.

L, S = Slope length factor and slope steepness factor.

Slope steepness = 20% for both East and West, 5:1 (H:V).

East slope, 580 feet at 20% slope = 9.82
West slope, 480 feet at 20% slope = 8.93
(Table 3, USDA Handbook No. 537, 1978).

C = Cover and management factor. Six inches rock cover, use Table 11, Handbook No. 537 for 100% cover undisturbed forest.
Factor 0.001 to 0.003; use 0.002.

P, the support practice factor, is not really applicable due to rock cover and no contouring.
A conservative factor of 1.0 is used.

East slope calculations:

```
     R     k     LS      C     P
A = 20 x 0.34 x 9.82 x 0.002 x 1 = 0.134 tons/acre/year
```

West slope calculations:

```
     R     k     LS      C     P
A = 20 x 0.34 x 8.93 x 0.002 x 1 = 0.1214 tons/acre/year
```

C.1.3 Soil Loss Calculations for 1,000 Years

For depth of soil loss, the following conversion was used:

$$\text{Inches/year} = \frac{\text{tons/acre/year}}{(\text{lbs/ft}^3)^{(1)} \frac{(1\ \text{ton})}{(2000\ \text{lb})} \frac{(1\ \text{ft})}{(12\ \text{in})} \frac{(43{,}560\ \text{ft}^2)}{(\text{acre})}}$$

Then:

1. Soil Loss, Top of Embankment:

$$\frac{0.2067}{(104) \frac{(1)}{(2000)} \frac{(1)}{(12)} (43{,}560)} = 0.0011 \text{ in/yr or } 1.1 \text{ inches in } 1{,}000 \text{ yrs.}$$

2. East side slope $= \frac{0.134}{188.6847} = 0.0007$ in/yr or 0.7 inches in 1,000 yrs.

3. West side slope $= \frac{0.124}{188.6845} = 0.0006$ in/yr or 0.6 inches in 1,000 yrs.

---

(1) Volume weight, lbs/ft^3 was measured to be 104 lbs/ft^3

C.2 WIND EROSION CALCULATION

C.2.1 Impoundment Top

Reference: U.S. Department of Agriculture, USDA, 1980, Soil Conservation Service, New Mexico, Technical Note No. 27, Re: Wind Erosion-Wind Erosion Equation, Revised February 1986. All tables and figures referenced below and attached hereto are taken from this publication.

The following provides the wind erosion equation and the input parameters used for each parameter.

Wind Erosion Equation: E = f(I k C L V)

where:

E = The potential annual soil loss in tons/acre/year (t/a/y).

f = A function of

I = The erodability of a soil by wind. From Table 1 (attached), a wind erodability index of 86 was selected for a soil cover that best fits WEG-3.

k = The surface roughness factor. When reseeding, will put furrow spacing 8 inches to 12 inches with ridge heights 2.5 inches to 3.5 inches; use a k = 0.5. Furrows will be at right angle to prevailing wind (see Figure 2 for soil ridge roughness).

C = Climatic factor. C value map dated February 1986 (attached); shows a C value of 50.

L = The unsheltered distance across a field along the direction of the most erosive winds. Average slope lengths were measured and are 1,000 feet.

V = Vegetation cover. A seed mixture of western wheatgrass, blue grama, sand dropseed, Indian ricegrass, and alkali sacaton will be seeded. Using Figures 4 and 5 and Table 4 (attached), it is estimated that 1,400+ pounds of flat small-grain residue per acre would remain.

Using Table 5 with C = 50, I = 86, k = 0.5, 1,000-ft slopes, and 1,400-lb residue, soil loss = 0.4 t/a/y.

Data used were confirmed on November 6, 1986 by Ken Walker, SCS, Grants, New Mexico. SCS had just completed a soil survey of the area on the two main series, the Penistaja and Venadito. Ken Walker stated that the Penistaja would fall under WEG-3 or I=86. When the two series were mixed, I=86 was perhaps conservative due to the percentage of clay in the Venadito. K factor and C factor were OK. At initial reseeding with 2,000-lb mulch/acre, here would be no wind erosion. As the vegetation becomes established with the seed mixture to be used, 1,400 lbs/acre residue plus standing crop would be a good figure; again, perhaps conservative.

Using the equation:

$$\text{Inches/year} = \frac{\text{tons/acre/year}}{(\text{lbs/ft}^3)\frac{(\text{tons})}{(2000\ \text{lb})}\frac{(\text{ft})}{(12\ \text{in})}\frac{(43{,}560\ \text{ft}^2)}{(\text{acre})}}$$

$$\text{Inches/year} = \frac{0.4}{(104/\text{ft}^3)\frac{(1)}{(2000)}\frac{(1)}{(12)}(43{,}560)} = 0.0021$$

104 lbs/ft^3 was measured.

Loss during 1,000 years = 2.1 inches.

(from USDA, 1980)

TABLE 1

Wind Erodibility Groups (WEG)

WEG	Predominant Soil Texture Class of Surface Layer	Dry Soil Aggregates Over 0.84 mm Percent 1/	Wind Erodibility Index (I) T/Ac/Yr
1	Very fine sand, fine sand, sand, or coarse sand	1	310 2/ 250 220 180 160
2	Loamy very fine sand, loamy fine sand, loamy sand, loamy coarse sand	10	134
3	Very fine sandy loam, fine sandy loam, sandy loam, or coarse sandy loam	25	86
4	Clay, silty clay, noncalcareous clay loam, or silty clay loam with more than 35 percent clay content	25	86
4L	Calcareous loam and silt loam, or calcareous clay loam and silty clay loam	25	86
5	Noncalcareous loam and silt laom with less than 20 percent clay content, or sandy clay loam, sandy clay	40	56
6	Noncalcareous loam and silt loam with more than 20 percent clay content, or noncalcareous clay loam with less than 35 percent clay content	45	48
7	Silt, noncalcareous silty clay loam with than 35 percent clay content	50	38
8	Soils not suitable for cultivation due to coarse fragments or wetness, wind erosion not a problem	--	--

1/ If sieving shows a different percentage of dry soil aggregates, arrive at "I" from Table 2 on page 5.

2/ The "I" factors for WEG 1 will vary from 160 for the coarse sands to 310 for the very fine sands. Use an I of 220 as an average figure. Use common sense in selecting the factor. If you have a coarse sand with gravel, use a lower figure. If you have no gravel and very fine sand, use a higher figure.

October 1980

(from USDA, 1980)

TABLE 4

Comparability of Range Grasses Used to Locate Data on Conversion to Flat Small Grain Residue Equivalent

DATA ON	NO DATA ON	MOST LIKE
1. Big bluestem	1. Indiangrass	1
2. Switchgrass	2. Sand bluestem	1
3. Little bluestem	3. Silver bluestem	3
4. Western wheatgrass	4. Sand dropseed	3
5. Blue grama	5. Sand lovegrass	3
6. Buffalograss	6. Weeping lovegrass	3
	7. Plains muhly	3
	8. Perennial threeawn	5
	9. Sideoats grama	4
	10. Hairy grama	5
	11. Black grama	5
	12. Needleandthread	3
	13. Alkali sacaton	3
	14. Inland saltgrass	6
	15. Burrograss	6
	16. Tobosa	4
	17. Threadleaf sedge	5
	18. Sacaton	1
	19. Giant sandreed	1
	20. Bottlebrush squirreltail	5
	21. New Mexico feathergrass	3
	22. Cane bluestem	3

October 1980

(from USDA, 1980)

TABLE 5 (E) SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR

C = 50
I = 86

SURFACE - K = 1.

(L) UNSHELTERED DISTANCE IN FEET	(V)- FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE													
	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600
10000	43.0	38.4	31.4	25.0	17.8	10.6	5.9	3.3	1.7	0.9	0.3			
8000	43.0	38.4	31.4	25.0	17.8	10.6	5.9	3.3	1.7	0.9	0.3			
6000	43.0	38.4	31.4	25.0	17.8	10.6	5.9	3.3	1.7	0.9	0.3			
4000	43.0	38.4	31.4	25.0	17.8	10.6	5.9	3.3	1.7	0.9	0.3			
3000	42.7	[illegible]	31.2	24.8	17.7	10.5	5.8	3.2	1.6	0.9	0.3			
2000	40.7	36.3	29.6	23.5	16.6	9.8	5.4	2.9	1.5	0.8	0.3			
1000	36.6	32.5	26.3	20.7	14.5	8.4	4.5	2.4	1.2	0.4				
800	35.1	31.2	25.2	19.8	13.8	7.9	4.2	2.2	1.1	0.4				
600	32.2	28.5	23.0	17.9	12.4	7.0	3.7	1.9	0.9	0.3				
400	28.1	24.0	19.8	15.3	10.4	5.7	2.9	1.5	0.5					
300	24.7	[illegible]	17.2	13.2	8.8	4.8	2.4	1.2	0.4					
200	21.2	[illegible]	14.6	11.1	7.3	3.9	1.9	0.9	0.3					
150	18.0	15.7	12.2	9.1	5.9	3.1	1.4	0.5						
100	14.8	12.6	9.9	7.3	4.6	2.3	1.0	0.4						
80	13.3	11.5	8.8	6.4	4.0	2.0	0.7							
60	10.4	9.0	6.8	4.9	3.0	1.4	0.5							
50	8.7	7.5	5.6	4.0	2.4	1.1	0.4							
40	7.0	6.0	4.4	3.1	1.8	0.7								
30	4.8	4.1	3.0	2.0	1.1	0.5								
20	3.3	2.8	2.0	1.3	0.6									
10	1.5	1.2	0.8	0.4										

(E) SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR

C = 50
I = 86

SURFACE - K = .75

(L) UNSHELTERED DISTANCE IN FEET	(V)- FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE													
	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600
10000	32.3	28.6	23.0	17.9	12.4	7.0	3.7	1.9	0.9	0.3				
8000	32.3	28.6	23.0	17.9	12.4	7.0	3.7	1.9	0.9	0.3				
6000	32.3	28.6	23.0	17.9	12.4	7.0	3.7	1.9	0.9	0.3				
4000	31.3	27.7	22.2	17.3	11.9	6.7	3.5	1.8	0.9	0.3				
3000	30.4	26.9	21.6	16.7	11.5	6.4	3.3	1.7	0.8	0.3				
2000	28.8	25.4	20.3	15.7	10.7	6.0	3.1	1.6	0.6					
1000	24.1	21.2	16.8	12.8	8.4	4.6	2.3	1.1	0.4					
800	23.2	20.4	16.1	12.3	8.2	4.4	2.2	1.1	0.4					
600	21.2	18.6	14.6	11.0	7.3	3.9	1.9	0.9	0.3					
400	18.5	16.1	12.6	9.4	6.1	(3.2)	1.5	0.5						
300	16.2	14.1	10.9	8.1	5.2	2.7	1.2	0.4						
200	13.3	11.5	8.8	6.4	4.0	2.0	0.7							
150	11.0	9.5	7.2	5.2	3.2	1.6	0.6							
100	8.9	[illegible]	[illegible]	4.0	2.4	1.2	0.4							
80	7.1	[illegible]	4.5	3.1	1.8	0.7								
60	4.7	4.0	2.9	2.0	1.1	0.4								
50	4.0	3.4	2.4	1.6	0.8									
40	3.3	2.7	1.9	1.3	0.6									
30	2.0	1.7	1.2	0.5										
20	1.3	1.1	0.7	0.4										
10														

(E) SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR

C = 50
I = 86

SURFACE - K = .5

(L) UNSHELTERED DISTANCE IN FEET	(V)- FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE													
	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600
10000	[illegible]	18.9	14.8	11.2	7.4	4.0	1.9	0.9	0.4					
8000	21.5	18.9	14.8	11.2	7.4	4.0	1.9	0.9	0.4					
6000	21.5	18.9	14.8	11.2	7.4	4.0	1.9	0.9	0.4					
4000	20.4	17.8	14.0	10.5	6.9	3.6	1.7	0.8	0.3					
3000	19.5	17.0	13.3	10.0	6.5	3.4	1.6	0.8						
2000	17.7	15.5	12.0	9.0	5.8	3.0	1.4	0.5						
1000	14.5	12.6	9.7	7.1	4.5	2.3	1.0	0.4						
800	13.5	11.7	8.9	6.5	4.1	2.0	0.9	0.3						
600	11.9	10.3	7.8	5.7	3.5	1.7	0.6							
400	9.7	8.3	6.3	4.5	2.7	1.3	0.5							
300	8.1	6.9	5.1	3.6	2.2	0.9								
200	5.3	4.5	3.3	2.2	1.3	0.5								
150	4.1	3.4	2.5	1.7	0.9	0.4								
100	3.0	2.5	1.8	1.2	0.6									
80	2.2	1.8	1.3	0.8	0.4									
60	1.5	1.3	0.9	0.4										
50	1.2	1.0	0.7	0.3										
40	0.9	0.6	0.2											
30	0.7	0.5	0.2											
20														
10														

NOTE SOIL LOSS OF LESS THAN 0.1 TON/ACRE/YEAR IS NOT RECORDED

FIGURE 2 -SOIL RIDGE ROUGHNESS *

Ridge Height, Inches	Furrow Spacing, Inches: 3	4	6	8	10	12	14	16	18	20	24	30	36	40	42	48	54	60
½	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1	.75	.75	.75	.75	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1½	.5	.75	.75	.75	.75	.75	.75	.75	.75	.75	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	.75	.5	.5	.75	.75	.75	.75	.75	.75	.75	.75	.75	1.0	1.0	1.0	1.0	1.0	1.0
2½	.75	.75	.5	.5	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	1.0
3	1.0	.75	.75	.75	.5	.5	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75	.75
3½	1.0	1.0	.75	.75	.75	.5	.5	.5	.5	.75	.75	.75	.75	.75	.75	.75	.75	.75
4	1.0	1.0	1.0	.75	.75	.75	.75	.5	.5	.5	.5	.75	.75	.75	.75	.75	.75	.75
4½	1.0	1.0	1.0	1.0	.75	.75	.75	.75	.75	.5	.5	.5	.75	.75	.75	.75	.75	.75
5	1.0	1.0	1.0	1.0	1.0	.75	.75	.75	.75	.75	.5	.5	.5	.75	.75	.75	.75	.75
5½	1.0	1.0	1.0	1.0	1.0	1.0	.75	.75	.75	.75	.75	.5	.5	.5	.5	.75	.75	.75
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.75	.75	.75	.75	.75	.5	.5	.5	.5	.5	.75
7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.75	.75	.75	.75	.75	.5	.5	.5
8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.75	.75	.75	.75	.75	.75	.5
9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.75	.75	.75	.75	.75	.75
10	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.75	.75	.75	.75
11	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.75	.75
12	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.75

* Smooth = 1.0 Semiridged = .75 Ridged = .5
Table for determining whether a field is smooth, semiridged, or ridged.
Developed from Agriculture Handbook No. 346, and Chart 1 on Page 7.

October 1980

(from USDA, 1980)

(from USDA, 1980)

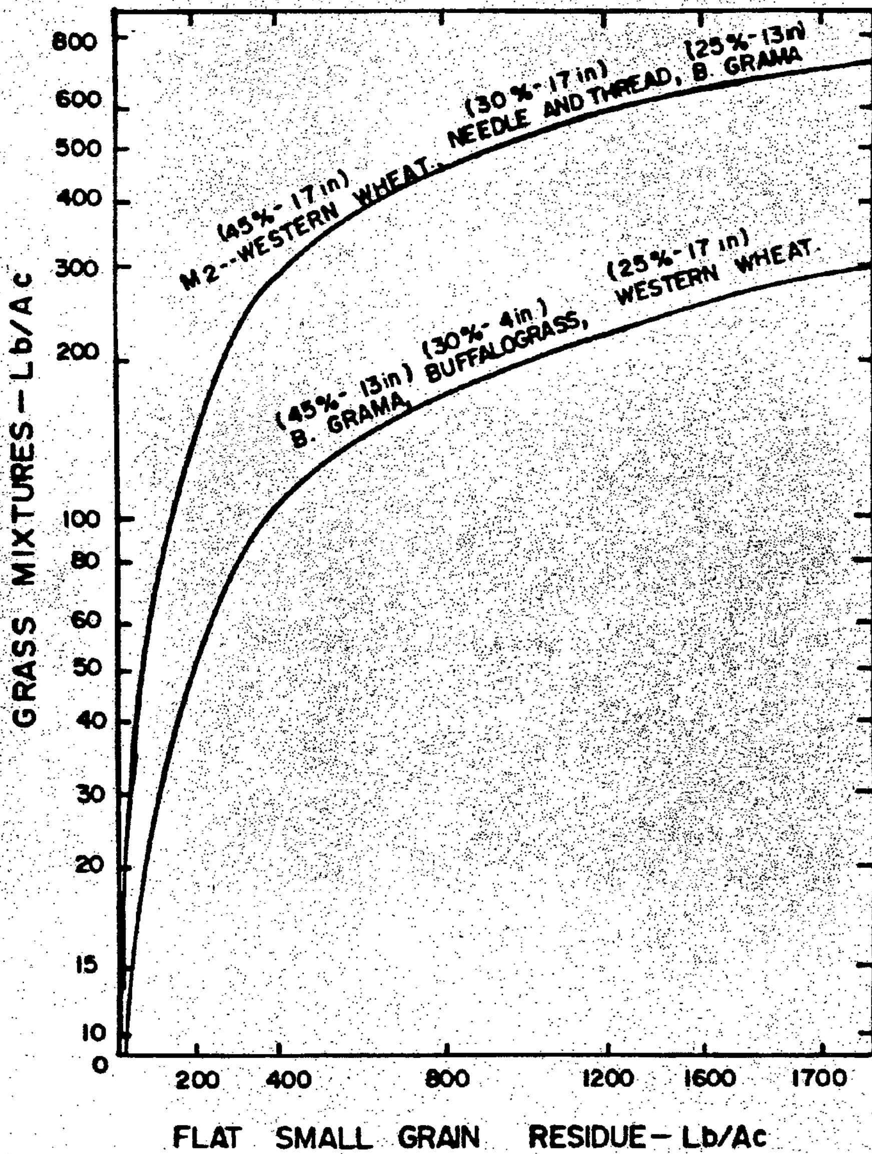


Figure 4. Converting ungrazed range grass mixture to equivalent quantity of flat small grain residue.

(from USDA, 1980)

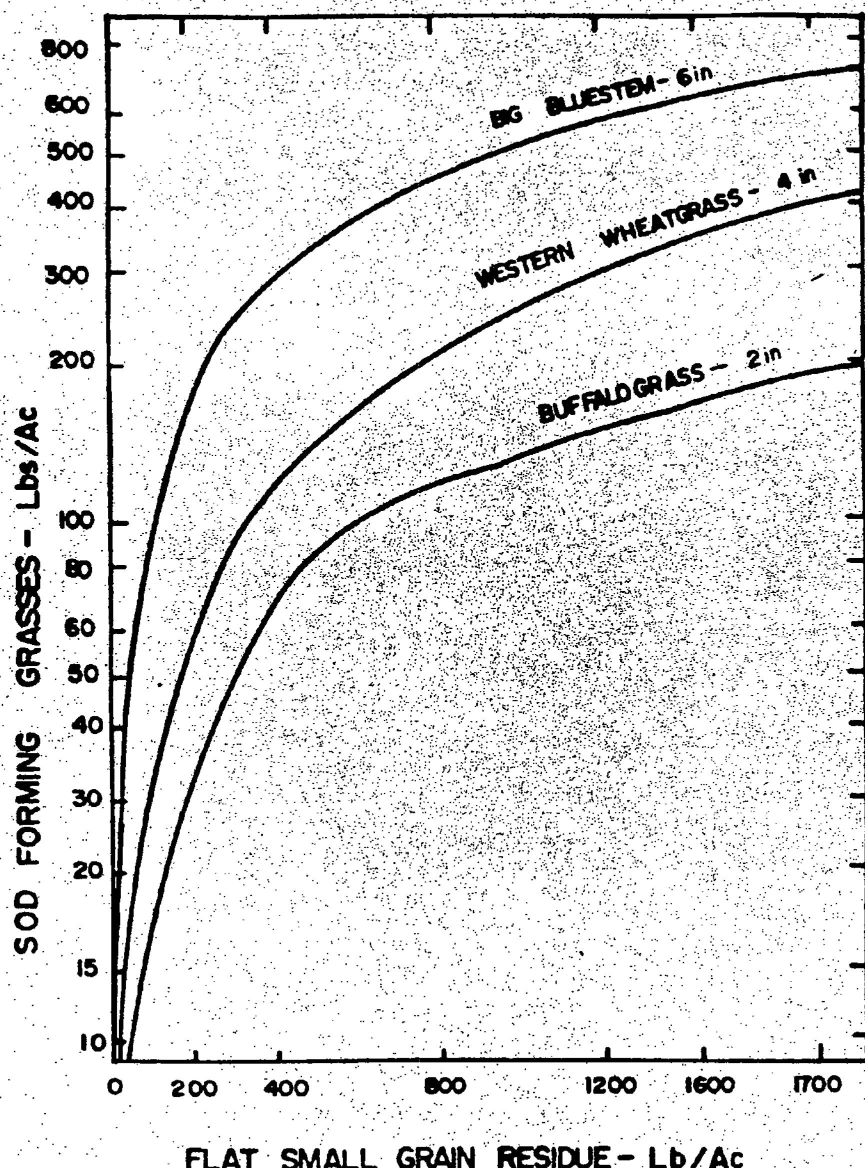
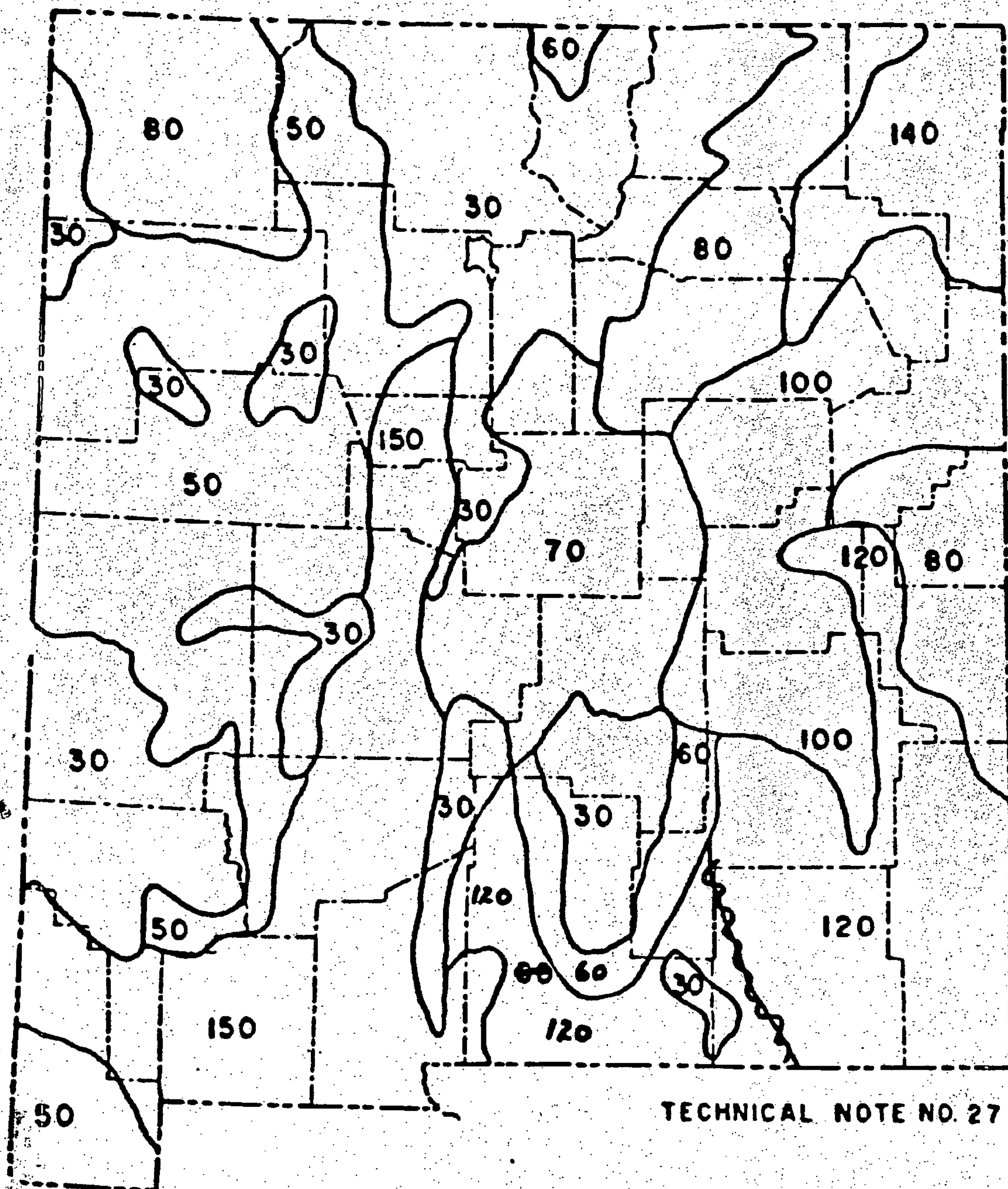


Figure 5. Converting properly grazed big bluestem, wheatgrass, and buffalograss to equivalent quantity of flat small grain residue.

(from USDA, 1980)

C VALUE MAP



TECHNICAL NOTE NO. 27

NEW MEXICO

FEBRUARY, 1986

April 28, 1987

CERTIFIED: P475754998

Mr. Harry J. Pettengill, Chief
Licensing Branch 2
Uranium Recovery Field Office
U.S. Nuclear Regulatory Commission
P.O. Box 25325
Denver, Co. 80225

Re: License No. SUA-1471
Docket No. 40-8903

Dear Mr. Pettengill:

This submittal is written in response to your letter of March 9, 1987 concerning Nuclear Regulatory Commission staff comments on Homestake Mining Company's Tailing Stabilization and Site Reclamation Plan.

Attached, please find the requested responses for each specific comment itemized by the NRC. Homestake's responses are not, at this time, being incorporated as revisions to the Reclamation Plan. Homestake proposes to make a single, final revision to the Plan, should it be found necessary, when all of NRC's concerns have been addressed and a general consensus has be reached.

Should you have any other comments or questions concerning the Reclamation Plan or these responses, please don't hesitate to contact me. Also, should it be felt a meeting on these matters may be of benefit, please notify me, and Homestake's contractor can be made available.

Very truly yours,

HOMESTAKE MINING COMPANY-GRANTS

Edward E. Kennedy
Director of Environmental
Affairs

EEK/bgl

xc: T.G. White
D.B. Crouch

HMCSL024727

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
URANIUM RECOVERY FIELD OFFICE
BOX 25325
DENVER, COLORADO 80225

RECEIVED
JUN 19 1987

JUN 17 1987

URFO:PJG
Docket No. 40-8903

Homestake Mining Company
ATTN: Mr. Edward Kennedy
P.O. Box 98
Grants, New Mexico 87020

Gentlemen:

We are in receipt of your letter dated April 28, 1987, providing a response to our March 9, 1987 request for information regarding your proposed reclamation plan. We conclude that the information presented is not adequate to enable us to evaluate the ability of the proposed design to meet the requirements of Criterion 6 of Appendix A to 10 CFR Part 40. We also disagree with statements made regarding the level of detail necessary.

Criterion 9 of Appendix A to 10 CFR Part 40 states that "Financial surety arrangements must be established by each mill operator...to assure that sufficient funds will be available to carry out...the reclamation of any tailings or waste disposal areas. The amount of funds...must be based on Commission-approved cost estimates in a Commission-approved plan for...the reclamation of tailings and/or waste areas in accordance with technical criteria delineated in Section I of the Appendix." Criterion 6 of Section I, in turn, states that a tailings impoundment shall be closed in accordance with a design which provides reasonable assurance of control of radiological hazards for 1000 years, to the extent reasonably achievable but for at least 200 years, and limits releases of radon-222 from uranium byproduct materials to an average release rate of 20 pCi/m^2s to the extent practicable. The proposed design must therefore contain sufficient detail to enable the staff to conclude that the proposed plan, as revised, meets the technical criteria discussed above.

Criterion 9 further states that the surety must be "at least sufficient to cover the costs of decommissioning and reclamation of the areas that are expected to be disturbed before the next license renewal." The projected time of mill closure is not a consideration.

JUN 17 1987

We conclude that the information provided in your April 28, 1987 submittal does not contain the level of detail required for us to make technical judgments regarding the adequacy of the proposed plan or the associated costs. Specifics are provided in the enclosure to this letter.

We have also determined that the inactive tailings pile located south of the main piles although originally designated as a Title III site has since been declared the responsibility of Homestake under it's Title II license. Therefore, the inactive pile must be addressed and included in your reclamation plan. We believe the most environmentally sound and technically feasible plan for long-term stabilization of the inactive pile would involve removing the material from its current location and using it to surcharge slimes areas of the active piles to achieve precover contours.

In the interest of cooperation, we request that you provide a response to this letter by August 1, 1987. Should you have any questions, please contact Mr. Pete Garcia of my staff on (303) 236-2820.

Sincerely,

Harry J. Pettengill, Chief
Licensing Branch 2
Uranium Recovery Field Office
Region IV

Enclosure: As stated

Enclosure

Request for Information

The numbering of the comments below corresponds to that used in your April 28, 1987 response to initial NRC comments.

I. Geotechnical Issues

B. A more detailed settlement monitoring program is necessary to assure that differential settlement does not affect the integrity of the radon barrier. We must, therefore, be able to conclude that the proposed monitoring program is adequate to determine when at least 90 percent of the total settlement in the slimes areas has occurred, so placement of the radon barrier can begin. Information to be submitted must include specific monitoring locations, monitoring methods, and frequencies. In addition, an annual frequency for settlement monitoring is not sufficient to establish the time-settlement curves which will be necessary to determine when 90 percent settlement has occurred. The annual inspection frequency discussed in Criterion 12 of Appendix A to 10 CFR 40, which you reference in your response, has nothing to do with the period of time during which the license is in effect. Criterion 12 discusses post-closure requirements which apply to the governmental entity responsible for long-term surveillance of the site following termination of the license.

D. The composition of the radon barrier layer is extremely critical to estimating long-term moisture contents for the radon barrier which, in turn, are a major factor in determining the thickness of the radon barrier. You state on page 6 that "all clays are candidate soil cover materials, along with the sands overlying them."

The RAECOM analysis performed by Homestake utilized a long-term moisture content of 12 percent for the radon barrier. This value appears to be the average in-situ value for 12 clay samples. Based on in-situ moisture contents for overlying sands, we cannot concur at this time that the 12 percent value is reasonably conservative for a composite radon barrier layer. Half of the soil samples exhibited moisture contents less than 3 percent.

A specific mix for the proposed radon barrier is necessary to enable an accurate determination of the required radon barrier thickness to be made. The information required must include the following:

1. The composition of the radon barrier based on the percentages of clay and sand.

2. Grain size analyses of the typical composite sample as well as the clay and sand fractions.

3. An evaluation of the availability of sufficient clay to achieve the proposed mix.

4. An evaluation of the dispersivity of the clay soils.

E. Specifications for construction and the quality control program are necessary to estimate costs associated with construction such as equipment and personnel requirements and enable us to conclude that the as-placed cover will meet design requirements. Please provide the required specifications for all material types.

II. Surface Water Hydrology

1. Detailed designs are necessary for several features of the proposed plan before we can conclude that the proposed plan will provide reasonable assurance of control of radiological hazards in accordance with Criterion 6 of Appendix A to 10 CFR 40. The features for which specific designs are required are listed below.

   a. the levee at the northeast corner of the impoundment,

   b. the rock cover along the north and west sides of the pile specifically, toe protection designed to prevent scour and undercutting of the riprap,

   e. the rock check dams and blankets located south of the pile.

   f. the diversion ditch on the south and east sides of the impoundment (include all information used in determining the drainage area which will contribute to flows in the ditch).

2. How were the cross-sections used in the HEC-2 PMF analyses developed? Was a topographic map used or were the sections surveyed? If a topographic map was used, please provide it.

EEK Rod.

July 21, 1987

Mr. Pete Garcia
Licensing Branch 2
U.S. Nuclear Regulatory Commission
Uranium Recovery Field Office
Region IV
P.O. Box 25325
Denver, CO 80225

Re: HMC's Discussion of NRC Comments on Tailing
Pile Reclamation Plan.

Dear Mr. Garcia:

Please find attached preliminary draft comments for discussion between Homestake and the NRC at the morning meeting scheduled for July 29, 1987.

If you have any questions in advance of the meeting, please don't hesitate to contact me.

Very truly yours,

HOMESTAKE MINING COMPANY-GRANTS

Edward E. Kennedy
Director of Environmental
Affairs

EEK/bgl

PRELIMINARY DRAFT

RESPONSES TO NRC'S COMMENTS OF JUNE 17, 1987
ON HOMESTAKE'S RECLAMATION PLAN

These responses have been prepared in preliminary draft form for discussion between Homestake and the NRC at a meeting scheduled for 7/29/87. They respond to the letter from NRC to Homestake of June 17 containing comments on Homestake's reclamation plan for its Grants uranium mill. The letter of June 17 contains the second set of NRC comments on the plan -- the first set of NRC comments was transmitted to Homestake on March 9, 1987. Both sets of comments raise questions for Homestake about some technical issues and about the level of detail needed in the plan, considering Homestake's intention to continue operation of the Grants mill. To help resolve its questions, Homestake will meet with NRC on 7/29. In preparation for that meeting, NRC has asked Homestake to prepare these draft responses so that NRC staff can review them and be prepared for more substantive discussion on 7/29.

The following responses are numbered in accordance with the system established in NRC's transmittal of March 9. Some of Homestake's responses of April 28 to those (March 9) NRC comments apparently were satisfactory, because NRC has made no mention of them in the June 17 transmittal. Therefore, the following responses use the original comment numbering system but address only the subjects included again in the June 17 letter from NRC.

DRAFT RESPONSES

I.B. Settlement Monitoring

As stated in the April 28 responses, the predicted total settlement in 90 feet of slimes is up to 3.7 feet. A significant portion has probably already occurred due to downward seepage pressure, and most of the remaining settlement will probably occur during and very soon after sand tailings surcharging. Therefore, we expect that settlements will pose less trouble for the cover than perceived by NRC. Nevertheless, Homestake will install settlement monumuents in each pond area after placement of the tailings surcharge. Each will be a brass cap set in a concrete base, cast in place in the tailings two feet below tailings surface. The caps will be extended to the top of the soil cover when the cover is placed, but eventually must be removed to the base of the cover to eliminate possible release pathways through the cover. Monitoring will be by precision land survey methods tied to control points established near to but off the impoundment. During surcharging and early consolidation the settlement monuments will be surveyed monthly initially, reducing to quarterly when two successive monthly readings show changes of one-third or less of the maximum monthly change previously recorded.

I.D. Soil Cover

NRC's comments do not indicate what data or form of analysis it would consider adequate to support evaluation and selection of a design moisture content of the soil cover. Homestake's first response on this question indicates that testing to specify the cover soil properties has been performed, and that the clay content of the soil can be increased if necessary to achieve the higher long-term moisture or to otherwise satisfy all Criterion 6 requirements. Both sand and clays soils are available in the same borrow pit and with about the same amount of excavation. The approximate soil mix proposed for the cover is described on page B-8 of the plan. This soil is a representative blend of sand and clay obtained from the augers during test drilling. Clearly, more clay than contained in this mix (40%) can be achieved. Section B.3.3, App.B of the plan, states that enough clay is available in the borrow area to construct the cover entirely with clay if necessary, and with no significant cost differential. Knowing this, Homestake has not considered additional testing or analysis to be necessary at this time. Homestake believes that a cover soil of suitable properties can be designed using existing data. To provide NRC with the assurance they seek, the borrow pit will be reconfigured to expose more clay, and the clay content of the cover soil will be increased.

Homestake does not object to specifying material properties, placement methods, and quality control procedures. In fact, this has been done in the plan and April 28 responses to a great extent. Unresolved, however, is the form and degree of specification required. While specifying technical standards within the plan is appropriate, preparing separate formal specifications would be premature at this time.

II. Surface Water Hydrology

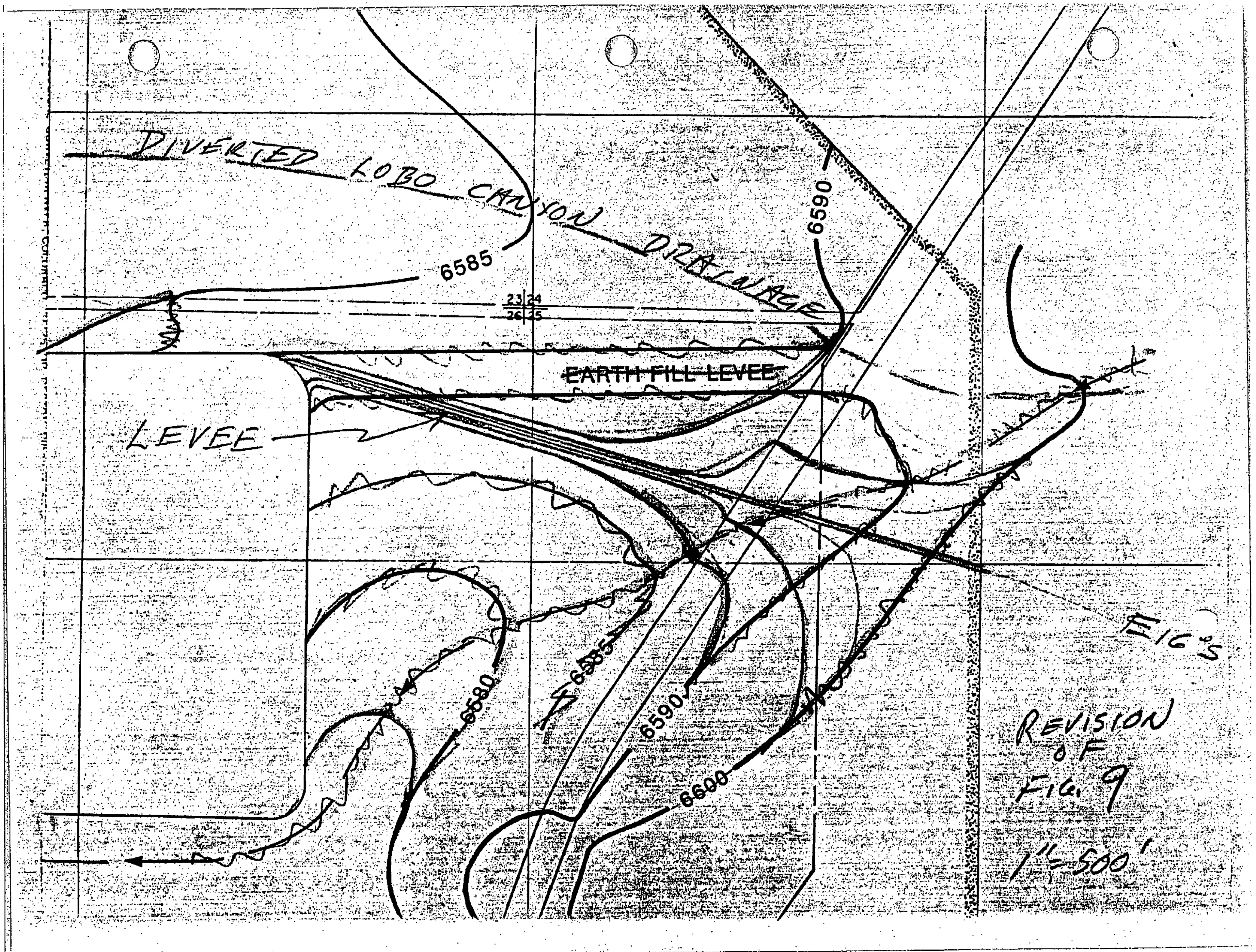
The following responses are numbered in the same way as the surface water hydrology comments of June 17.

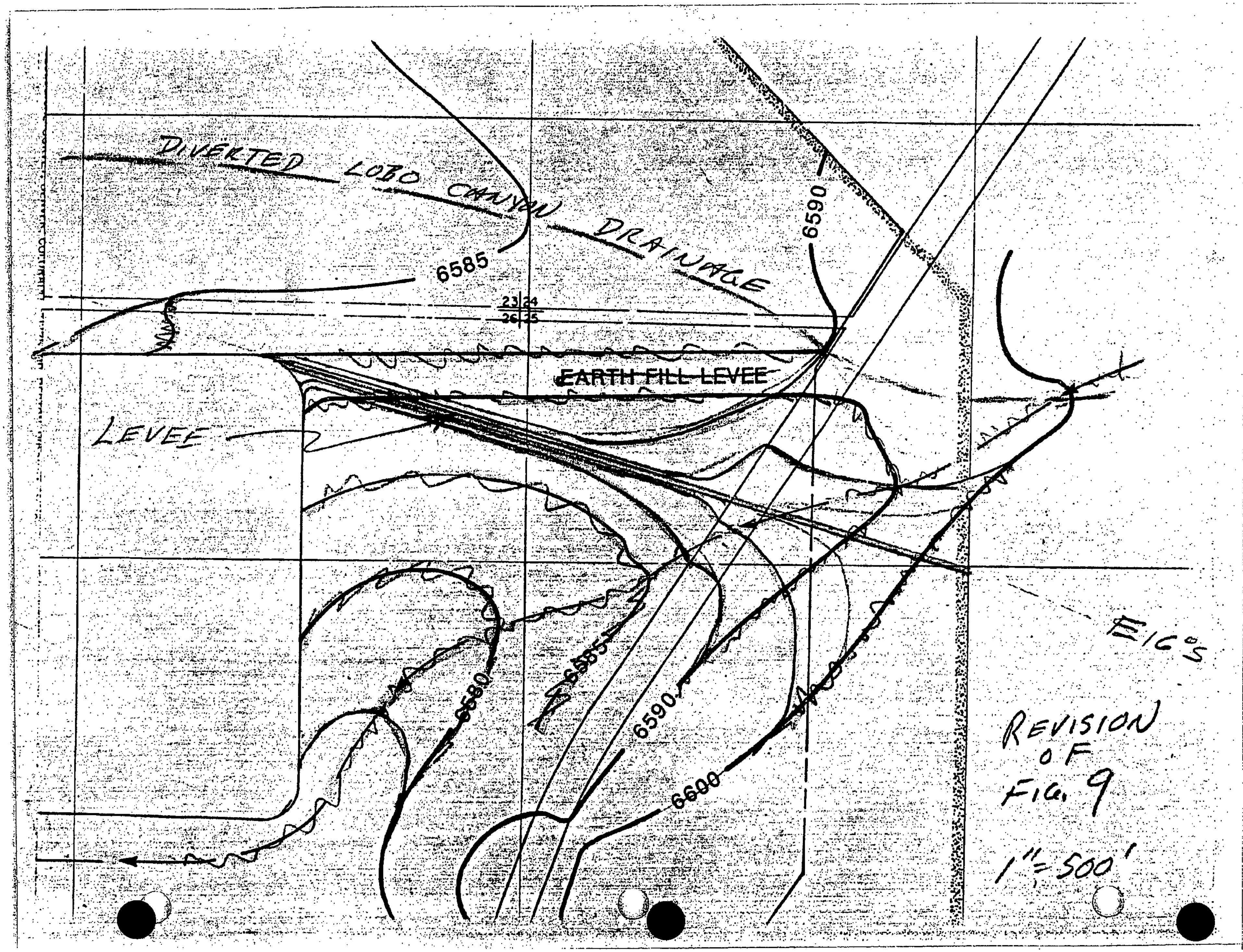
1.a. The levee at the northeast corner of the embankment has been realigned to run E 16 S to take better advantage of existing topography and to minimize or eliminate off-site cut and fill. The poorly defined course of the Lobo Canyon drainage will be rechannelized north of the impoundment. These changes are shown on the attached sketch of the Fig. 9 revision, in which pink highlights the scrub-outs, green the levee crest, and solid blue the revised contours. Figure 12 will also be revised to reflect these changes, as shown on the attached sheet. The flood routing will determine what crest elevation is needed, but at this time the levee is being designed for 3:1 (H:V) slopes and a 20 foot wide crest at elev. 6605. Fill will be sandy soil excavated for Lobo Canyon drainage rechannelization and compacted to at least ~~105 pcf dry density~~.
95% proctor

1.b. Other than drawings showing details, the design of rock cover and riprap has already been addressed in the April 28 responses, including calculations. The drawings to be prepared will show the approximate gradations of rock to be used in the cover (including the filter blanket of crusher fines), a typical section of the slope and toe, and a plan of riprap placement.

1.e. & f. Because of the redesign of the Lobo Canyon drainage diversion and levee, the runoff area tributary to the south diversion has been reduced. As a result, the discharge and velocity of the PMF flow in the south ditch will be lower, and the check dams will not be necessary. Details of the ditch design are being prepared to show the plan and typical cross sections, the confluences with the impoundment drainage channels, erosion protection where needed, and appropriate details. Supporting calculations will include drainage area measurements, Rational Method small basin runoff estimates, velocity and design shear of PMF flow.

2. The attached letter explains the development of the cross sections used in the HEC-2 analyses. The topo maps used are listed and are available from the USGS in Denver.


DIVERTED LOBO CANYON DRAINAGE
6585
6590
23 24
26 25
EARTH FILL LEVEE
LEVEE
6580
6585
6590
6600
REVISION OF FIG. 9
1" = 500'



DIVERTED LOBO CANYON DRAINAGE
6585
6590
23 24
26 25
EARTH FILL LEVEE
LEVEE
6580
6585
6590
6600
E16°S
REVISION OF FIG. 9
1" = 500'

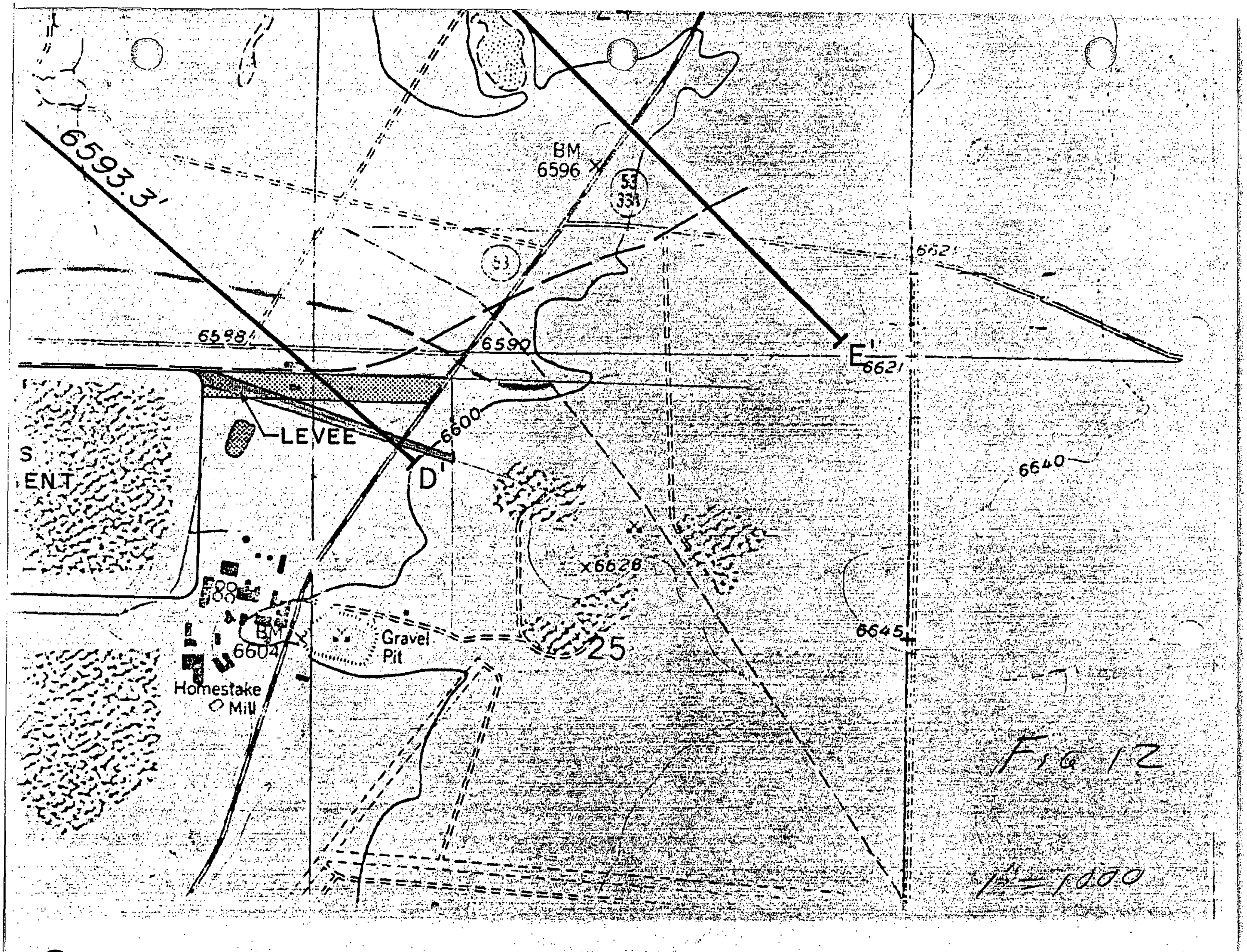


Fig 12

1" = 1000

HMCSL024738

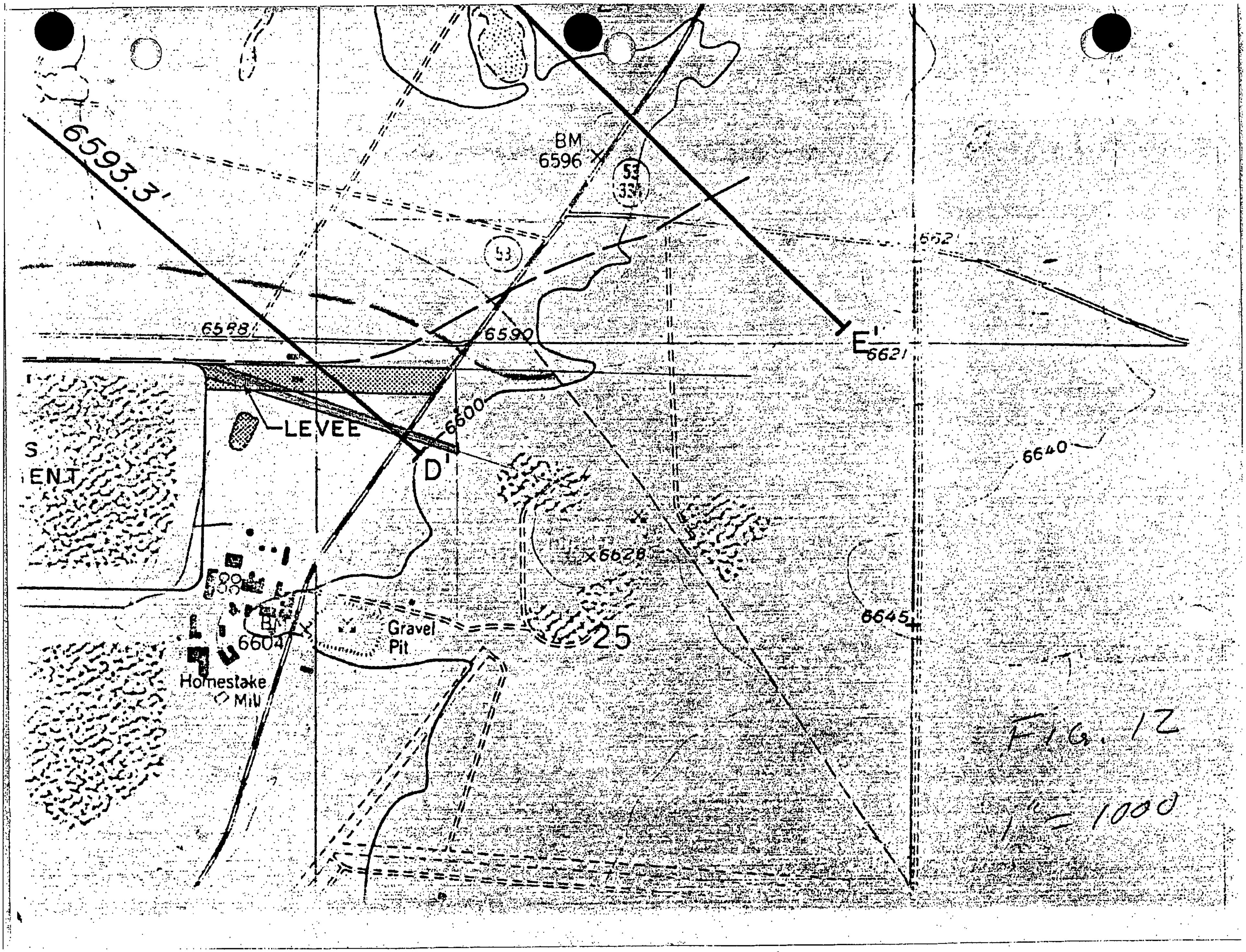


FIG. 12

1" = 1000'

HMCSL024739

Canonie Environmental

Ca[illegible]
655[illegible] South Re[illegible]
Suite 155
Englewood, Co[illegible]

Phone 303 79[illegible]

July 6, 1987

RM 86-065

Dr. Alan Kuhn
13212 Manitoba Drive, N.E.
Albuquerque, New Mexico 87111

<u>Cross Section Origination</u>
<u>Homestake Mill</u>
<u>Grants, New Mexico</u>

Dear Al:

I have written a short paragraph explaining the origination of the cross sections used in the PMF floodplain determination for the Homestake Mill near Grants, New Mexico. The paragraph follows:

"Sections Z-Z′, A-A′, and C-C′ were developed from an enlargement of a composite map made from USGS 7.5-minute topographic map sheets of Bluewater, Dos Lomas, Milan, and Grants, New Mexico. This enlarged composite was used as the base map for Figures 8 and 12. Sections B-B′, D-D′, and E-E′ were surveyed in either 1980 or 1981 by Homestake personnel using laser surveying equipment. The sections for B-B′ and C-C′ were modified to include the reclaimed borrow pit configuration as shown on Figures 8 and 9."

Al, please check Figure 8 to make sure that this figure shows the borrow pit configuration. Gene's copy of the reclamation copy is missing Figure 8.

Please call if you have any questions.

Very truly yours,

Michael J. Timmer
Project Supervisor

MJT/klg

HMCSL024740

Rad. 16.

UNITED STATES

NUCLEAR REGULATORY COMMISSION

REGION IV

URANIUM RECOVERY FIELD OFFICE
BOX 25325
DENVER, COLORADO 80225

AUG 20 1987

RECEIVED
AUG 24 1987

URFO:ROG
Docket No. 40-8903

Homestake Mining Company
ATTN: Mr. Edward Kennedy
P.O. Box 98
Grants, New Mexico 87020

Gentlemen:

At the meeting you attended in our office on July 29, 1987, agreement was reached on several issues, and commitments were made for providing additional information needed in our review of the Homestake Reclamation Plan. It was agreed that you would provide us the information when available and at least within 60 days, unless testing results are not available.

Commitments made for providing additional information are as follows:

1. Design details and general construction specifications (QC) for major design features (i.e., radon barrier, rock armor, levee, etc.) will be provided.

2. Soil testing of proposed radon cover (manufactured samples) from the borrow area and a complete set of index testing along with moisture-density relationship determination, permeability and dispersive testing will be submitted. The radon attenuation will be reconsidered using these values and an appropriate long-term moisture to determine the required thickness of cover.

3. The October 1986 Triad Inc. report, "Radon Emanation and Dispersion Modeling" will be submitted. The emanation coefficient will be set at 0.35, unless a differing value is substantiated by test results.

4. The method that will be used to determine when sufficient settlement has occurred so that the radon cover can be placed, will be submitted. Also, the proposal to further reduce surveying to annually will be considered after reviewing several sets of settlement data.

5. In designing riprap, Homestake used a 1-hour PMP = 3.4 inches. (See page 2 of Attachment IIB of 4/28/87, submitted and Table 1 of

Reclamation Plan.) Staff believes PMP should be 11-12 inches. Therefore, Homestake will provide basis for the 3.4-inch PMP value or recalculate using appropriate (defendable) value.

6. Additional drainage will be diverted to the north of the pile. Therefore, a revised PMF analysis is required, and design of riprap on north and west sides of pile has to be reevaluated to assure it is adequate.

7. Design basis for ditch located south of the pile (between the old and new piles) will be provided. Ditch dimensions plus flow depth, discharge and flow velocities will be provided.

8. Swales on top of pile will be armored with rock. Homestake will provide design details of the swales and rock to be used for armoring.

9. Design details of levee to be constructed to divert Lobo Canyon at northeast corner of pile will be provided. A 100-year flood event will be considered to determine potential for scour and erosion of diversion levee during low flow events.

10. Minimum requirements for rock source to be used for riprap will be provided.

11. An evaluation of the potential for scour on the north and west sides of the pile will be made. If there is a potential for undercutting of the toe of the armored slope, the riprap will be extended to the estimated scour depth.

12. A discussion of how the cross-sections along the north side of the pile were determined. (It appears that the 7½-minute quadrangle maps used have a 20-foot contour interval. It is nor clear how these maps were used.)

We also want to remind you that the inactive tailings pile located south of the main pile has to be addressed and included in your reclamation plan. This requirement was previously stated in a letter to you dated June 17, 1987.

Sincerely,

Edward F. Hawkins

Edward F. Hawkins, Chief
Licensing Branch 1
Uranium Recovery Field Office
Region IV

HMCSL024742

Rad. 1b,

HOMESTAKE MINING COMPANY

P.O. BOX 98
GRANTS, NEW MEXICO
87020

August 28, 1987

Mr. Michael J. Timmer
Canonie Environmental
6551 South Revere Parkway
Suite 155
Englewood, Colorado 80111

Re: Additional Hydrologic/Hydraulic Analysis
Homestake Mining Company

Dear Mr. Timmer:

We are in receipt of your letter of August 25, 1987 concerning the above referenced matter. The referenced items are hereby approved for your analysis as directed by Alan Kuhn. Please bill Homestake as you have in the past for work done (P.O. No. 154037).

If you have any questions or comments concerning the identified tasks, please don't hesitate to contact me or Alan Kuhn.

Very truly yours,

HOMESTAKE MINING COMPANY-GRANTS

Edward E. Kennedy

Edward E. Kennedy
Director of Environmental Affairs

EEK/bgl

xc: Alan Kuhn

CanonieEnvironmental

RECEIVED
AUG 28 1987

Canonie Environmental Services Corp.
6551 South Revere Parkway
Suite 155
Englewood, Colorado 80111

Phone: 303-790-1747
86-065

August 25, 1987

Mr. Edward Kennedy
Homestake Mining Company
P.O. Box 98
Grants, New Mexico 87020

Additional Hydrologic/Hydraulic Analysis
Homestake Mining Company Mill
Grants, New Mexico

Dear Mr. Kennedy:

Mr. Alan Kuhn has indicated the need for additional hydrologic and hydraulic analyses for the reclamation plan for Homestake Mining Company's (Homestake) at Grants, New Mexico. Mr. Kuhn has asked that Canonie Environmental Services Corp. (Canonie) provide the scope and expected costs for this work.

The tasks involved include the following:

1. Determination of revised one-hour and six-hour PMP amounts from the Bureau of Reclamation or NOAA.

2. Recalculation of the PMF for both San Mateo Creek and Lobo Canyon drainage using revised PMP amounts.

3. Routing the PMF through both San Mateo Creek and Lobo Canyon using existing HEC2 input files.

4. Analysis and explanation of effects of converging peak flows on flood heights in Lobo Canyon.

5. Explanation of channel cross section determinations and effects of 20-foot contour intervals on accuracy of flood modeling.

6. Determination of 100-year rainfall amount, 100-year flood hydrograph, and 100-year flood heights and velocities in Lobo Canyon drainage.

7. Determination of PMF and 100-year flood flow velocities along dikes and levees and sizing of riprap, if needed, on Homestake property.

8. Revisions and additions to existing reclamation plan text.

The expected cost for performance of these tasks is $3,800. Canonie has started on Task 1 because of the importance of acquiring the revised PMP amounts.

Please call if you have any questions.

Michael J. Timmer
Project Supervisor

MJT/bk

cc: Alan Kuhn, Albuquerque

Attachment B-2

A Report on Alkaline Carbonate Leaching at Homestake Mining Company

A REPORT

ON

ALKALINE CARBONATE LEACHING AT HOMESTAKE MINING COMPANY

by

Kenneth E. Skiff

and

John P Turner

November 12, 1981

TABLE OF CONTENTS

List of Figures

Introduction

Homestake Mining Company is a major uranium mining and milling operation near Grants, New Mexico.

The Mill, originally built in 1958, had a capacity of 1650 tons per day. With subsequent improvements and the addition of the adjacent Homestake New Mexico Partners mill, the HMC mill is currently rated at about 3500 tons per day.

An alkaline type leach process is utilized by the mill. Milling consists of five basic steps:

A. Ore handling and preparation
B. Extraction
C. Liquid-solid separation
D. Precipitation and purification
E. Product preparation

A. Ore Handling and Preparation

1. Ore

The primary source of ore for the HMC mill is from its four under-ground mines located in the Ambrosia Lake Bed area. Lesser amounts of ore are received from the United Nuclear Corporation and Cobb Nuclear Corporation. These mines are all within thirty miles of the mill site.

Two basic types of ore are processed by the mill. Sandstone accounts for approximately 80% to 85% of the mill feed with the balcnce being limestone. The principle mineralization of these ores includes coffinite [$U(SiO_4)_{1-x}(OH)_{4x}$], uraninite [$U^{+4}_{1-x}, U^{+6}_{x}) O_{2+x}$, ideally UO_2, tyuyamunite [$Ca(UO_2)_2(VO_4)_2$ 5 - 8 H_2O] , and carnotite [$K_2(UO_2)_2(VO_4)_2$ 3 H_2O]. This mineralization generally occurs as an impregnation,

a pore filling, or as a cement between sand grains. In the ore there is often the presence of carbonaceous materials in association with the uranium mineral, In addition **to** the uranium in the ore, there are trace amounts of molybdenum, selenium, titanium, gold, and silver.

2. Ore Receiving

Trucks hauling 22 to 28 tons of ore deliver their load to the mill from the mines. When a loaded truck arrives at the mill from **the** mines, it is weighed and the ore is sampled for moisture. The moisture determined from the ore in the trucks is used as the basis to calculate the number of dry tons of ore for metallurgical accounting. Each mine's ore is kept separate in lots for control purposes through crushing and sampling. Lots vary from 200 to 2000 tons each.

The ore grade ranges between 0.04% and 0.30% U_3O_8. To minimize fluctuations in the grade of the feed to the mill, the ore lots are selectively crushed.

3. Crushing

An 18 inch grizzly covers a sub-grade hopper on the ore pad. Ore is discharged from this hopper onto an apron feeder. This ore then discharges through an anchor chain curtain onto the crusher iced belt. As the ore discharges from the crusher feed belt onto a rotating wobbler the minus 2 inch fraction is allowed to by-pass the crusher. The crusher discharge and rotating wobbler undersize are combined and sized to plus or minus 3/4 inch by the use of vibrating screens. The 3/4 inch screen oversize is recycled no the crusher and the 3/4 inch undersize is transferred to the sample plant.

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4. Drying

Ores containing more than 8 to 9% moisture generally require drying. When required, a 10 foot diameter by 80 foot co-current fired rotary dryer is used. The burner has a capacity of 70 million BTU per hour. Firing can be either natural gas or light fuel oil.

The feed to the dryer is the rotating wobbler undersized (minus 2 inch) and the crusher discharge. Ore discharges the dryer at about 5% moisture. A conveyor belt returns the ore to the vibrating screens in the crusher plant.

5. Sampling

A representative sample of each ore lot is obtained by using four stages of samplers. The first stage operates on the entire crushing plant output and discharges the sample into a small surge bin. A load sensing device is mounted in the surge bin to control the speed of the belts feeding the remaining samplers. This insures a steady stream of falling ore for each sampler. A roll crusher is in the sample stream between the second and third sampler to reduce the particle size to minus 1/4 inch. The fourth and final stage of sampling cuts a quantity equivalent to one pound of sample for each four tons of ore crushed. After the final sample is cut, the ore is continuously dried and crushed to minus 10 mesh. With further sample preparation, chemical and metallurgical testing data is obtained from this sample for metallurgical accounting.

6. Fine Ore Bins

Four concrete silos comprise the fine ore bins, with each being 35 feet in diameter by 50 feet in height. At full capacity tine ore bins contain approximately 6000 tons of ore. Since each lot of ore must retain its identity until the ore reaches the ore bins, there is very

little blending of the ore prior to milling. A conveyor belt transports the ore from the sample plant to the too of the ore bins. A belt tripper in used to discharge the ore into anyone of the four ore bins or into a truck hopper for return to the ore pad.

The ore bins are used **to** segregate different types of ores in order to process the refractory ores such as limestone ore that require a finer grind and a longer retention tire during leaching to maximize the uranium recovery. The mill utilizes two parallel circuits in grinding, thickening, and leaching. These circuits are referred to as the north and south circuits. A majority of the mill's sandstone ores is processed in the north circuit while the south circuit uses a secondary grind and a longer atmospheric leaching time to process the limestone and other refractory type ores. These ores are directed to the two ore bins that feed the mill's south circuit.

The feed to the grinding circuit is withdrawn from the ore bins by means of two belt feeders under each ore bin. A collecting belt transfers the discharge from the feeder belts to the ball mill belt feed.

7. Grinding

Each primary grinding circuit consists of a ball mill which **is** operated in closed circuit with a spiral classifier.

The grinding circuits utilize]0 feet by 66 inch Hardinge Conical ball mills. The ball charge in each mill is approximately 22 tons. Equal weights of 2 and 2 1/2 inch forged steel balls are used for charge make up. Each ball mill is driven by a 400 hp, 4160 volt, motor geared through a pinon shaft to the ball mill. Operation of the ball mills is maintained at 20 rpm or 83% of critical speed. The ball discharge

density is maintained at 65% solids in a sodium carbonate and sodium bicarbonate mill solution containing 37 grams $Na_2\ CO_3$ per liter and 7 grams $Na\ HCO_3$ per liter.

A 72 inch Wemco spiral classifier is operated in closed circuit with the ball mill. Overflow from the classifier is controlled at 20% solids. The overflow product of the classifier is about 10% plus 48 mesh and 35% minus 200 mesh.

The north circuit spiral classifier overflcx goes directly to the north thickening circuit. As compared to the south circuit containing limestone and other refractory ores the overflow is fed to a 20 inch cyclone which is in closed circuit with a regrind ball mill, this mill is a Denver 6 feet diameter by 6 feet long mill. A 200 hp, 480 volt, motor is connected to a conventional belt drive system that provides the drive to the mill. The mill contains approximately 4 tons of 1 inch forged steel balls.

The regrind cyclone overflow product is about 5% plus 65 inch and 50% minus 200 mesh. This product then goes to the south thickening circuit.

8. Preleach Thickening

The HMC mill has two thickening circuits. Overflow from each grinding circuit is pumped to its respective 20 inch cyclone in the thickening circuit. The cyclone overflow advances **to** the thickener where a polyacrylamide flocculant is used to aid in settling and clarification. Both thickeners overflow by gravity to a common mill solution storage tank for recycle to the grinding circuit. The thickened slurry from the thickener is removed at about 40% solids. The thickener

underflow and the cyclone underflow are recombined in their respective preheat tank **of the** leaching circuit.

B. Extraction

1. Theory

The chemistry of the alkaline leaching system requires the oxidation of tetravalent uranium to the hexavalent state, Oxygen available in the air is the most common oxidant used. The hexavalent uranium dissolves in the presence of carbonate alkalinity to form a uranyl tricarbonate complex ion according to the following reactions.

$$2\ UO_2 + O_2 \bullet 2UO_3$$

$$2\ UO_3 + 6\ Na_2\ CO_3 + 2\ H_2O \bullet 2\ Na_4\ UO_2\ (CO_3)_3 + 4NaOH$$

The uranium will not dissolve in a sodium carbonate solution because the hydroxide alkalinity formed with the complex ion causes the ion to decompose. In a solution containing sodium bicarbonate, the hydroxide alkalinity is neutralized immediately, and the reaction proceeds as follows:

$$UO_3 + Na_2\ CO_3 + 2\ Na\ HCO_3 \bullet Na_4\ UO_2\ (CO_3)_3 + H_2O$$

2. Leaching

The extraction of the uranium from the ore is accomplished in a two stage circuit. The first stage consists of a pressure leach where the pressure is maintained at 60 PSIG and the temperature is maintained a 200°F. Retention time of the slurry **in** the pressure leach is 4.5 hours. The second stage consists of an air agitated atmospheric leach at a temperature of 170°F. The atmospheric leach slurry has a retention tire of 12 hours for the slurry coming from the north leach circuit and of 24

hours for the slurry coming from the south leach circuit.

a. Pressure Leach

Pressure leaching is accomplished **in** two separate circuits each containing eight autoclaves. The autoclaves are 12 feet diameter by 16 feet high, domed, pressure tanks equipped with a top mounted 'Lightnin' mixer. Each tank has two, turbine type, 42 inch diameter impellers mounted on a 14 foot, 4 inch diameter shaft. Oxidation air is fed into the bottom of the autoclaves through a 30 inch bubble-cap diffuser. Pressure in an autoclave circuit is maintained by an automatic bleed–off valve on the Pipe header connected to each autoclave, Heat for leaching is supplied by steam coils. Temperature and pressure in the autoclave circuit is maintained by automatic controls.

Each of the two circuits is operated as a series of eight autoclaves. The ore has a retention time about 4.5 hours in the circuit. The first unit in each leaching circuit is a preheat tank in which the thickener underflow and the cyclone underflow are recombined and heated to 150°F. This preheated slurry at about 55% solids is pumped to the first autoclave leaching tank of its circuit. The flow through the autoclaves is by gravity, and the feed to each autoclave enters the slurry surface and discharges from the bottom through an internal riser. A six inch drop between autoclaves provides the head for flow through the piping in the circuit. The operating volume of each autoclave is approximately 11,000 gallons. The discharge from the last autoclave in each circuit flows into a letdown tank. From the letdown tank, the leached slurry discharges through a concentric tube heat exchanger that cools the slurry from 200°F to 170°F. The pressure of the system provides

the energy to push the partially leached slurry through the heat exchanger to the atmospheric leach.

b. Atmospheric Leach

Atmospheric leaching also consists of **o** separate circuits. The north circuit pressure leach discharges **to** the first of three pachuca tanks with a retention time of 12 hours. The south circuit pressure leach discharge, is split where half the flow goes to the first of another three pachuca tanks and the other half of the flow goes to the first of another three pachuca tanks. Retention time for the south circuit is 24 hours. Each pachuca tank is 19 feet in diameter by 38 feet tall. Four, ten inch air lifts provide agitation for each pachuca. Heat for the circuit is provided through steam jackets on the air lift pipes. Additional air for oxidation and agitation is supplied through five pipes that are suspended from the top of each tank. The air enters the slurry approximately 3 feet from the bottom of the tank.

The slurry from the pressure leach circuit is added to the top of the first pachuca tank of its circuit and f1cxs by gravity through the tanks and discharges into a sump where the slurry is pumped to the liquid—solid separation circuit.

C. Liquid-Solid Separation

1. Filtration

The leached slurries from both atmospheric leach circuits are pumped to the fitter feed tank in the liquid—solid separation circuit. This leached slurry is pumped to each of the first stage of filters, where the soluble uranium values are removed by three codified stages of counter current filtrations. A dilute solution of flocculant is pumped into the tuber feed line where the filter feed and flocculant are mixed. A

thorough mixing takes place as the filter feed slurry and flocculant flow through the pipes, the filter feed valves, and a small mixing chamber on each filter tub.

Each filter stage contains five, 650 square foot and two, 570 square foot rotary drum vacuum filters. The filters are 11 ½ feet in diameter and are equipped with polypropylene grids. A heavy duty nylon filter cloth is used to cover the filters. A 14 gauge stainless **steel** wire is wound on the filters to retain the filter cloth.

The first stage filter cake is washed with a hot filtrate solution from the third stage of filters. The filtrate is sent to clarification, and the first stage filter cake discharges into repulpers for repulping with third stage filtrate. The repulped slurry flows by gravity through an agitated sump and into the second stage of filters. Flocculant is added to the repulper solution to aid in the second stage of filtration. The second and third stage of filters are operated in much the sane manner as the first stage; except that recarbonated barren solution from the precipitation circuit is used as a filter wash and in the repulpers on the second stage, and tailings pond solution or water is used as a wash and in the repulpers on the third stage. The wash solution for each stage of filters is maintained at 100°F, The second stage filtrate is sent to the mill solution circuit, and the third stage filtration is used as a wash and repulper solution on the first stage of filters. The filter cake from the third stage of filters is repulped with recycled tailings pond solution and slurried for tailings disposal.

2. Clarification

The filtrate produced by the first stage of filters is the pregnant

uranium solution for the precipitation circuit. The solution must be clarified before precipitation to remove slimes that have penetrated the filter cloths. Clarification occurs **in** a thickener where a major portion of the silica and shire contaminants settle out. The pregnant solution for precipitation is then pumped from the thickener through heat exchangers to heat the solution from 125°F to 180°F before flowing into the precipitation circuit. The heat is obtained by cooling the pressure leach discharge slurry from 200°F to 170°F.

3. Tailings Disposal

The filter cake from the third stage filters is repulped with recycle solution from the tailings pond ion exchange system and transferred through launders to a tailings slurry tank. Disposal of the tailings slurry is handled by three Ash pumps in series and a cyclone truck. The pumping capacity of these pumps is rated at 1500 gallons per minute.

Tailings disposal encompasses an area of 110 acres. Construction of the pond is done by pumping the tailings slurry at about 40% solids through two, truck mounted, 20 inch cyclones. Underflow from the cyclone is deposited on the dike that surrounds the pond and the cyclone overflow is directed into the pond where the slimes settle out of the tailings solution. Recovery of the tailings solution is through two centrally located decant towers. The reclaimed tailings pond solution flows underground to a pump basin and is returned to the mill where it is processed in an ion exchange circuit for uranium removal.

4. Tailings Pond Ion Exchange

Prior to the reclaimed tailings pond solution being returned to

the third stage filters, the solution is treated **in** a NIMCIX system to remove the soluble uranium.

The NIMCIX plant is rated to treat 1200 gallons per minute of solution yielding a tail of less than 10 ppm U_3O_8.

D. Precipitation and Purification

1. Precipitation

The pregnant solution from clarification after being heated to 180°F is pumped to the precipitation circuit. The precipitation is conducted in two stages. First the pregnant solution is mixed in the dissolving tank with recycled yellow cake to increase the soluble uranium content. Second, caustic soda is added to precipitate the uranium. The uranium in the pregnant solution exists as a uranyl tricarbonate complex. When the pH is raised above 12.0 with caustic soda, the complex ion decomposes to form carbonate and sodium diuranate. The latter salt is a yellow precipitate commonly called yellow cake.

$$2\ Na_4\ UO_2\ (CO_3) + 6\ Na\ OH \bullet Na_2\ U2O_7 + 6\ Na_2\ CO_3 + 3H_2O$$

The technique of recycling yellow cake was developed to achieve a more complete precipitation of the uranium in the original pregnant solution. The dissolving tank operates with a yellow cake recycle equivalent to 500% to 700% of the uranium in the incoming pregnant solution. In five hours of contact with the pregnant solution, a portion of the yellow cake dissolves; and the soluble grade of uranium in the solution increases. The precipitation efficiency of the circuit will vary with the level of soluble uranium in the feed. The undissolved yellow cake in circulation does not appreciably effect the precipitation.

The precipitation circuit consists of nine agitated tanks in a

series. The solution has a retention tine of about 12 hours. A solution of 50% caustic soda is metered into the first tank of the precipitation circuit of sufficient quantity to neutralize the sodium bicarbonate and also to maintain an excess of 5 grams per liter caustic soda in the barren solution. The caustic soda may also be added to the pipeline feeding the tank to change the characteristics of the precipitated yella cake and the efficiency of precipitation, which are affected by the point of addition.

The yellow cake slurry from the precipitation circuit flows into a 40 foot diameter by 12 foot deep thickener. The thickener is insulated with a floating two inch Styrofoam lid and two inches of Fiberglass insulation on the sides. Because the thickener operates at 170° to 180° F, the cover insulation is necessary to minimize evaporation and heat loss which create thermal currents that hinder settling. The thickener underflow is pumped at about 35 - 40% solids to the vanadium removal section or to the yellow cake dissolving tank for recycle. The thickener overflow is pumped through three plate and frame filter presses for final clarification and then to caustic barren storage.

2. Recarbonation

The caustic barren solution produced in the precipitation circuit contains sodium carbonate and a small quantity of sodium hydroxide. To reuse the barren solution, the caustic must he converted to sodium carbonate and sodium bicarbonate. This conversion is accomplished in two packed towers in which the caustic barren solution is contacted with boiler flue gas. The CO_2 in the flue gas neutralizes the sodium hydroxide and converts some of the carbonate to bicarbonate, the recarbonated

barren solution is pumped to the liquid-solid separation circuit for use as a wash and repulping solution on the second stage of filters.

3. Purification

The primary precipitation of yellow cake produces a product which, when washed and dried, will assay around 75 to 77% U_3O_8, 5 to 6% V_2O_5, 2 to 2.5% CO_3 and 7.5% Na. Although the uranium content is satisfactory, the vanadium, carbonate, and sodium content of the precipitate exceeds contract specifications. Removal of these contaminants is required before the yellow cake is acceptable to the upgrading process plants.

a. Vanadium Removal

The removal of the vanadium and, quite incidentally, carbonate from the yellow cake is accomplished by roasting followed by water leaching. The yellow cake thickener underflow is pumped to a disc filter to dewater the slurry. The filter cake is agitated with a small quantity of sodium carbonate before being fed to the yellow cake roaster.

Yellow cake roasting is accomplished in an 8 foot 6 inch diameter, six hearth, Pacific furnace. The yellow cake is dried at around 1600°F. The calcined yellow cake discharges into a water cooled screw conveyor which cools the yellow cake to approximately 200°F before discharging into a ball mill conveyor. Water is used to dissolve the vanadium and carbonate contaminants in the yellow cake. The leached yellow cake slurry is collected in a 16 foot diameter by 10 foot deep thickener. The thickener overflow, containing the vanadium, is filtered and sent to vanadium storage. The vanadium solution is concentrated and cold to a carry vanadium producer.

b. Sodium Removal

Vanadium solution contained in the yellow cake slurry in the sixteen foot yellow cake thickener underflow is removed on a four and one-half foot diameter by six foot long, vacuum, drum filter. Then the yellow cake is washed and repulped with water. This yellow cake containing approximately 7.5% sodium as sodium diuranate is dissolved with sulfuric acid at a pH of around 2.2. Next, ammonia is added to maintain a pH of around 7.4. The uranium reprecipitates as yellow cake, ammonium diruanate and basic sulfate, generally containing less than 0.5% sodium. This product is filtered and washed with ammonium sulfate solution on two six foot diameter by eight-foot long, vacuum, drum filters in series before being dried in a four hearth Pacific roaster and packaged as described under the section on Product Preparation.

E. Product Preparation

The filter cake from the second yellow cake filter discharges into an agitated sump, from where it is pumped to the yellow cake dryer. Yellow cake drying is accomplished by an 8 foot 6 inch diameter, four hearth, Pacific furnace, which is fired to about 1000°F. By the time the yellow cake reaches the bottom of the yellow cake dryer, the moisture and ammonia have been removed. The yellow cake is discharged from the drier through a pulverizer into a hopper, where it is held until packaging.

Yellow cake is packaged in 55 gallon open head drums. A vibrator under toe drum loading station is used to settle the contents or each drum. After the drums are sealed, sampled, and weighed, the drum is cleaned and placed in storage until it is shipped.

Each drum contains a maximum of 1000 pounds of yellow cake and about 45 drums comprise a shipping lot.

F. Acknowledgments

The authors of this report wish to express their thanks to the HMC management for their support and assistance in presenting this paper.

Figure 1

ORE HANDLING AND PREPARATION (A)

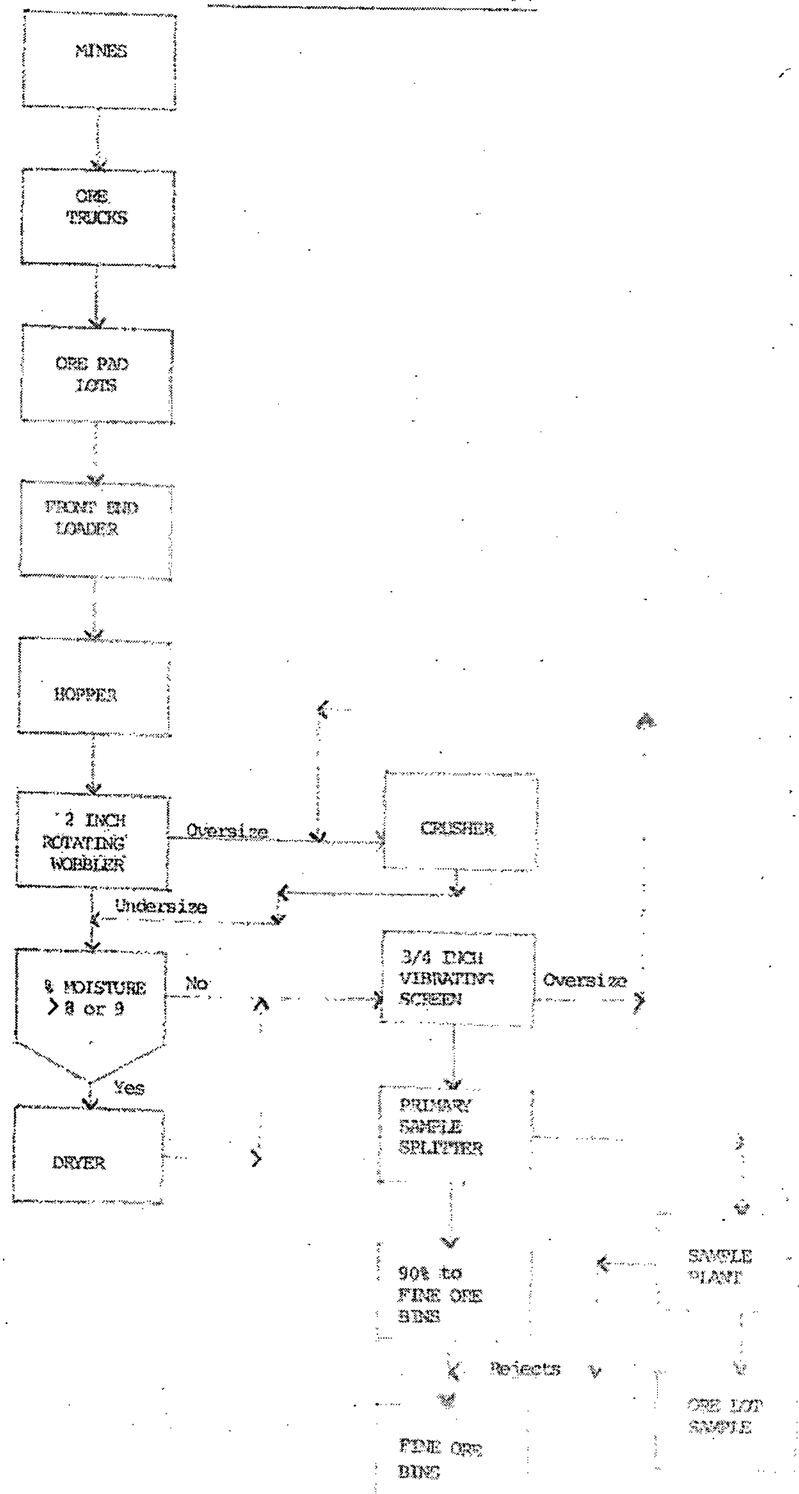


Figure 2
ORE HANDLING AND PREPARATION (B)

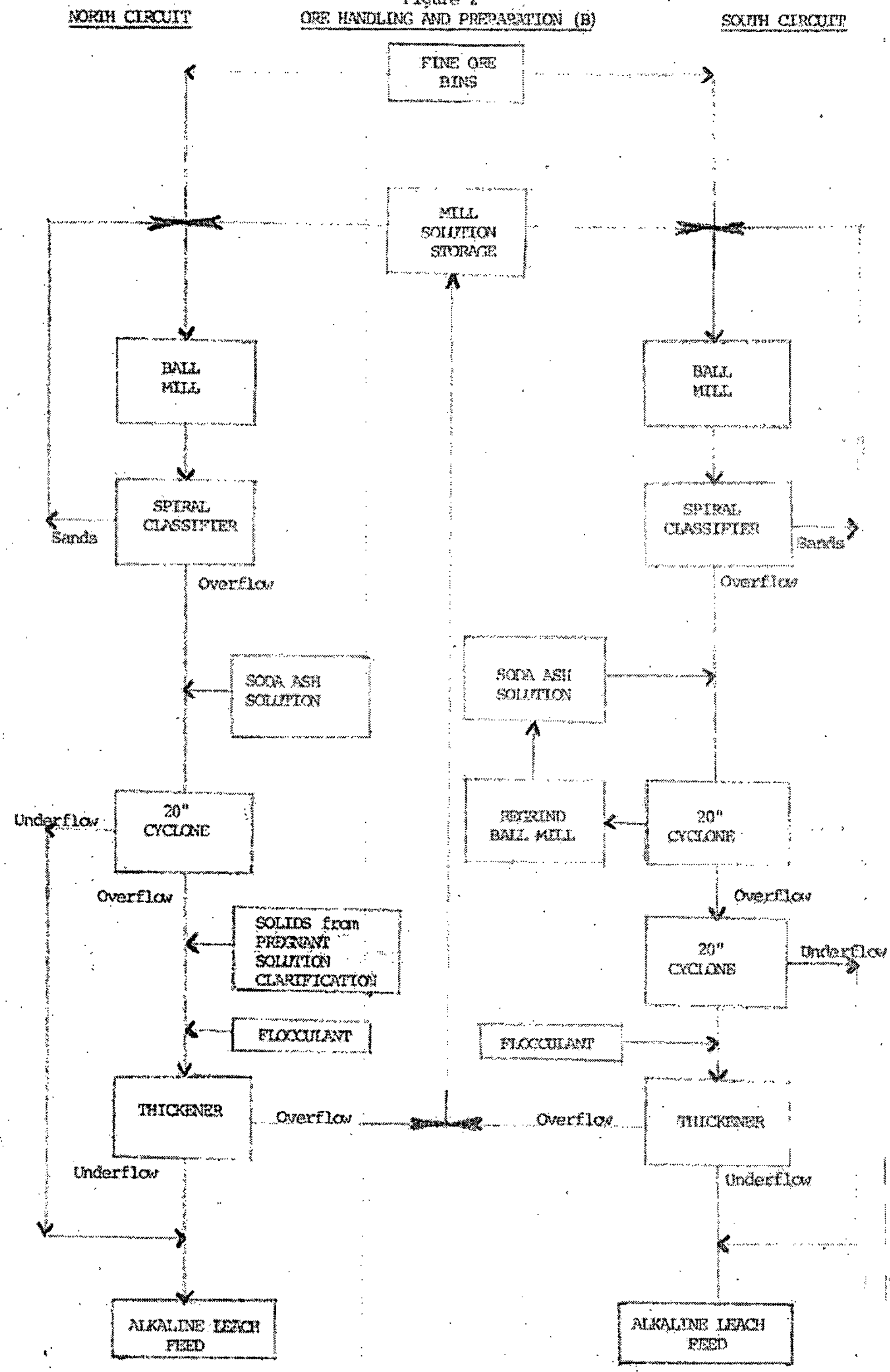


Figure 3

EXTRACTION

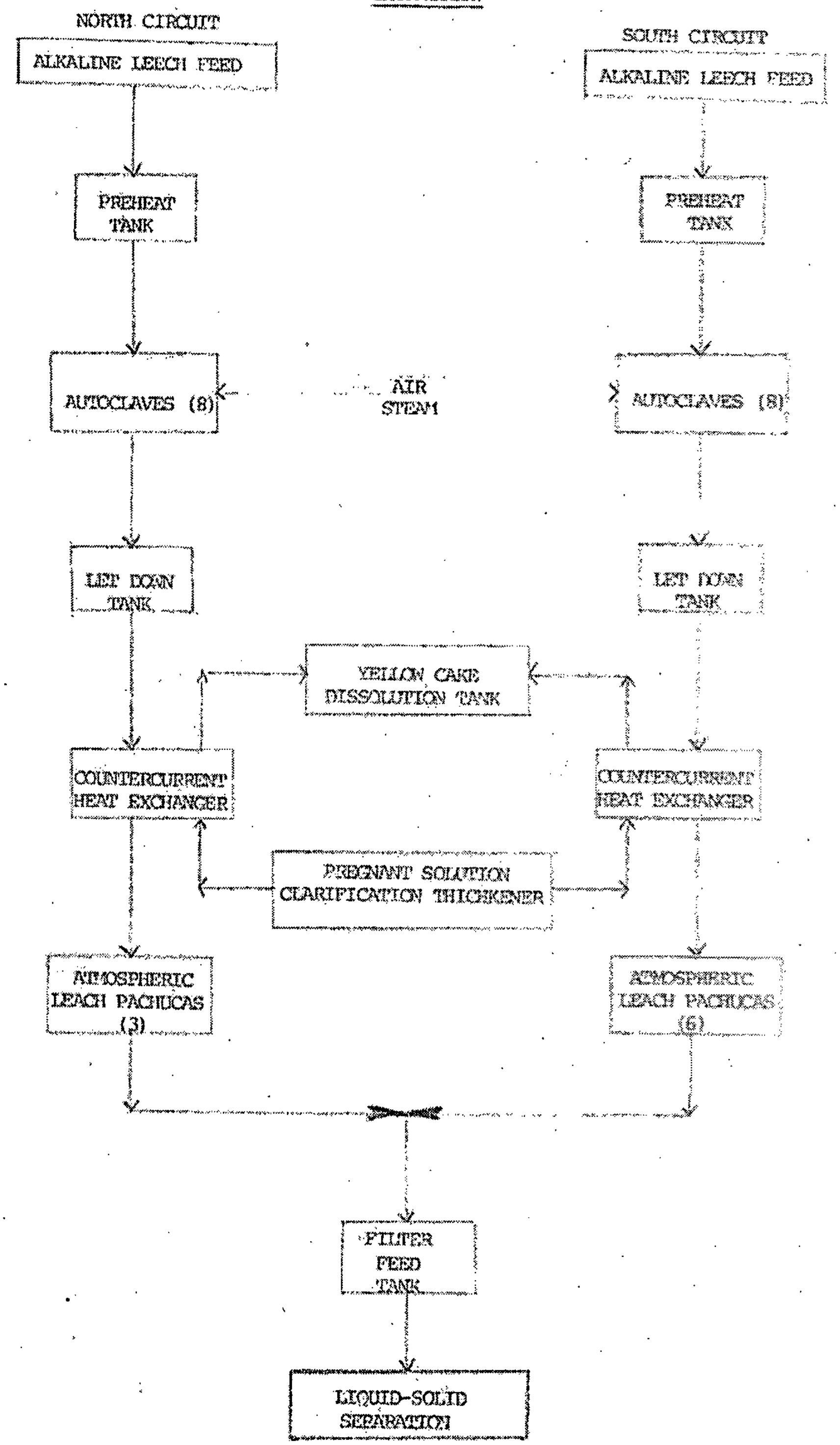


Figure 4

LIQUID-SOLID SEPARATION

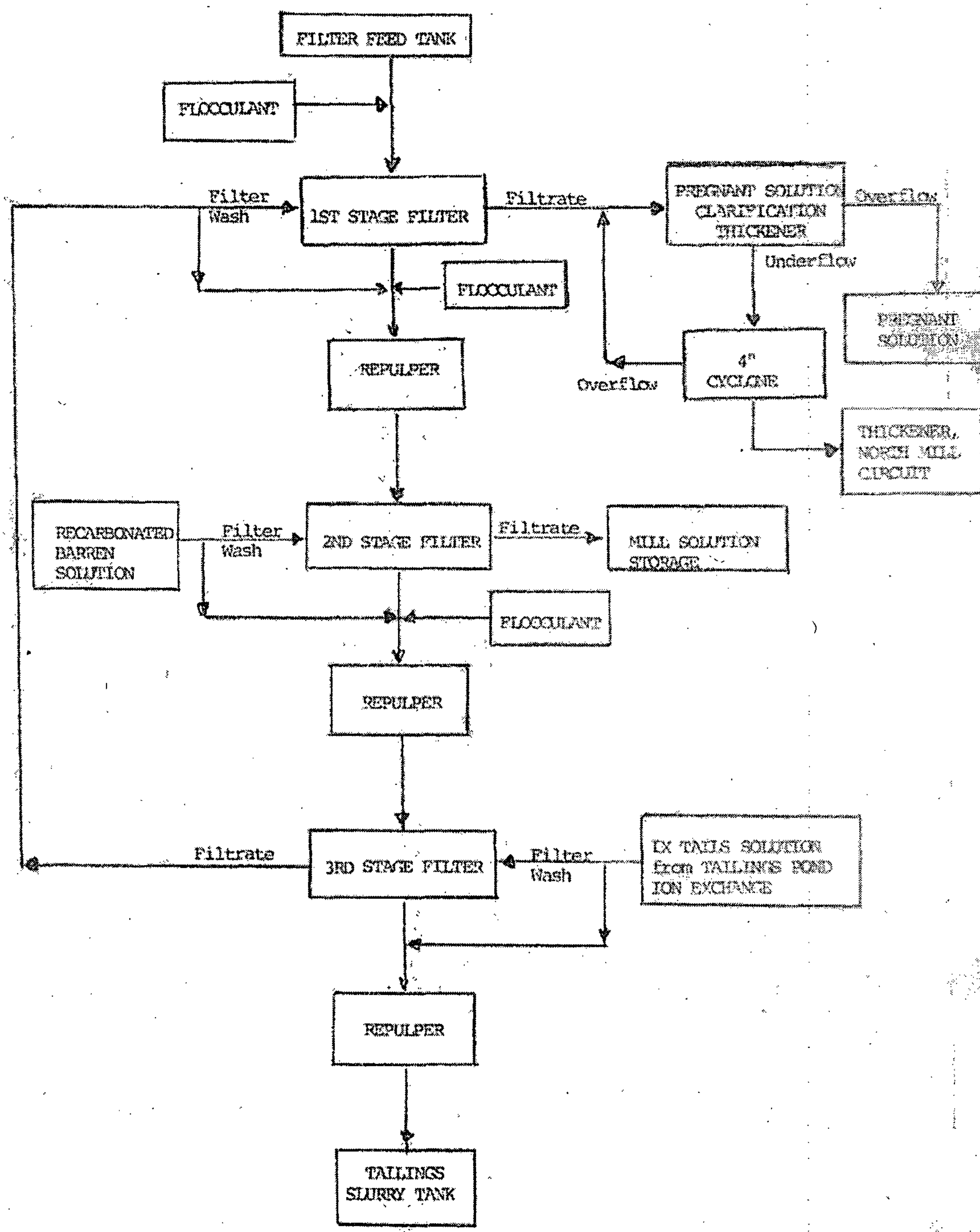


Figure 5

TAILINGS DISPOSAL

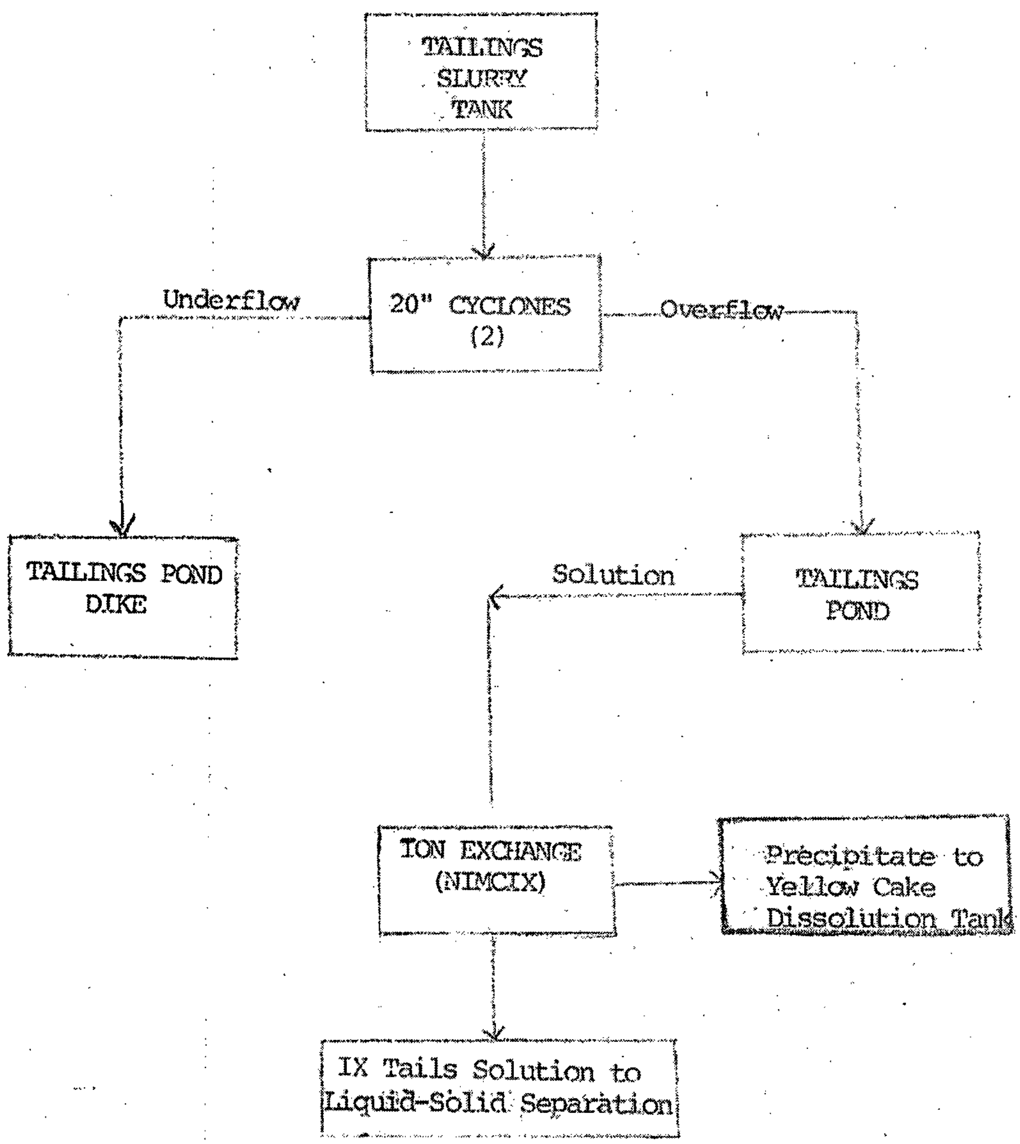


Figure 6 a

PRECIPITATION, PURIFICATION, AND PRODUCT PREPARATION

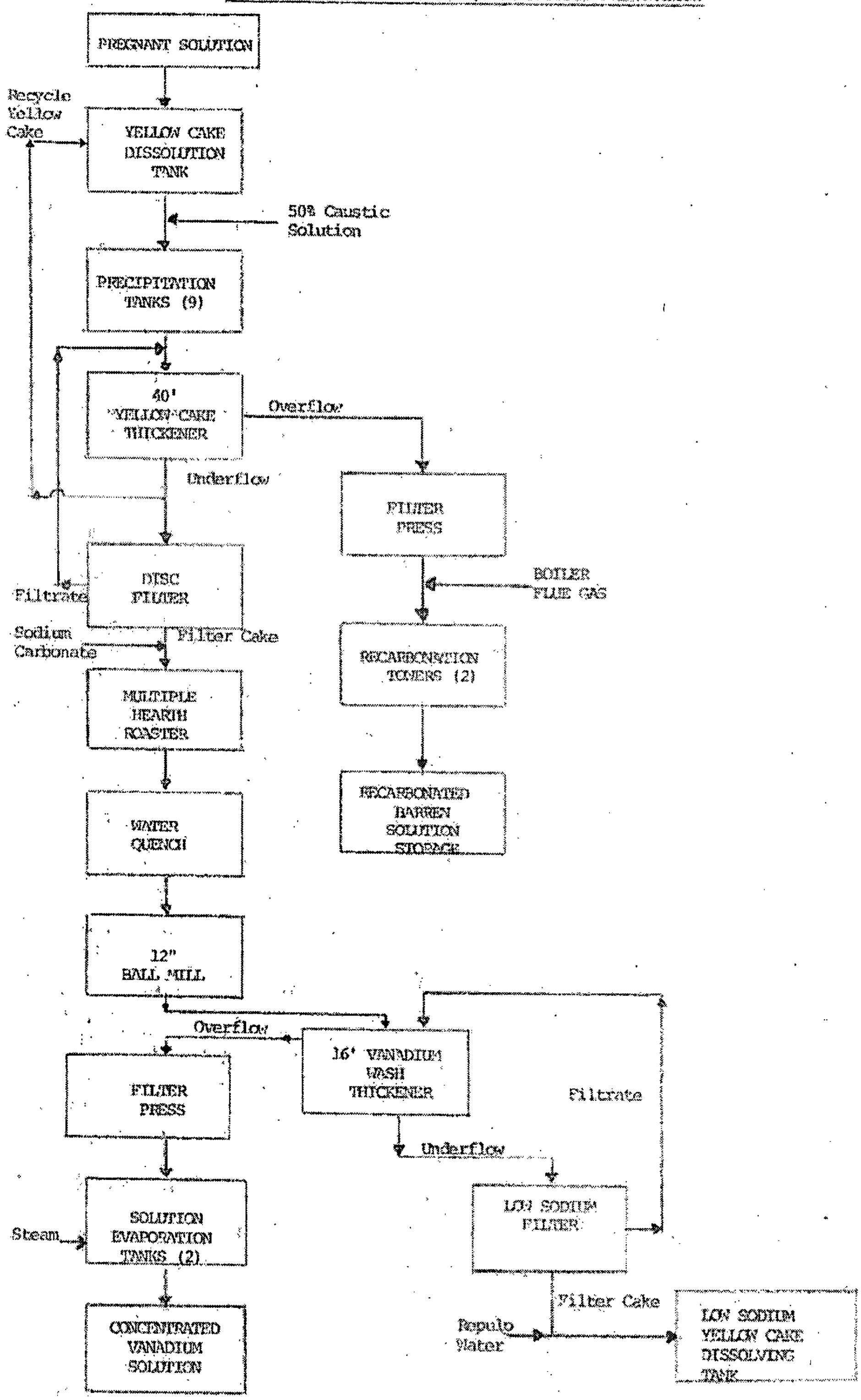
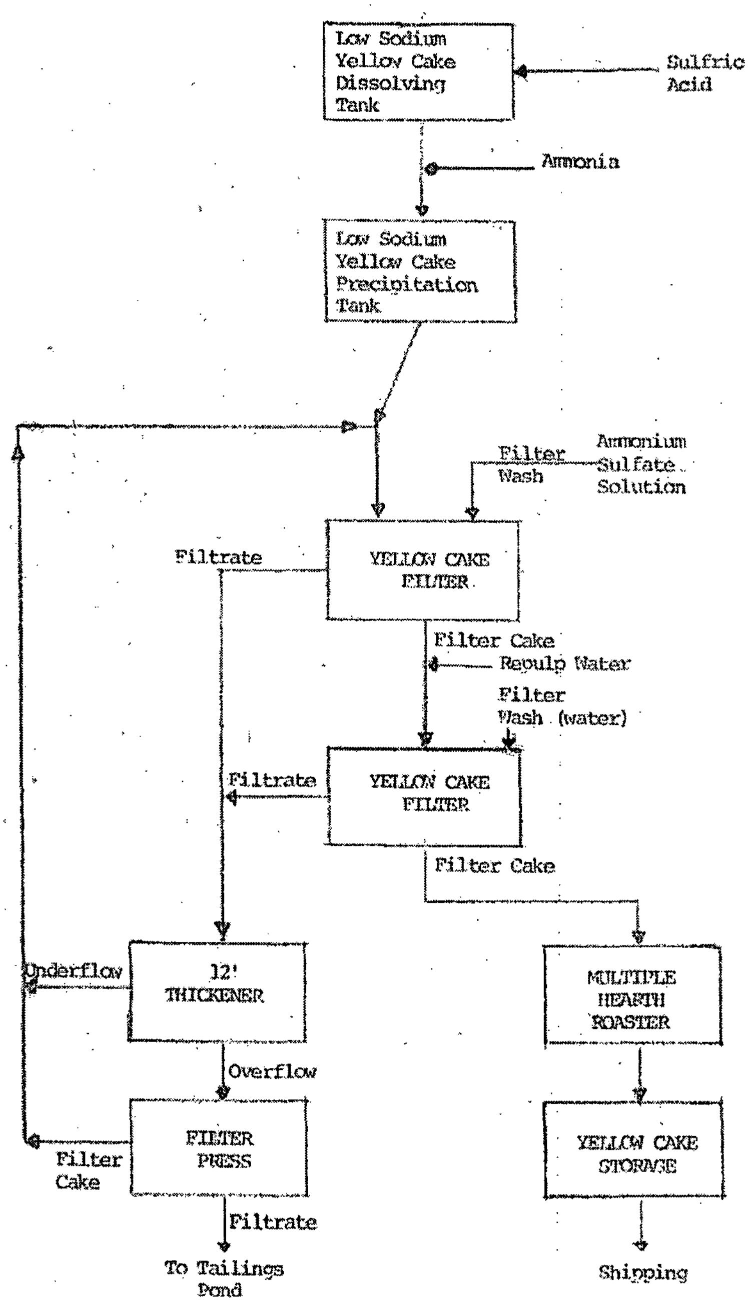


Figure 6 b

PRECIPITATION, PURIFICATION, AND PRODUCT PREPARATION



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APPENDIX C – HYDROGEOLOGIC UNITS

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INTRODUCTION

This appendix is intended to present relevant data about the hydrogeologic units at the site that are impacted by seepage from the LTP or are involved with the operation of the CAP. **Table C-1** describes the hydraulic and transport properties of the local aquifers. **Table C-2** describes the characteristics of the hydrogeologic units in the region.

Table C-1: Hydraulic and Transport Properties of Local Aquifers

Aquifer		**Alluvial Aquifer**			**Chinle Formation Aquifer**				**San Andres-Glorietta Regional Aquifer**
Depth		Uppermost			Upper, Middle & Lower	Upper Chinle Aquifer	Middle Chinle Aquifer	Lower Chinle Aquifer	--
Aquifer Type		Unconfined	Unconfined	Unconfined	Each one of these three aquifers bounded by an overlying and underlying low				Confined
Composition		Quaternary Alluvium and Quaternary andesite and basalt flows interbedded into the alluvium, located on the unconformably eroded surface of the Chinle Formation			Very low permeability, massive shale	Laterally continuous sandstone, average thickness of sandstone is 35 feet	Laterally continuous sandstone	Shale with enough developed permeability to behave as a limited aquifer	Two regional aquifers in the San Andres Limestone and Glorietta Sandstone, considered a single aquifer in the Grants area
Thickness (ft)	**Aquifer Average**	95 (saturated and unsaturated zones)	--	--	850	15 – 65 (saturated thickness)	10 – 80 (saturated thickness)	--	--
	Near Site	35 (saturated thickness)	--	--	--	35 (saturated thickness)	44 (saturated thickness)	--	--
Hydraulic Conductivity (ft/day)	**Aquifer Average**	10 - 200	--	--	--	0.1 – 100	--	0.1 - > 50	615
	Near Site	--	--	--	--	--	25	--	--
Hydraulic Gradient (ft/ft)		0.0025	--	--	--	--	--	0.01 ft/day	0.00086
Effective Porosity		--	--	--	--	--	--	--	0.1
Transmissivity (gpd/ft)		500 - 40,000	--	--	--	100 to 2,000	500 to 7,000	100 to 1,000	222,000 to 460,000
Dispersivity (ft)		2 to 26			--	--	--	--	--

Aquifer		**Alluvial Aquifer**			**Chinle Formation Aquifer**				**San Andres-Glorietta Regional Aquifer**
Retardation Factor		Uranium = 3 Molybdenum = 4.5 to 5 Selenium = 1 to 1.2			--	--	--	--	--
Specific Yield	**Aquifer Average**	0.038 – 0.28	--	--	--	--	--	0.1	--
	At Site	0.2	--	--	--	0.1	--	0.1	--
Storage Coefficient		--	--	--	--	5×10^{-5}	3×10^{-5}	3.4×10^{-5} - 1.2×10^{-4}	4.2×10^{-4} - 1.4×10^{-3}

<u>**Notes:**</u>

ft = feet

ft/day = feet per day

ft/ft = foot per foot

gpd/ft = gallons per day per foot

Table C-2: Description of Hydrogeologic Units

Aquifer	Alluvial Aquifer			Chinle Formation Aquifer				San Andres-Glorietta Region Aquifer
	San Mateo	Rio San Jose	Lobo	Upper, Middle & Lower	Upper Chinle Aquifer	Middle Chinle Aquifer	Lower Chinle Aquifer	
Groundwater Flow Direction	Near the site predominantly southwest, but highly variable	Southeast	--	--	--	--	--	--
Recharge	From direct infiltration is very limited	--	--	--	From alluvial aquifer along subcrop on east side of the East Fault	--	--	--
Dipping	--	--	--	--	Northeast	Northeast	East, at locations north of the residential subdivisions and south of the residential subdivisions	East and northeast
Notes	--	--	--	Serves as an aquitard between the surficial alluvial aquifer and the underlying San Andres-Glorietta regional aquifer	--	--	Permeability of aquifer not consistently high enough to serve as a viable aquifer	--

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Appendix D – Surface Water and Groundwater Interactions

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INTRODUCTION

This appendix is intended to present relevant data about the surface water and groundwater interactions in the proximity of the site. **Table D-1** describes the recharge and evaporation rates applied to the site. **Figure D-1** presents the mean daily streamflow for the San Mateo Creek from 1977-1982. **Figure D-2** presents the mean monthly streamflow for the San Mateo Creek from 1977 to 1982. **Figure D-3** presents the mean daily streamflow for the Arroyo del Puerto from 1979-1982. **Figure D-4** presents the historic peak streamflow for the Rio San Jose from 1968 to 2010.

1.0 SURFACE WATER BODIES

The natural land surface gradients of the site are usually less than 1 percent; the average grade is 0.1 percent. Surface drainage across the site is predominantly directed to the southwest, although there are generally no established drainage courses or signs of active erosion. Ponding occurs after significant precipitation events, but this water either evaporates or infiltrates the alluvium.

The site lies partially within the broad floodplain of the San Mateo Creek, which is part of the Rio Grande drainage basin. There are 291 square miles of upstream watershed. The San Mateo Creek drains into the Rio San Jose near Milan. The Arroyo Del Puerto is an ephemeral tributary stream to the San Mateo Creek drainage, which is also ephemeral at their confluence; this confluence is located approximately 10 miles north of the site. A drainage map of the site is provided as **Figure 3.2.1-1**.

The San Mateo Creek watershed drainage covers approximately 76 square miles and is part of the Rio Grande drainage basin (Byrd et al. 2003). The headwaters of the creek are on the north flank of Mt. Taylor, where it receives runoff from precipitation. Springs maintain a small perennial flow above San Mateo Reservoir, which is an on-stream reservoir on upper San Mateo Creek used for irrigation purposes (Roca Honda Resources 2009). However, San Mateo Creek is intermittent over its middle reach, which is normally dry in the summer with the exception of high rainfall events, and ephemeral in its lower reach. Some of the flow is diverted for irrigation just below the San Mateo Reservoir during summer months. The remainder infiltrates into the alluvium of the stream bed within a few miles. During peak runoff from snow melt in the late spring or during heavy summer and fall rain storms, San Mateo Creek may flow west for a few miles, but it rarely reaches the Rio San Jose (Brod and Stone 1981, Stone et al. 1983). Proposed discharge related to future mine operations at the Roca Honda mine near the headwaters of the San Mateo Creek may create surface flow that could reach the Rio San Jose, which would change the ephemeral nature of the flow regime (Roca Honda Resources 2009).

An investigation of the streamflow in San Mateo Creek was conducted in the early 1970s by the New Mexico Environmental Institute (NMEI) as part of the environmental baseline study of the Mt. Taylor area associated with the permitting of the proposed Gulf Mineral Resources Company (GMRC) Mt. Taylor uranium mine (NMEI 1974). NMEI concluded that the mean annual runoff from San Mateo Canyon was 1,800 acre-feet per year (acre-ft/yr), and that of this volume, about 0.5 cfs (approximately 360 acre-ft/yr) was contributed by spring and groundwater discharge, all of which entered San Mateo Creek in its upper watershed above San Mateo Reservoir. The NMEI concluded that the perennial section of San Mateo Creek was limited to the reach above the reservoir (NMEI 1974). Additionally, NMEI

distinguished between upper elevations (higher than 7,950 feet above mean sea level) that generally contain snowpack for most of the winter and contributed snowmelt to the stream in late April and early May, as compared to lower elevations (below 7,950 ft-amsl) that receive runoff in mid to late March.

Table D-1: Recharge and Evaporation Rates

Water Body	Recharge Rate	Evaporation Rate
San Mateo Creek	0.5 in/yr	54.6 in/yr
Arroyo Del Puerto	0.5 in/yr	54.6 in/yr
Rio San Jose	0.5 in/yr	54.6 in/yr

Source: Hydro-Engineering 2011

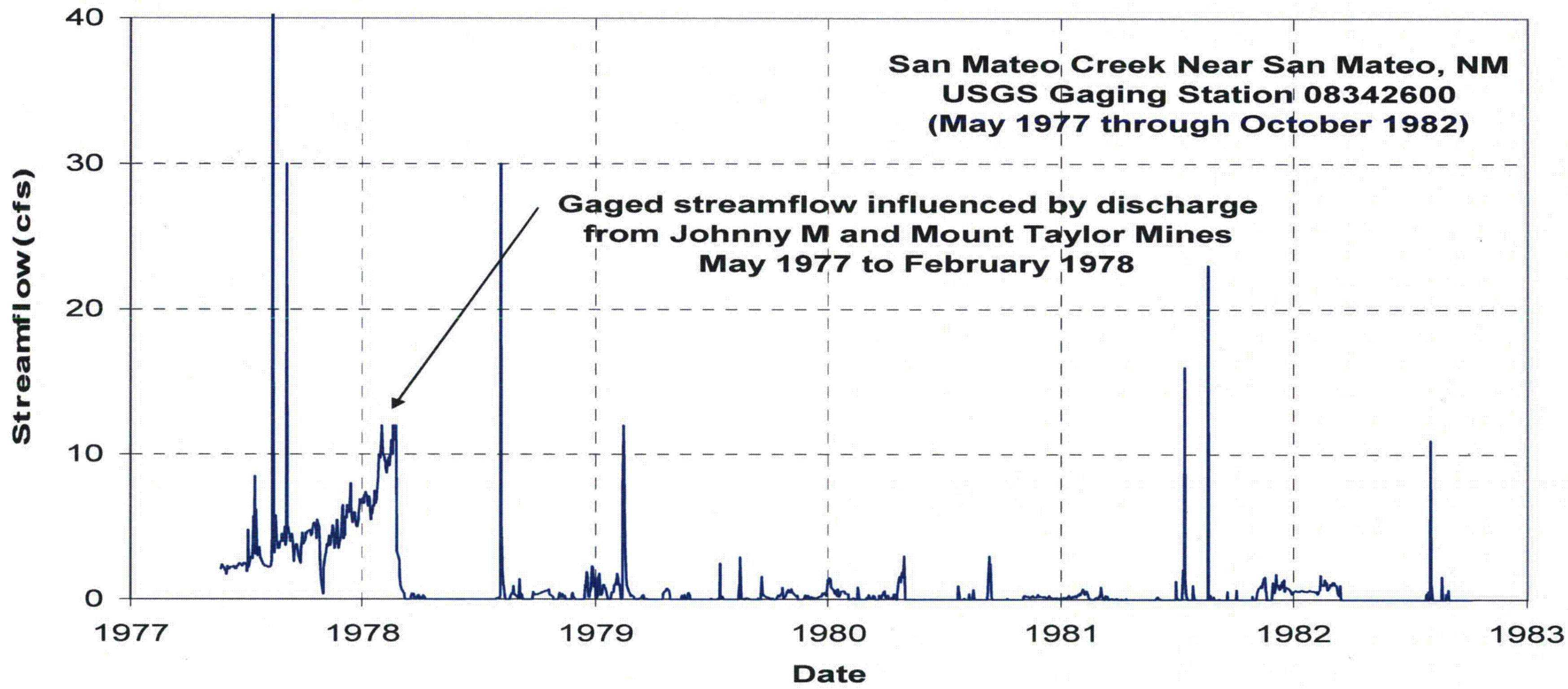
2.0 SITE STORMWATER CONTROL

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 San Mateo Creek. 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 (Hydro-Engineering 1993). The former determines the parameters of the flood, the Probably Maximum Flood (PMF) that would originate upstream and pass across portions of the site, while the later determines the maximum rainfall (PMP) directly onsite and the resulting PMF runoff originating on the site itself (**Figure 3.2.1-1**). Hydrologic analyses conducted for the general storm or regional PMP/PMF event show that the peak PMF discharge would be 169,800 cubic feet per second (cfs) resulting from a PMP of 12.2 inches over a storm duration of 24 hours (HMC 1988). Consequently, the erosion protection designs took into account two different and separate PMP/PMF events. The other PMP/PMF event that affects potential erosion is the local one-hour PMP/PMF, the rainfall and resulting runoff from the site. The local one-hour PMP would result in rainfall totaling 9.94 inches (Hydro-Engineering 1993). The details of the resulting velocities and discharges of runoff determined for the regional, local and one-hour PMP/PMF event are reported in the 1993 Reclamation Plan Volume 1 (Hydro-Engineering 1993).

To keep the potential erosion due to onsite precipitation to a minimum, several design measures were used in the reclamation plan. To reduce the potential for erosion of the tailing impoundments, the top surfaces were contoured to minimize slope gradients and flowpath lengths to the extent possible without compromising other design objectives. Hydrological analyses of the regional or general storm of the San Mateo watershed indicated that the toe portions of the north and west side slopes of the large impoundment required protection against potential erosion caused by the regional PMF (approximately 8 feet thick layer of sand and rock covering) (HMC 1988; Hydro-Engineering 1993)]. For the rest of the site, cover placement and recontouring in the mill area were designed to keep surface gradients sufficiently flat, so that PMP runoff will produce shear stresses less than allowable shear stresses for the cover materials used, i.e. gravelly sand (Hydro-Engineering 1993).

In addition, 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 during flood events, some of this discharge would flow across a portion of the mill area and between the tailing impoundments. A flood diversion levee was constructed to divert not only San Mateo flood flows and Lobo Canyon floods to the north and west of the mill and the reclaimed tailing

embankments, but also a large portion of what would otherwise be the upstream end of the onsite watershed (Hydro-Engineering 1993).



Source: Roca Honda Resources, 2009

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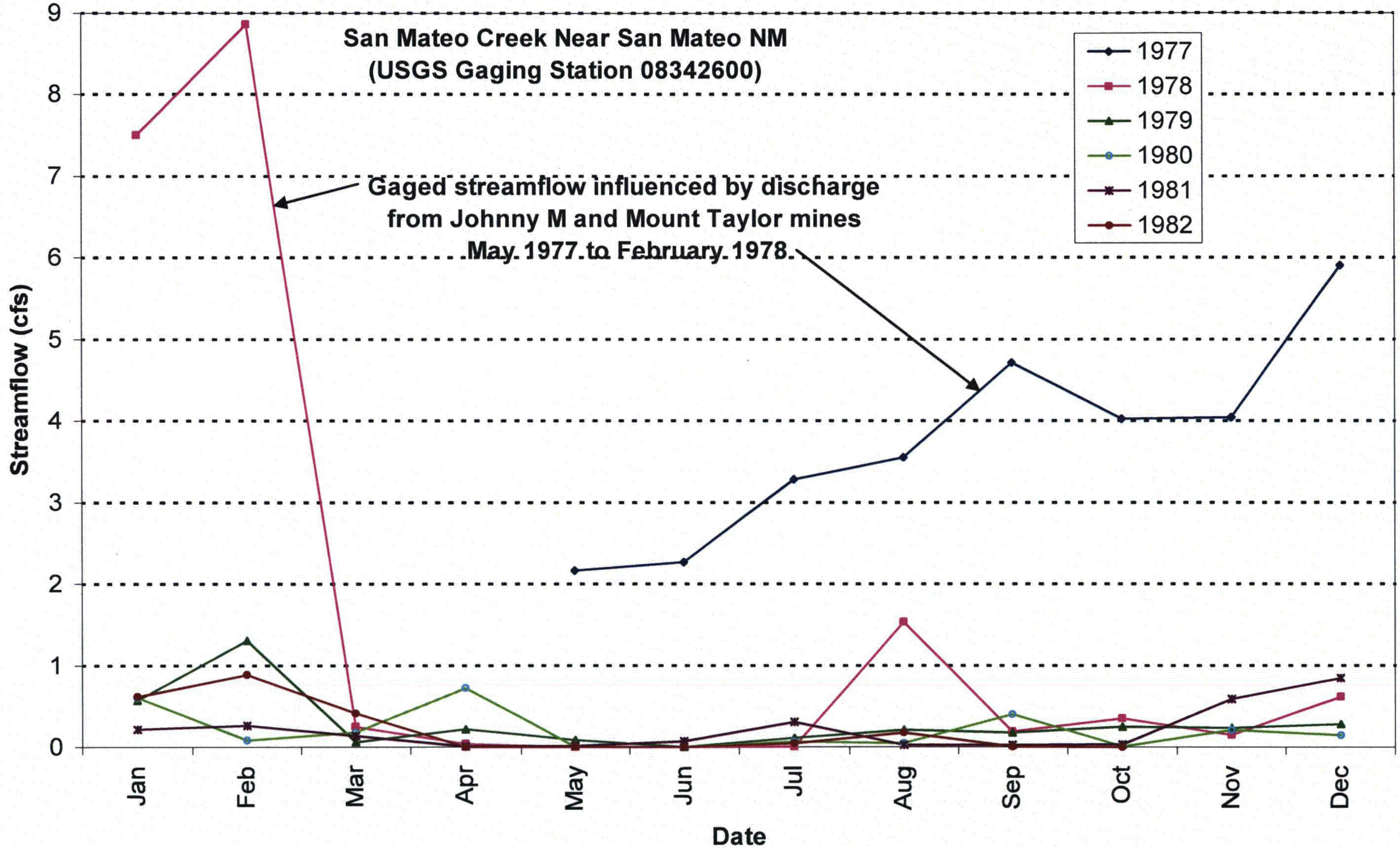
FIGURE D-1
MEAN DAILY STREAMFLOW FOR THE SAN MATEO CREEK, 1977-1982

K:\AO000120-Grants\Illustrators\Figure D-1 Mean Daily Streamflow for the San Mateo Creek 1977-1982.ai @ 11/07/2011 PREPARED BY: JC



K:\AO000120-Grants\Illustrators\Figure D-2 Mean Monthly Streamflow for the San Mateo Creek 1977-1982.ai @ 11/07/2011 PREPARED BY: JC

Source: Roca Honda Resources, 2009

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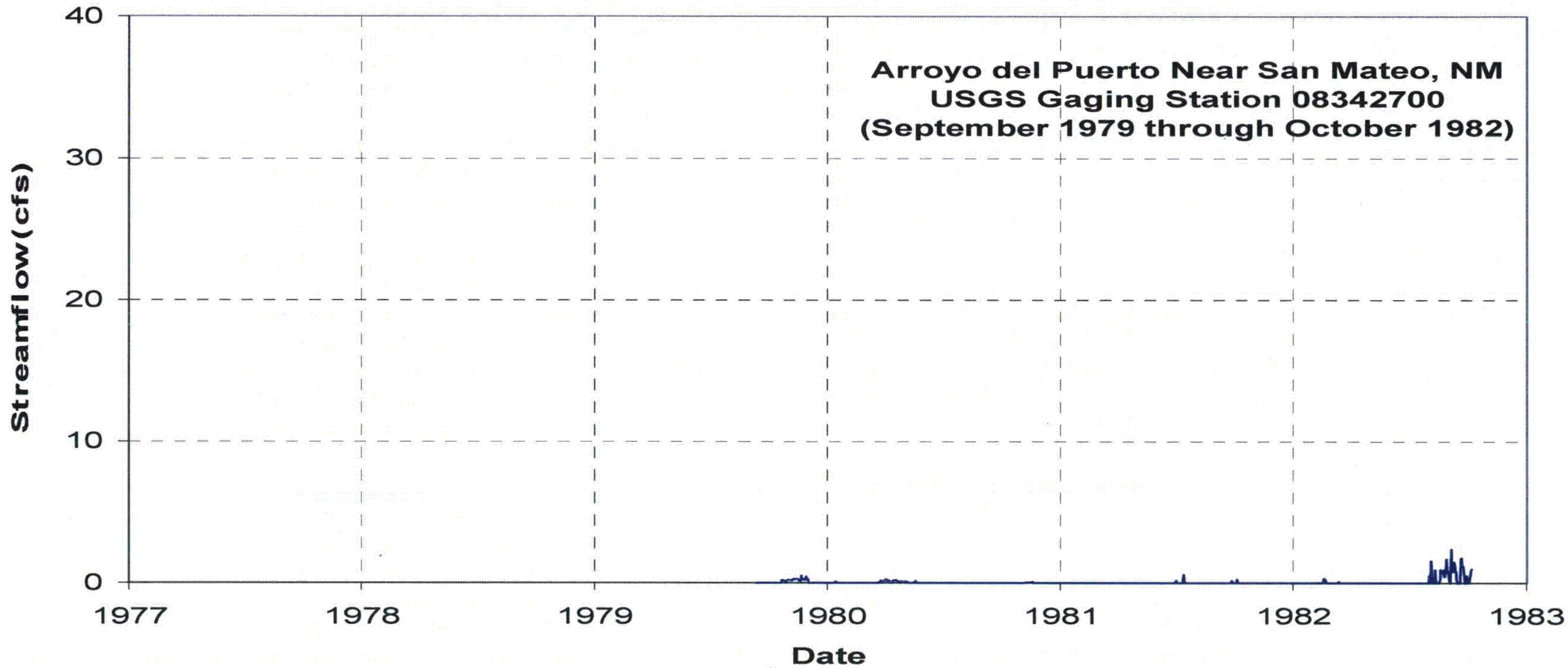
FIGURE D-2
MEAN MONTHLY STREAMFLOW FOR THE SAN MATEO CREEK, 1977-1982



Source: Roca Honda Resources, 2009

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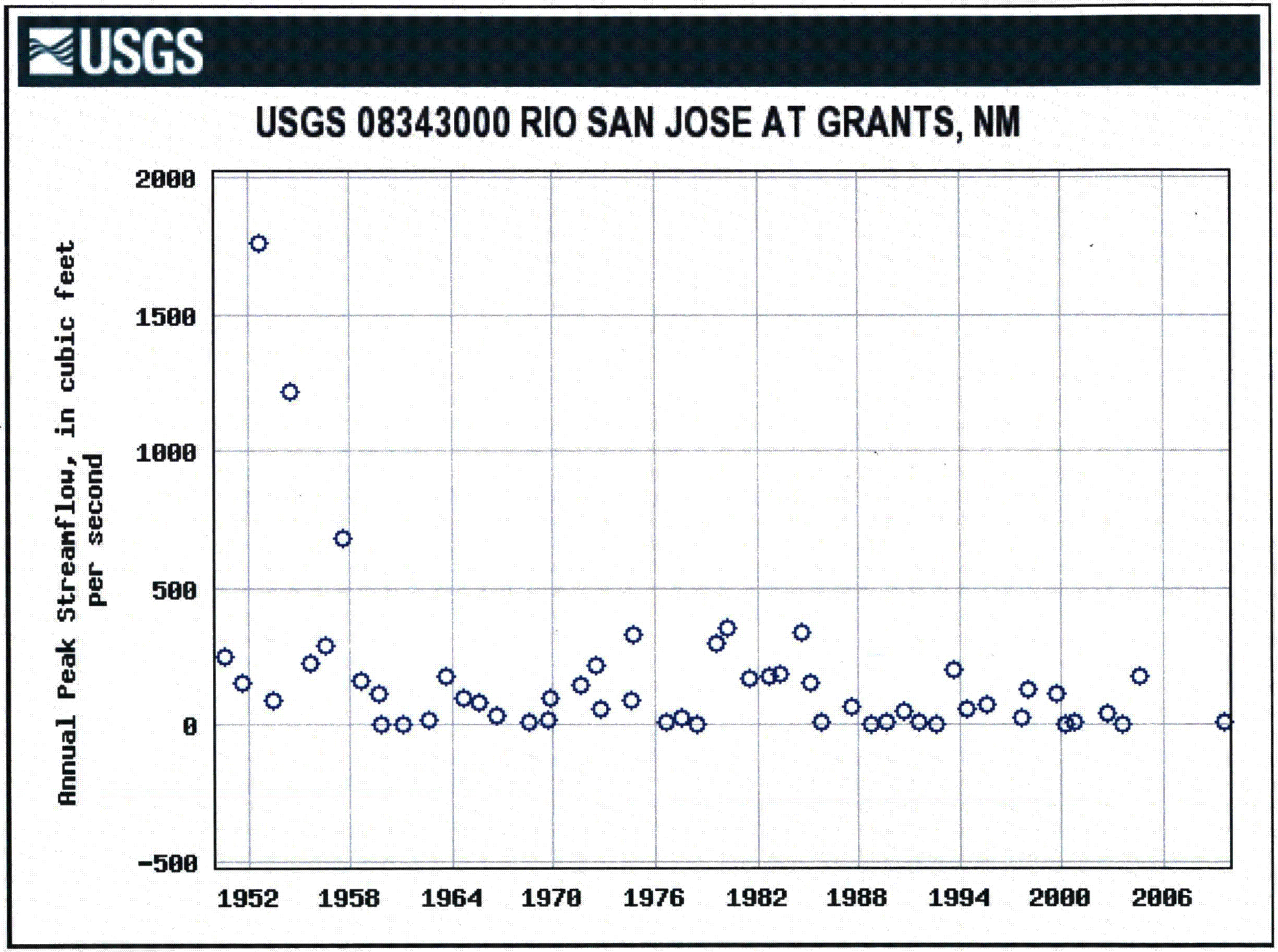
FIGURE D-3
MEAN DAILY STREAMFLOW FOR
THE ARROYO DEL PUERTO, 1979-1982



Source: USGS, 2011

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FIGURE D-4
HISTORIC PEAK STREAMFLOW FOR THE RIO SAN JOSE, 1968-2010

K:\AO000120-Grants\Illustrators\Figure D-4 Historic Peak Streamflow for the Rio San Jose 1968-2010.ai @ 11/07/2011 PREPARED BY: JC

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Appendix E – Groundwater Quality

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INTRODUCTION

This appendix is intended to present relevant data about the groundwater quality at the site that is involved with the Corrective Action Program (CAP). Groundwater monitoring at the site has been required in some capacity since the late 1950s. This appendix will provide data summarizing the site contaminant of concern (COC) standard exceedances (**Table E-1**) and wells used to create site COC plume maps (**Table E-2**). Additionally, a summary of the approach supporting the mass removal analysis completed at the site, and the mass removal analysis itself are also provided (**Table E-3**).

SITE STANDARD EXCEEDANCES

The following table identifies exceedances of standards for site COCs by aquifer.

Table E-1: Exceedances of Site Standards for COCs by Aquifer

Aquifer	Constituent of Concern	Site Standard Exceeded?	Location(s) of Exceedance
Alluvial Aquifer	Sulfate Chloride TDS	Yes	Small localized areas east of Valle Verde In close proximity to the LTP and STP
	Uranium	Yes	Collection area near the tailings Four wells in Felice Acres One well in Murray Acres Seven wells in Section 28 Seven wells in Section 27 Eight wells in Section 3 Three wells in Section 35 south of Felice Acres
	Selenium	Yes	Collection area near the LTP and southeast of the STP
	Molybdenum	Yes	Collection area near the LTP and STP Southeast of the STP West of the LTP Two wells in Felice Acres
	Nitrate	Yes	West of the LTP LTP and STP East of the tailings piles Southeast of Valle Verde
	Radium-226 + -228	Yes	Immediately underneath the LTP
	Thorium-230	Yes	Immediately underneath the LTP
	Vanadium	Yes	Immediately underneath the LTP
Upper Chinle Aquifer	Sulfate Chloride TDS	Yes	Wells CE7 and CE13
	Uranium	Yes	Twelve Upper Chinle wells
	Selenium	Yes	Six wells in the mixing zone
	Molybdenum	Yes	Three wells near the tailings Six wells south of the Collection Ponds
	Nitrate	No	Not applicable
	Radium-226 + -228	No	Not applicable
	Thorium-230	No	Not Applicable
	Vanadium	Yes	One well near the LTP
Middle Chinle Aquifer	Sulfate	Yes	Wells CW24 and WR25
	Chloride	Yes	Well ACW
	TDS	Yes	Three wells in Felice Acres One well west of the West Fault
	Uranium	Yes	Wells WR25, CW17, CW35, and CW1 Western portion of Felice Acres

Aquifer	Constituent of Concern	Site Standard Exceeded?	Location(s) of Exceedance
			Western portion of Broadview Acres
	Selenium	Yes	Wells CW28, 493, and CW17
	Molybdenum	Yes	Wells CW17 and 482
	Nitrate	No	Not applicable
	Radium-226 +228	No	Not applicable
	Thorium-230	No	Not applicable
	Vanadium	No	Not applicable
Lower Chinle Aquifer	Sulfate		
	Chloride	Yes	Far downgradient areas
	TDS		
	Uranium	Yes	Four wells, two of which are near the subcrop of the Lower Chinle Aquifer with the alluvial aquifer south of Felice Acres
	Selenium	No	None
	Molybdenum	No	None
	Nitrate	No	Not applicable
	Radium-226 +228	No	Not applicable
	Thorium-230	No	Not applicable
	Vanadium	No	Not applicable
San Andres Aquifer	Sulfate	No	Not applicable
	Chloride	No	Not applicable
	TDS	No	Not applicable
	Uranium	No	Not applicable
	Selenium	No	Not applicable
	Molybdenum	No	Not applicable
	Nitrate	No	Not applicable
	Radium-226+228	No	Not applicable
	Thorium-230	No	Not applicable
	Vanadium	No	Not applicable

Source: HMC and Hydro-Engineering 2011

PLUME MAP WELLS

Table E-2 below identifies the wells that were used to generate the plume maps.

Table E-2: Wells Used to Generate Plume Maps

0490	0491
0493	0494
0496	0497
0531	0532
0647	0649
0688	0802
0844	0845
0846	0861
0862	0869
0910	0920
0921	0929
0934	0935
0942	0999
1J	B
B11	BC
BP	C6
CW17	CW18
CW2	CW24
CW28	CW29
CW3	CW32
CW33	CW35
CW37	CW42
CW43	CW44
CW45	D1
DC	DD
F	FB
I	K4
K5	KZ
L	L10
L6	L8
L9	M5
MO	MQ
NC	P
P2	Q
R	S2
S3	S4
SA	SS
ST	SUB1
SUB2	SUB3
SV	T
TA	TB
W	WCW
WR25	X

DETAILED SUMMARY AND APPROACH SUPPORTING MASS REMOVAL ANALYSIS

A mass removal analysis was performed to assess the effectiveness of a full-scale flushing program at the site in removing dissolved uranium mass from groundwater within the alluvial aquifer. Specifically, the analysis was completed using the method of spatial moments.

A spatial moments analysis evaluates the spatial distribution of the dissolved-phase contaminant mass within a plume. Spatial moments are statistical descriptions of a population distributed in space where each monitoring well location is defined by a location vector. For a distribution in two dimensions (i.e., samples collected from monitoring wells with unique x- and y-coordinates), spatial moments can be used to estimate the total contaminant mass in the dissolved-phase plume and other characteristics of the contaminant mass distribution. When these statistics are calculated for plume configurations observed at different times, they can be used to quantitatively determine total contaminant mass removal (for additional discussion on the use of spatial moments to analyze groundwater plumes see Freyberg [1986] and Adams and Gelhar [1992]).

The zeroth spatial moment (M_0) represents the total solute mass in the dissolved-phase plume. For fully screened wells, M_0 is calculated by:

$$M_0 = \sum_{i=1}^{N} b_i A_i C_i \phi(x, y) \quad (1)$$

where b_i is the aquifer thickness, A_i is the area (or weight) associated with each well, C_i is the measured concentrations at each well and ϕ is the total porosity at each sampling location.

Thiessen polygons were used to define the individual regions of influence, or representative areas for each sampling point (monitoring well). Thiessen polygons divide a plane, assigning the representative area to each point in the set such that any location within a particular polygon is nearer to that polygon's point than to any other point. Mathematically, a Thiessen is defined by the perpendicular bisectors of the lines between all points.

For the mass removal analysis, a database of geochemical sample results was used based on site groundwater sampling. A data query was performed to segregate individual groundwater well locations with greater than 6 years of dissolved uranium concentration data for sample years 2000 to 2011. Well locations with continuous yearly sampling limited the number of wells available for the mass removal analysis, which excluded sampling years 2000 and 2011 from the analysis. The groundwater well network used in the mass removal analysis was then reduced to locations within an estimated composite plume

boundary representative of the maximum spatial extent of dissolved uranium concentrations greater than 0.16 milligram per liter (mg/L) during the 2001-2009 timeframe (**Figure 4.2.4-1**). Data were then further reduced to only include individual sample locations with no more than two missing (non-consecutive) sample years. Values for missing sample years were estimated from the arithmetic mean of previous or preceding yearly data to create "synthetic" uranium concentrations for the mass removal analysis. If multiple samples were available for a given year, the maximum dissolved uranium concentration was used. The final selected well locations and maximum yearly dissolved uranium concentrations are detailed in **Table 4.2.4-1**. A plan view map of the selected well network and "composite" plume boundary is shown in **Figure 4.2.4-2**.

Other data inputs for the mass removal analysis include a total porosity value, saturated aquifer thickness in feet, and the estimated area of influence for each individual well location (**Table 4.2.4-1**). The total porosity value of 20 percent, representative of a typical porosity for mixed sand and gravel sediments, was used for each well location (Fetter 2001). The saturated aquifer thickness in feet at individual sampling points was estimated using Environmental Visualization System (EVS) modeling of the saturated extent of the alluvial aquifer. Thiessen polygons were then generated using ArcGIS and used to define the individual regions of influence associated with each individual sampling point (monitoring well). A total of 73 polygons were used in the mass reduction analysis. The area of each polygon in square feet was then estimated using ArcGIS (**Figure 4.3.4-2**). The Thiessen polygons used in the analysis had an average area of approximately 679,000 square feet and a total area of approximately 49,600,000 square feet.

MASS REMOVAL ANALYSIS

Table E-3: Well Network and Data Inputs for Mass Removal Analysis

Well ID	Well Type	Porosity	Estimated Saturated Thickness (feet)	Area of Influence (square feet)	Dissolved Uranium Concentrations										
					2001 max U (mg/L)	2002 max U (mg/L)	2003 max U (mg/L)	2004 max U (mg/L)	2005 max U (mg/L)	2006 max U (mg/L)	2007 max U (mg/L)	2008 max U (mg/L)	2009 max U (mg/L)	2001 max U (mg/L)	2002 max U (mg/L)
0482	Collection	0.20	22.8	354,692.2	**0.2970**	0.2970	0.3260	**0.2530**	0.1800	0.2360	0.1500	0.1440	0.1240	0482	Collection
0490	Collection	0.20	19.7	1,891,836.3	0.2450	0.2540	0.2880	0.3237	0.2300	0.3160	0.2800	0.3370	0.3160	0490	Collection
0491	Collection	0.20	26.3	672,755.9	0.6600	0.8980	0.9660	0.8600	0.7770	0.6010	0.5220	0.3280	0.3180	0491	Collection
0496	Collection	0.20	22.8	1,277,438.2	0.5200	0.4330	0.3260	0.1730	0.1130	0.0985	0.0940	0.0629	0.1240	0496	Collection
0634	Collection	0.20	23.2	620,253.6	0.2170	0.3960	**0.3095**	0.2230	0.2660	0.2260	0.2790	0.2150	0.2020	0634	Collection
0653	Collection	0.20	15.9	211,420.3	1.1200	0.9680	0.9500	1.0170	0.8970	0.7350	0.6260	0.4710	0.4540	0653	Collection
0659	Collection	0.20	25.4	574,873.7	0.2000	0.2340	**0.2250**	0.2160	0.1680	0.2780	0.2860	0.2180	0.2510	0659	Collection
0802	Domestic	0.20	27.3	237,731.6	1.9600	1.0300	0.9240	0.8230	0.8730	0.5760	0.4890	0.4320	0.3330	0802	Domestic
0862	Collection	0.20	22.7	1,130,672.6	0.4800	0.6000	0.7320	0.8320	0.6640	0.5940	0.6250	0.4620	0.4800	0862	Collection
0864	Unassigned	0.20	9.1	564,529.5	0.6500	0.5310	0.4810	0.3030	0.4100	0.3500	0.3880	0.3020	0.2540	0864	Unassigned
0869	Collection	0.20	14.7	356,368.2	0.0290	0.4270	0.4310	0.4310	0.2280	0.2530	0.3150	0.3120	0.3370	0869	Collection
0881	Collection	0.20	23.5	569,999.9	0.2370	0.2420	**0.2345**	0.2270	0.1900	0.1920	0.3470	0.4350	0.4120	0881	Collection
0884	Unassigned	0.20	4.0	528,942.3	0.5540	0.2820	**0.3780**	0.4740	0.1520	0.0451	0.0385	0.0254	0.0228	0884	Unassigned
0886	Collection	0.20	18.9	801,004.2	0.4840	0.4950	**0.5185**	0.5420	0.4080	0.6070	0.3960	0.2440	0.3180	0886	Collection
0888	Unassigned	0.20	12.0	3,527,304.8	0.5410	0.5420	**0.5530**	0.5640	0.4390	0.1300	0.1540	0.0924	0.0830	0888	Unassigned
0890	Collection	0.20	21.8	490,977.2	0.1650	0.1320	**0.1465**	0.1610	0.1550	0.1560	0.2030	0.1960	0.1790	0890	Collection
0935	Domestic	0.20	37.3	4,650,836.1	0.2750	0.2470	0.1260	0.1370	0.1250	0.1010	0.1070	0.0859	0.0848	0935	Domestic
1K	Unassigned	0.20	13.1	1,697,856.4	2.5800	2.1200	3.6100	2.3900	1.4700	**1.6600**	1.8500	7.6500	**7.6500**	1K	Unassigned
B	Reversal	0.20	29.1	201,733.9	0.3903	0.4900	0.3930	0.3657	0.0832	0.1640	0.0249	0.1060	0.0285	B	Reversal
B11	Collection	0.20	33.9	1,218,358.9	13.1200	14.5000	10.1000	5.0600	3.4200	9.0600	8.3200	5.6000	5.6000	B11	Collection
B3	Collection	0.20	35.7	874,417.1	13.3300	**12.7650**	12.2000	12.7000	23.3000	16.9000	26.3000	30.3000	30.3000	B3	Collection
BC	Unassigned	0.20	37.5	1,445,210.1	0.2208	0.2630	0.1900	0.2926	1.1000	1.8300	0.0730	1.3900	1.4800	BC	Unassigned
BP	Monitor	0.20	31.8	403,768.3	1.3000	1.1500	**1.0330**	0.9160	0.8490	0.8080	0.4820	**0.4330**	0.3840	BP	Monitor
C1	Unassigned	0.20	33.1	128,876.3	**1.4000**	1.4000	0.5090	0.2600	0.2650	0.2400	0.2430	0.2030	0.2350	C1	Unassigned
C10	Collection	0.20	26.5	133,927.3	40.8100	29.3000	24.4000	19.5000	14.9000	12.1000	12.7000	**12.3500**	12.0000	C10	Collection
C11	Collection	0.20	28.3	209,753.0	37.1000	19.3000	14.8000	16.6000	11.2000	9.6000	7.5600	**6.7200**	5.8800	C11	Collection
C12	Collection	0.20	26.0	231,787.1	17.5000	11.3000	8.4000	6.5500	32.5000	4.6400	3.3400	**3.0300**	2.7200	C12	Collection
C2	Unassigned	0.20	36.0	537,634.0	0.4820	0.4410	0.2600	0.2000	0.1660	0.6940	0.3060	0.4450	0.5610	C2	Unassigned
C5	Monitor	0.20	30.8	176,288.6	0.9200	0.6290	**0.4215**	0.2140	0.2000	**0.1730**	0.1460	0.2140	0.1860	C5	Monitor
C6	Collection	0.20	29.2	118,082.4	16.7000	9.5800	4.4600	2.8000	1.6600	1.8800	1.7500	**1.3330**	0.9160	C6	Collection
C7	Collection	0.20	27.6	174,020.7	13.2000	13.0000	13.6000	10.8000	11.1000	12.4000	14.8000	**16.0000**	17.2000	C7	Collection
C8	Collection	0.20	25.9	173,372.3	**11.0000**	11.0000	10.2000	8.9600	7.0900	8.3400	9.1200	**9.2700**	9.4200	C8	Collection
C9	Collection	0.20	25.4	133,258.3	18.9000	12.7000	13.5000	10.5000	8.8200	7.8800	6.2900	**7.2350**	8.1800	C9	Collection
CW44	Collection	0.20	22.6	617,272.3	1.0100	0.8460	1.0500	0.7970	0.6360	0.6620	0.6770	**0.5845**	0.4920	CW44	Collection
D1	Unassigned	0.20	34.5	201,171.5	1.3700	1.1500	1.0900	1.1800	1.1000	1.1500	0.9550	5.3400	1.3400	D1	Unassigned
ED1	Tailings Pond Collection	0.20	27.2	4,322,347.6	44.2000	34.0000	35.5000	20.0000	17.8000	20.7000	12.3000	2.3100	0.9060	ED1	Tailings Pond Collection
K10	Collection	0.20	29.6	115,355.6	13.6400	4.3400	2.6400	2.1400	2.1200	1.2100	2.9200	3.1000	2.8600	K10	Collection
K11	Collection	0.20	29.4	121,649.9	11.0100	4.9700	1.8400	1.5900	1.2200	0.9690	1.4400	1.3000	0.9880	K11	Collection
K4	Unassigned	0.20	27.9	606,907.4	5.3800	3.5700	2.7300	1.2600	1.2000	0.7220	1.4900	1.2400	1.0100	K4	Unassigned
K5	Collection	0.20	29.2	208,298.4	4.2660	1.6200	0.6510	0.5760	0.5300	0.4430	**0.4445**	0.4460	0.5640	K5	Collection

Well ID	Well Type	Porosity	Estimated Saturated Thickness (feet)	Area of Influence (square feet)	Dissolved Uranium Concentrations										
					2001 max U (mg/L)	2002 max U (mg/L)	2003 max U (mg/L)	2004 max U (mg/L)	2005 max U (mg/L)	2006 max U (mg/L)	2007 max U (mg/L)	2008 max U (mg/L)	2009 max U (mg/L)	2001 max U (mg/L)	2002 max U (mg/L)
K7	Collection	0.20	28.8	221,263.6	2.3500	1.4900	1.3400	2.0700	2.2500	1.3900	1.5800	1.1200	0.9890	K7	Collection
K9	Collection	0.20	29.5	127,341.7	8.4060	3.6700	2.1000	1.6100	1.0900	1.3500	1.4200	0.9050	0.8340	K9	Collection
KF	Unassigned	0.20	35.9	112,286.5	0.2258	0.1240	0.0590	0.0703	0.0977	0.1160	0.0879	0.0772	0.0674	KF	Unassigned
KZ	Reversal	0.20	32.7	136,819.8	0.6100	0.4200	0.1080	0.0940	0.1260	0.0743	0.1250	0.0825	0.1020	KZ	Reversal
L	Unassigned	0.20	18.7	101,384.0	1.7300	1.5500	1.1800	0.7690	0.6900	0.7580	0.5100	0.7740	0.5220	L	Unassigned
L10	Unassigned	0.20	16.8	174,551.9	1.5100	1.2200	0.6440	0.3950	0.4450	0.5500	0.3240	0.3560	0.3170	L10	Unassigned
L5	Unassigned	0.20	23.6	181,654.7	2.3200	1.0300	0.4010	0.4350	0.3580	0.2650	0.2310	0.3740	0.3630	L5	Unassigned
L6	Unassigned	0.20	19.8	750,029.3	1.2100	0.4660	0.3750	0.3840	0.2200	0.1490	0.1800	0.1730	0.1940	L6	Unassigned
L7	Unassigned	0.20	15.9	342,381.3	2.4880	1.1200	0.4900	0.4500	0.2690	0.3310	0.2260	0.2320	0.2280	L7	Unassigned
L8	Unassigned	0.20	14.7	208,733.0	1.5200	0.8090	0.3930	0.3880	0.2190	0.1740	0.2250	0.2240	0.1810	L8	Unassigned
L9	Unassigned	0.20	14.2	217,218.3	1.4660	1.0100	0.3970	0.3170	0.2350	0.2270	0.2540	0.2580	0.2020	L9	Unassigned
M3	Collection	0.20	54.2	327,430.7	11.2000	6.5100	6.5500	**6.8700**	7.1900	8.3600	6.9700	7.1800	10.4000	M3	Collection
M5	Unassigned	0.20	50.9	488,311.9	2.3000	1.9700	**1.6450**	1.3200	0.6990	**0.6065**	0.5140	1.0900	0.2410	M5	Unassigned
MO	Collection	0.20	16.4	1,285,623.1	0.2840	0.3360	0.4080	0.4100	0.4450	0.7260	0.5020	0.4740	0.5640	MO	Collection
MQ	Collection	0.20	21.6	1,294,322.2	1.5500	1.8800	**2.2450**	2.6100	2.1600	2.3100	2.7100	2.0100	2.1800	MQ	Collection
MR	Collection	0.20	24.8	1,242,427.2	0.4990	0.4580	**0.5020**	0.5460	0.5090	0.4630	0.7570	**0.7160**	0.6750	MR	Collection
MT	Unassigned	0.20	6.8	626,616.4	0.3060	0.1480	**0.1405**	0.1330	0.0955	0.0729	0.0441	**0.0461**	0.0480	MT	Unassigned
NB	Monitor	0.20	32.3	1,476,236.3	62.1000	67.5000	63.3000	16.4000	40.0000	**41.5000**	43.0000	21.0000	**21.0000**	NB	Monitor
S2	Reversal	0.20	53.1	750,568.2	15.0000	15.8000	12.1000	7.8700	4.9500	7.8800	9.3000	7.1800	12.6000	S2	Reversal
S3	Unassigned	0.20	63.6	384,773.0	9.0000	7.7000	**7.0750**	6.4500	3.6000	2.9000	4.1000	**2.7450**	1.3900	S3	Unassigned
S4	Unassigned	0.20	50.7	177,834.1	3.3800	2.5300	2.0200	5.7200	4.4100	2.8500	1.0100	0.8400	0.5790	S4	Unassigned
SA	Collection	0.20	58.7	125,003.7	10.8000	**9.0850**	7.3700	8.5700	10.1000	5.9300	40.1000	9.5000	1.7900	SA	Collection
SQ	Collection	0.20	50.6	92,686.7	22.3000	10.7000	16.7000	9.3800	**10.5400**	11.7000	14.1000	16.5000	17.0000	SQ	Collection
SS	Collection	0.20	54.0	72,026.1	14.6000	13.0000	10.2000	10.2000	12.5000	5.6500	4.1000	2.8800	0.8010	SS	Collection
ST	Collection	0.20	57.5	63,471.5	5.3340	3.4200	4.0500	**4.9350**	5.8200	4.1800	4.6000	2.6800	2.9900	ST	Collection
SUB1	Domestic	0.20	30.2	596,568.7	0.2597	0.1740	0.2160	0.1831	0.1630	0.1120	0.1050	0.1160	0.1060	SUB1	Domestic
SV	Monitor	0.20	44.4	839,416.4	**19.6000**	19.6000	23.2000	23.3000	24.6000	9.5500	12.9750	16.4000	11.9000	SV	Monitor
T	Collection	0.20	24.1	321,008.4	11.6000	3.9600	2.4600	1.7200	1.4600	1.3600	1.4900	2.3200	3.0100	T	Collection
T2	Monitor	0.20	56.7	553,957.9	13.6100	14.9000	**13.2500**	11.6000	9.2200	9.5700	11.1000	9.0600	21.8000	T2	Monitor
TA	Collection	0.20	23.1	300,926.4	2.5440	1.6000	1.0900	0.6760	0.7390	1.0800	1.1400	1.3100	1.3200	TA	Collection
TB	Collection	0.20	21.0	880,496.6	4.4430	0.4200	**0.5190**	0.6180	0.8640	0.7970	1.0600	3.2000	1.8500	TB	Collection
WD3	Monitor	0.20	40.4	2,323,167.6	**0.0003**	0.0003	29.3000	15.2700	1.2400	6.3000	7.7100	10.7000	2.5700	WD3	Monitor
X	Unassigned	0.20	30.2	263,596.2	0.0523	0.0290	0.0407	0.0820	0.1200	0.1620	0.1270	0.0511	0.0920	X	Unassigned

Legend:
0.2970 indicates preceding year value ("synthetic" U concentration)
0.2530 indicates average value of previous year and preceding year ("synthetic" U concentration)
7.6500 indicates previous year value ("synthetic" U Concentration)

Assumptions:
1) Initial data query segregated individual sample locations at the site with greater than 6 years of dissolved uranium concentration data.
2) Data from 2000 and 2011 were eliminated from the spatial data set due to lack of continuous (yearly) sampling at individual sample locations.
3) Data points were reduced to locations within an estimated "composite" plume boundary indicating the maximum spatial extent of dissolved uranium concentrations > 0.16 mg/L during 2001-2009.
4) Data were then further reduced to only include individual sample locations with no more than 2 missing (non-consecutive) sample years.
5) If multiple samples were available for a given year, the maximum dissolved uranium concentration was used.

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