Goodson & Associates, Inc.
Consulting Engineers

# FINAL REPORT

# LICENSING ASSISTANCE/

# GEOTECHNICAL AND HYDROLOGICAL

# EVALUATIONS/URFO

## TASK ORDER NO. 2

## REVIEW OF

## HOMESTAKE MINING COMPANY
## SUBMITTAL

## MILAN MILL

APRIL 30, 1987

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(5603.01)

TABLE OF CONTENTS

## PURPOSE

The purpose of this geotechnical evaluation is to determine the adequacy of the information submitted by Homestake Mining Company regarding the stability of the uranium mine tailings embankment at the Milan Mill site. This work was performed in accordance with Contract No. NRC-31-85-377 between the Nuclear Regulatory Commission (NRC) and Goodson & Associates, Inc. (G&AI).

## SCOPE OF WORK

The scope of work performed by G&AI for this study consisted of the following:

1. Conduct a site visit on March 10, 1987, to observe the condition of the tailings ponds and embankment.

2. Review the following reports:

   a) "Stability Assessment," prepared by D'Appolonia Consulting Engineers, Inc., dated November 1980.

   b) Quarterly stability reports, dated March 7, 1984, to September 5, 1986, submitted by Homestake Mining Company to the State Engineer of New Mexico.

   c) "Reevaluation of Friction Angle of Sand Tailings" report, dated December 30, 1986, and prepared by Dr. Alan Kuhn, P.E.

3. Evaluate the adequacy of the stability analyses performed and prepare a safety evaluation report. This evaluation is based upon a review of data obtained by others and the results of the onsite examinations. No independent field investigations, laboratory testing, nor stability analyses were performed by G&AI.

## DESCRIPTION

The Milan Mill is located in Valencia County, north of Grants, New Mexico. Based upon data furnished by the Homestake Company, the east tailings pond was formed by construction of a 10-foot-high starter dam composed of native sandy clay. There was no starter dam for the west pond, which is contiguous to the east pond. Tailings were reportedly hydraulically disposed in a center-line method of construction with cyclones. In general, coarser fractions of the tailings were placed on the downstream side of the crest and finer fractions were placed on the upstream side. A total of approximately 20 million tons of tailings were deposited in the east and west tailings ponds.

According to surveys dated December 20, 1986, the tailings embankment has a maximum crest elevation of 6680 feet at section 6-6' (Figure 1), a maximum height of approximately 100 feet, and downstream side slopes ranging from 2:1 to 2.3:1. Since operations have been severely curtailed, tailings are presently being deposited in the ponds at a low rate of approximately 2,000 tons per month, according to officials of Homestake Mining Company.

## SITE EXAMINATION

A site visit was made on March 10, 1987, to the Milan Mill, located near Grants, New Mexico. Ray Gonzales and Dawn Jacoby of the NRC, Denver office, accompanied Ralph Rabus and Al Zlaten of G&AI on the field trip.

There was water in the east and west ponds. Seepage through the tailings embankment was visible along the downstream toe. The observed seepage does not adversely affect the safety of the embankment.

A visual examination of the tailings embankment disclosed no areas of structural distress.

## ADEQUACY OF STABILITY ANALYSIS

In a letter from the U.S. Nuclear Regulatory Commission (NRC), dated October 9, 1986, to Homestake Mining Company, the appropriateness of using 29° as the friction angle for the strength value of the uranium mill tailings in stability analyses of the tailings embankment was questioned. In response, Dr. Alan K. Kuhn prepared a report entitled "Reevaluation of Friction Angle of Sand Tailings, Homestake Mill, Grants, New Mexico," dated December 30, 1986, (Kuhn Report) in which the basis for selection of a friction angle of 29° is documented and evaluated. The materials test data used in the Kuhn Report were originally developed for a report entitled "Engineer's Report, Stability Analysis, Uranium Mill Tailings Pond, United Nuclear-Homestake Partners, Grants, New

Mexico," dated November 1980, prepared by D'Appolonia Consulting Engineers, Inc. (D'Appolonia Report).

As noted in the D'Appolonia Report, stability analyses were performed on embankment cross sections taken at eight different locations (1-1' through 8-8', shown on Figure 1). Factors of safety at three locations, 1-1', 4-4', and 5-5' (Figure 1) did not meet the requirement of a 1.5 safety factor as specified in the NRC Regulatory Guide 3.11.

Three remedial procedures for stabilizing the tailings embankment were proposed in the D'Appolonia Report. All three options would result in a general flattening of the slopes. According to Homestake officials, slopes were flattened by moving upper slope material towards the toe and by moving the crest inward towards the pond.

The phreatic level used in the stability analyses for the D'Appolonia Report was based upon piezometric measurements obtained in 1980. To monitor the phreatic surface, piezometers were installed in 1977 and in 1980 by D'Appolonia (Figure 1). The D'Appolonia Report noted that the phreatic surface within the tailings embankment did not significantly affect the safety factor until it became 50 percent greater than the piezometric level that existed in 1980. Assessments of the location of the phreatic surface have been made periodically and are kept current by Dr. Kuhn. Based upon the stability results presented in the quarterly stability report dated September 5,

1986, the existing phreatic level has not increased 50 percent over the 1980 level.

Our review of available data indicates that the selection of the friction angle of 29° for the uranium mill tailings at the Milan Mill tailings pond is based on 10 consolidated-undrained (CU) triaxial shear test made on representative samples that were remolded to approximate the in situ densities encountered in the embankment. Based on our judgment and experience, a friction angle of 29° for the type of tailings material produced by the Milan Mill is reasonable and on the conservative side.

According to the available data, the following safety factors are the most recent for the eight cross sections for which stability analyses are performed:

| Section | SF Static | SF Psuedo-static | Date |
|---|---|---|---|
| 1-1' | 1.88 | 1.23 | May 86 |
| 2-2' | 1.87 | 1.19 | Aug 85 |
| 3-3' | 1.56 | 1.07 | Sep 86 |
| 4-4' | 2.08 | 1.32 | Aug 85 |
| 5-5' | 1.76 | 1.09 | Sep 86 |
| 6-6' | 1.66 | 1.09 | Sep 86 |
| 7-7' | 2.05 | 1.32 | Aug 85 |
| 8-8' | 1.69 | 1.12 | Sep 86 |

Sections with a more recent date (May and September 1986) for the safety factors had a relatively low safety factor value in the past and additional stabilizing work, such as flattening slopes, was performed at the location of these cross sections, resulting in an increase of the factors of safety to the current adequate values. Stability analyses have not been

performed on Sections 2-2', 4-4', and 7-7' since August 1985, because the conditions affecting stability on these sections have not changed significantly and the sections have high factors of safety.

Additional slope stabilization was being performed at the time of the onsite examination in the area of Section 3-3' (Figure 1), which has a relatively low factor of safety as indicated in the table above. The slope stabilization consisted of moving the crest of the embankment towards the pond, resulting in a general flattening of the slope. Based upon the stability analyses performed, this procedure does increase the factor of safety of the slope.

Results of potential for liquefaction studies contained in the D'Appolonia Report indicate that the potential for liquefaction under earthquake loading does not endanger the stability of the embankment. Due to the relatively low phreatic surface, the potential for liquefaction is low except at the toe of the dam where seepage from tailings ponds tends to saturate the sand tailings. In this restricted area, minor surficial sloughing of the embankment can occur. This minor sloughing should not endanger the stability of the embankment. Based on our observations of the site and a review of available data, failure of the tailings embankment due to liquefaction is unlikely.

## CONCLUSIONS

Based on a review of available data and on an onsite examination of the tailings embankment, the shear strength, density and moisture values of the tailings materials used in the stability analyses of the Milan Mill tailings embankment have been obtained by generally recognized and approved methods in the geotechnical profession, are judged to be reasonable, and result in reasonably accurate factors of slope stability.

The stability of the Milan Mill tailings embankment is being monitored on a periodic (quarterly) basis and remedial work is being done to increase the stability in the area where the safety factor values become marginal due to changes in the slope from placement of tailings from mill operation, wind blown movement of tailings, and change in phreatic surface. Continued monitoring is warranted as long as tailings are being deposited and changes in conditions affecting stability are occurring.

Based on a review of available data and on an onsite examination, the Milan Mill tailings embankment is considered to be stable and satisfies the stability requirements of NRC Regulatory Guide 3.11.

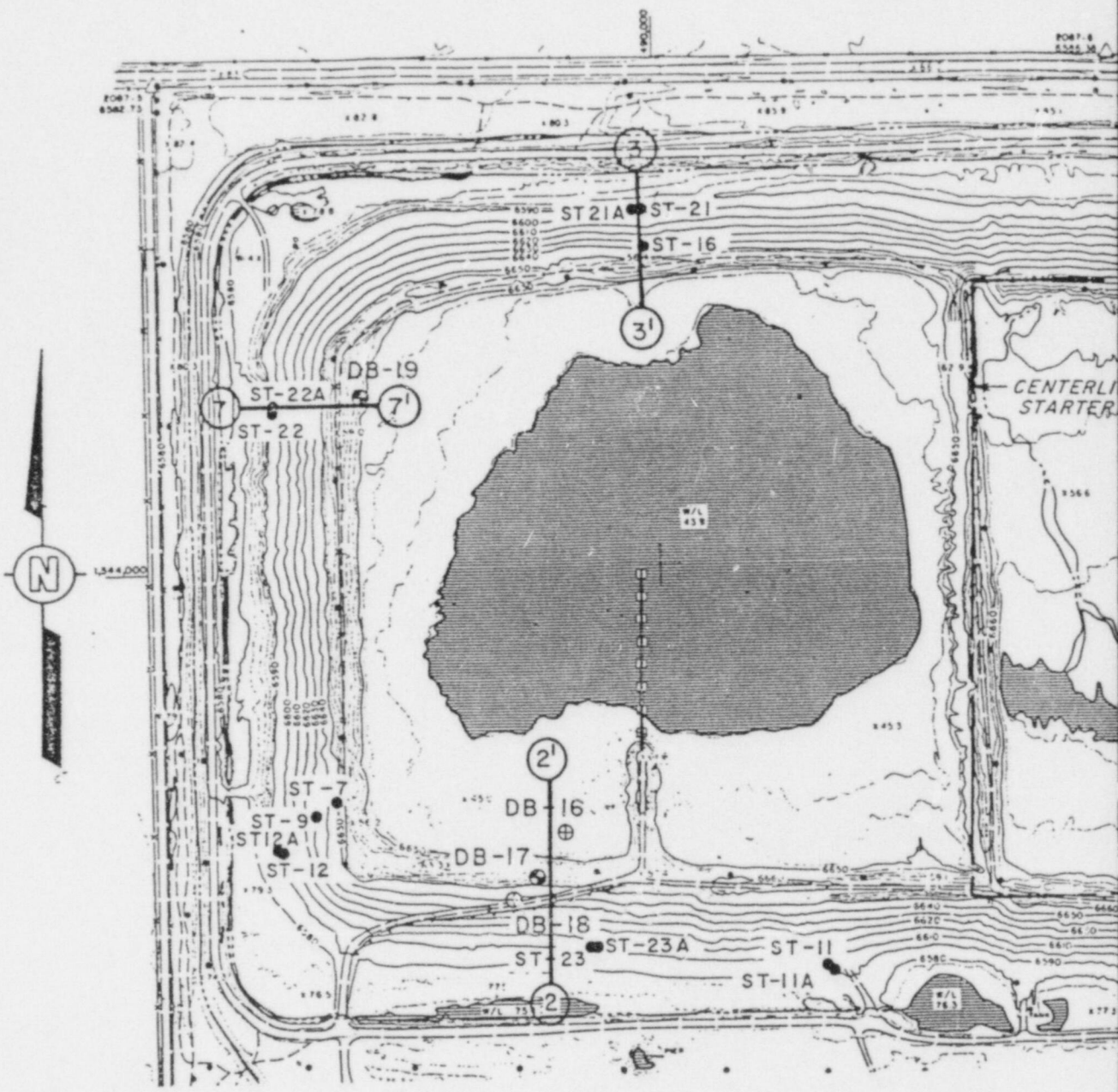
## RECOMMENDATIONS

Additional stability analysis, to verify the stability of the tailings embankment, will be required if changes in existing conditions steepen existing slopes, raise the embankment

height, or produce a higher phreatic surface than what was measured for the most recent stability analyses.

In the event that topsoil and seeding is used during final reclamation of the tailings embankment, flattening of the existing slopes for greater erosional stability should be considered. Final grading of the slopes should also remove all windblown sand that may have been deposited tending to oversteepen the existing slopes.

| DRAWN BY | MJG | CHECKED BY | TJH | 10-27-80 | DRAWING NUMBER | RM80-311B-1 |
|---|---|---|---|---|---|---|
| | 10/14/80 | APPROVED BY | AKR | 10-27-80 | | |




LEGEND

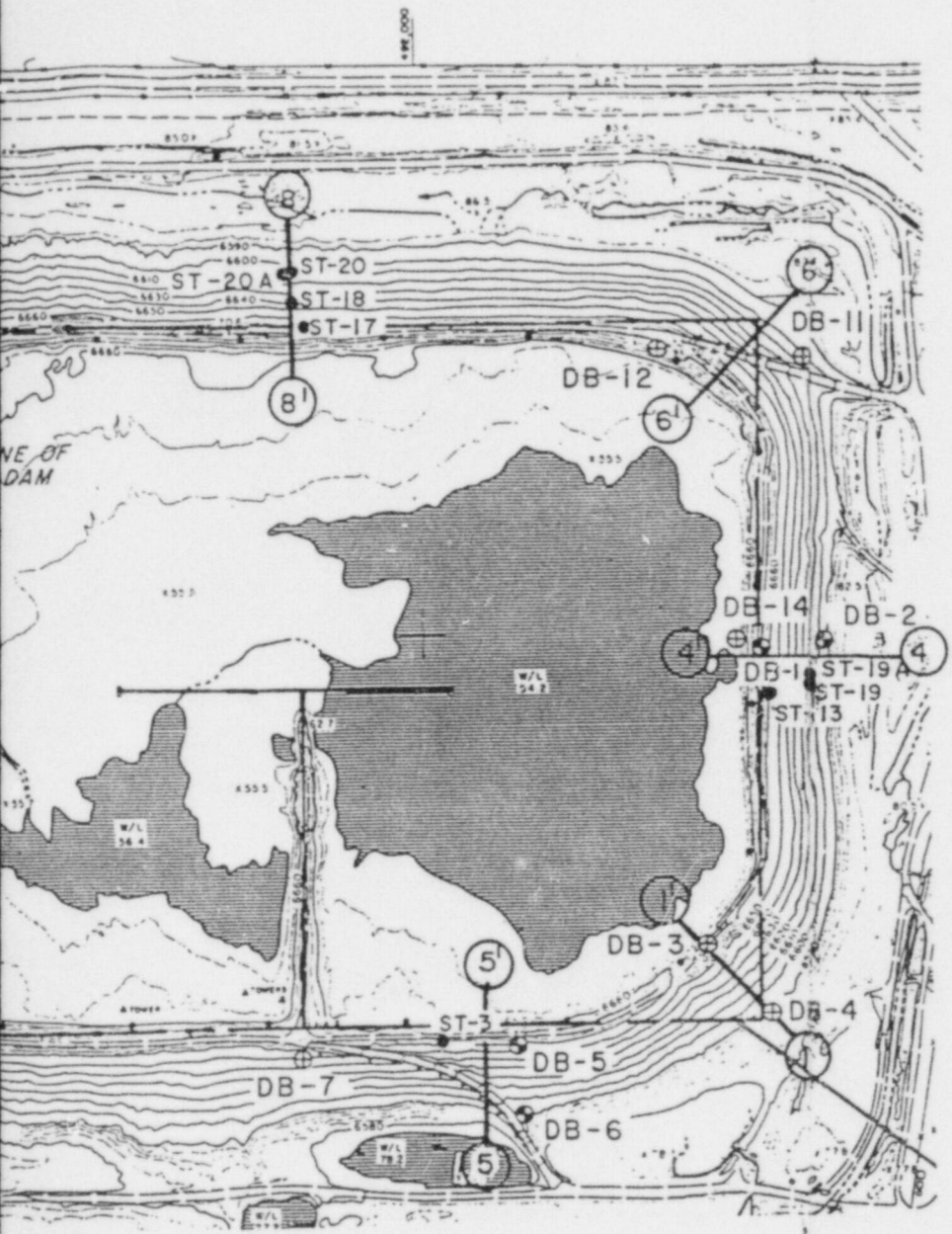
⊕ D'APPOLONIA BORINGS WITH SINGLE PIEZOMETERS

D'APPOLONIA BORINGS WITH DOUBLE PIEZOMETERS

1—1' T

**TI APERTURE CARD**

**Also Available On Aperture Card**




| CROSS SECTION | FIGURE NUMBER |
|---|---|
| 1 - 1' | 3 |
| 2 - 2' | 4 |
| 3 - 3' | 5 |
| 4 - 4' | 6 |
| 5 - 5' | 7 |
| 6 - 6' | 8 |
| 7 - 7' | 9 |
| 8 - 8' | 10 |

400 0 400

SCALE IN FEET

8705270663-01

IEZOMETER FROM 1977
IELD INVESTIGATIONS

YPICAL CROSS SECTION

BORING AND PIEZOMETER
LOCATION PLAN

PREPARED FOR

UNITED NUCLEAR-HOMESTAKE PARTNERS
GRANTS, NEW MEXICO

D'APPOLONIA

Figure 1

11949 West Colfax Avenue / Denver, CO 80215 / (303) 233-2244