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HEALTH & ENVIRONMENT department

STATE OF NEW MEXICO
ENVIRONMENTAL IMPROVEMENT DIVISION
P.O. Box 968, Santa Fe, New Mexico 87503
(505) 827-5271
Thomas E. Baca, M.P.H., Director

Bruce King
GOVERNOR

George S. Goldstein, Ph.D.
SECRETARY

Larry J. Gordon, M.S., M.P.H.
DEPUTY SECRETARY

RADIATION PROTECTION SECTION

December 14, 1979

M E M O R A N D U M

TO: COMMENTORS ON BOKUM RESOURCES CORPORATION APPLICATION FOR RADIOACTIVE MATERIAL LICENSE

FROM: Alphonso A. Topp, Jr.
ALPHONSO A. TOPP, JR. ENVIRONMENTAL PROGRAM MANAGER

SUBJECT: REPLY TO COMMENTORS, BOKUM APPLICATION

1. Site specific and germane comments on the Bokum application were provided to the applicant for response.

2. The applicant's response to comments is enclosed herewith for the information of commentors.

3. As normal procedure with an application for Radioactive Material License for a uranium mill, appropriate comments are encouraged as soon as possible but are accepted at any time prior to disposition of the application.

BOKUM RESOURCES CORPORATION

P. O. Box 1833
142 W. Palace Avenue
Santa Fe, New Mexico 87501
(505) 982-1824

December 5, 1979

Mr. Alphonso A. Topp,
Program Manager
Radiation Protection Section
ENVIRONMENTAL IMPROVEMENT DIVISION
P. O. Box 968
Santa Fe, New Mexico 87501

Dear Mr. Topp:

The purpose of this letter is to clarify certain topics presented in the Discharge Plan, and to address specific questions that have resulted from various reviews of this plan.

In regard to riprap implacement on the Diversion Structure and other specific operation and maintenance concerns, we will construct:

1. 24 inch dumped rock riprap (at least 50% by weight having this minimum size) will be used over a 36 inch filter blanket (inner, 18" of 6 mm. median diameter, $\sigma = 3.0$; outer, 18" of 60 mm. median diameter, $\sigma = 2.0$), and

2. keyed at least 4 feet below channel grade, and

3. the riprap will cover the east side of the structure, top to bottom between stations 0+00 and 8+00, and

4. this shall be accomplished within the first 18 months after start up. There is no environmental hazard associated with this 18 month period as few structures will yet have been built behind the diversion and all structures are above flood pool even if the diversion failed, and

5. this change in riprap consideration replaces those stated in the Discharge Plan of October 25 and results from our consideration of Dr. Lagasse's consulting review of the plan, and

6. inspections will be conducted and periodic maintenance performed as required to insure the integrity of both the riprap and unprotected slopes of the diversion system, and

7. after operations are terminated and prior to reopening the diversion structure, at its intersection with Canon de Marquez, the channel will be prepared as discussed in DM #6. This also includes taking into account the impact of the reestablished alignment as it relates to gradient, meander pattern, channel width, channel roughness and the added inflow from Arroyo Hondo. Specifications on the methods of handling this reestablished system will be presented to the EID for their review and concurrence prior to accomplishing this task, and

8. the length of channel to be reclaimed will be from the point of diversion to below the confluence with Canon Seco, and

9. the channel will be surveyed within 12 months of mill start up to establish a baseline configuration to be used for future reclamation control.

Concerning those points referred to in the November 20, 1979, letter from Mr. Donald Runnells, we will:

1. employ the information gained by the use of Trench #1 in the operation and final design of future trenches. Specifically, to consider the possible impact resulting from acid/shale reaction as this relates to swelling, gas generation and reduction of storage capacity, and

2. the upward migration of potential contaminants will be controlled by lowering the fluid level, below the top of the tailings, to 10 feet. It should be noted that the capillary rise calculations show a potential for about 9 feet of rise (DM #7), whereas the majority of reclamation coverage is greater than 10 feet in thickness. Additionally, as a contingency consideration, if subsequent coring indicates fluid rise is occurring detrimentally, a gravel blanket will be used. This gravel blanket will be used as the first step underlying the reclamation cover of future trenches. It will also be placed over the existing cover of Trench #1 and recovered with soil for additional revegetation, and

3. All annual reports on reclamation progress will address observations and/or data obtained on salt movement, and

4. Molybdenum will be added to the list of constituents analyzed from core samples taken from reclaimed pits. It will also be a constituent measured in water samples from the groundwater sump. Furthermore, after a trench

4. (Cont'd). is reclaimed four samples of grass-type vegetation will be analyzed annually for Molybdenum. This monitoring will continue through the same period as the groundwater monitoring program.

Concerning those questions on the location of Trenches 2 thru 6, we reiterate:

1. as stated in Designer's Memorandum #11, Trenches 2 thru 6 will be located in the La Laguna area. Individual configurations may be redefined, but the total surface area of 132 acres will be the entire area occupied by these trenches. The external mapped boundary shown in DM #11 will be the external boundary controlling and configuration of Trenches 2 thru 6. It would be wasteful and not at all useful to provide design specifications on future trenches because Trench 1 operation provides excellent design control on future trenches with respect to mill operation, sequencing, tailings volume, and environmental protection. This concept has been stated in Dr. Runnells' consulting report to the EID and is, in our opinion, better than locking in design now. The 2 thru 6 Trench area has been selected on the basis of numerous borings; additional borings are required prior to trench design; the drilling data and design specifications are required to be submitted to and approved by the EID prior to construction; the permit is for a maximum of five years and may be revoked if the environment is threatened. We think the above allows the state more control than if a locked-in approach is used.

Concerning those questions on Alternative Site studies we submit:

1. The present tailings disposal scheme is the third design submitted to the NMEID for approval, and

2. other areas have been examined in previous design presentations, and

3. the present scheme takes advantage of several design elements and naturally occurring geologic conditions: a) an engineered compacted earth, secondary catchment dam; b) an engineered Diversion System; and c) several hundred feet of Mancos Shale, underlying the site. This shale has a low permeability and excellent ion-exchange capability, and

4. the present plan capitalized on the fact that design criteria, (i.e. below grade disposal) override site criteria and agrees with those conditions presented in GEIS (NUREG 05-11), and

5. a brief assessment has been previously completed on alternative sites within this same general area, and

6. the present site is an exceptional fit to the non-required but preferred method of tailings disposal by EID and NRC, namely, below grade.

Regarding those questions raised by the Sandoval Environmental Action Community in their November 20, 1979, letter, we submit:

1. as previously stated, Trenches 2 thru 6 will be located in the La Laguna area. Further, as stated on page 86 of the Dishcarge Plan, borings will be completed in every trench area to evaluate permeability and finalize design specifications. The results of both this drilling and trench design specifications will be submitted to the NMEID, prior to initiating any construction, and

2. response presented as answers to Mr. Bob E. Watt's letter, and

3. elaboration on the subject of geology and specifically faulting, plus the relationship of these topics to this site is presented in: a) the Discharge Plan, October 22, 1979, pages 33 thru 48, the "Marquez Quadrangle Map" and Drawing C-6, plus the "Marquez Tailings Area Fence Diagram and Accompanying Index Map"; b) Fault Investigation of the Marquez Mill Area, Marquez, New Mexico, April, 1979; c) Addendum to the Ground Water Discharge Plan, February, 1979, page 34 and Appendix E; d) Ground Water Discharge Plan, August, 1978, pages 22-25; and e) Radioactive Material License Application, February, 1978, pages 2-23 thru 2-40 and Appendices A, G and J. The data gathered and its subsequent interpretation indicate that faults are present. However, their viability has been determined to be inactive. This conclusion suggests that their potential for inducing seismic events is severely limited, and

4. the subject of alternative site consideration is discussed above. Suffice it to say that, other alternative engineering and site considerations have been undertaken.

Concerning those points referred to by the Southwest Research and Information letter of November 26, 1979:

1. the details of liquid distribution into the evaporation ponds is given in DM #10 and referenced again in DM #12. The major change between DM #10 and DM #12, with respect to construction, is to increase the clay liner thickness from 3 to 5 feet. Required freeboard is set in both of these DM's. Cut slopes are given. The locations of evaporation ponds is specified in DM #12 as being in the Rincon del Oso area (as mapped), and incised in the areas marked as Trenches 2 and 3 in DM #11. These are, in fact, committed areas and there is nothing vague about this area. The outer boundary of the area for Trenches 2 thru 6 is fixed, by topography and drilling data, to the external boundaries shown in DM #11. Cross-sections of the pond construction for the Rincon del Oso area are given in DM #12. Also in DM #12, sections for an incised pond, such as would be placed in the area of Trenches 2 and 3, is provided, and

2. We believe that we have made it clear in the Discharge Plan that engineering specifications for construction of various structures and field data necessary for designing construction are to be reported, for approval by the EID, before construction. For further clarification, we hereby include as part of the October 25, 1979, Bokum Resources Ground Water Discharge Plan, that no construction of any structures, wells, pipelines, or other ancillary features and/or operations referred to and/or identified in said plan will be initiated prior to approval of plans, specifications, and designs for said structures by the New Mexico Environmental Improvement Division. In addition, we reiterate that annual reviews by external consultants of the reclamation plan, construction, and operations of the tailings system will be submitted to the EID. We believe this approach affords the maximum possible review and control of our tailings operations to the EID, particularly considering that the agency may terminate a permit at any time it feels the Discharge Plan or Radiation License is being violated. The above statements address the majority of questions raised in the SRIC letter, and

3. With respect to placing an evaporation pond over a previous tailings trench, we have the following comments:

a. Mr. Al Topp of the EID asked us, in order to conserve space and place all operations behind the dam, to consider placing some evaporation ponds over completed trenches. We did so and found it to be an excellent suggestion, and

b. in fact, there is no better place to put a pond with respect to seepage. If seepage occurs, it enters the trench, and

Pond Liner?

c. seepage is designed to be controlled by a five foot sheath of very low permeability, Zone 1 material, and

d. we have committed in the Discharge Plan and in this letter to maintain a final liquid level in the trenches at least ten feet below the solid tailings level. This committment is valid whether or not additional liquid seeps from a pond over a tailings trench.

4. With respect to tailings deposition, we have the following comments:

a. Calculations presented in several DM's substantiate our contention that gravity decantation is sufficiently rapid to comply with Plan requirements, and

b. we have also stated in the document that should more rapid separation of liquid be necessary, there are several processing alternatives available and they would be used. The simplest is merely to increase decantation time.

Other?

5. the diversion system has been constructed essentially to the initial design specifications except for implacement of riprap. This has previously been discussed, and

6. the trench used to cut off groundwater inflow to the site is simply an excavation cut through the alluvial gravels and barely into bedrock. In fact, it will be the same trench used to key in the riprap in that area of the diversion system. When the diversion embankment and tailings dam are reopened, this is accomplished by simply dozing down to bedrock, at the base of the original channel and replacing the gravel. The groundwater flow net is now restored, and

7. with respect to behavior of groundwater in the alluvial gravel, at the sides of the present channels, it will be no different after reclamation than it is now. The recharge to these gravels and their subsequent discharge is controlled by the water level in the channel, not by the thickness of cover above them. This groundwater will have no impact on the reclaimed area, and

8. with respect to bonding requirements, they are neither set by, nor proposed by the applicant. They are the perogative of the state, and

9. there are no plans at this time to backfill tailings, nor is such required. Therefore, such procedures do not form part of the Discharge Plan. Should backfilling become a viable alternative to trench construction, SRIC is correct that this would represent a modification and thus a new application.

Concerning those points referred to in Mr. Bob E. Watt's letter of November 14, 1979:

1. Radiation hazard from the residual liquid after full operations is not a problem. The liquid will not be handled by personnel but pumped to the final trench, and

2. Assume on the other hand, that all radiation is out of the liquid and in one of two forms: a) penetrated into the pore space of the liner; or b) in precipitated solids lying at the bottom of the pond. Penetration into the liner has been calculated to be at least 30 cm. (see DM #2). In either case a or case b or a combination of the two, radiation below the 1 cm. depth is shielded by the material. This holds true even if the material is being moved. Even though we agree with Mr. Watt that he has used a high value for radiation, we will use his value of 1,000 Ci as Th230. Using 100 acres of final pond acreage, the areal density is:

$$\text{areal density} = \frac{1.0\ \text{E3 Ci Th230}}{100\ \text{ac.} \times 4.05\ \text{E3 m}^2/\text{ac.}} = 2.47\text{E} - 3\ \text{Ci/m}^2$$

and

3. with the activity distributed evenly (as it should be considering the source is a liquid solution) in the top 30 cm. of liner or precipitate, the areal density causing

3. (Cont'd.). radiation hazard is:

$$\frac{2.47E-3}{30} \frac{Ci}{m^2} = 8.10E-5\ Ci/m^2 = 8.10E7\ pCi/m^2$$

Only the contribution from the top 1 cm. of material is considered because the decay radiation of Th230 consists of alpha particles and low intensity, weak X-rays. All of these emissions, except for the X-rays from the top 1 cm of material, are effectively shielded by the material iteself, and

4. The total body dose rate at a point 1 meter above the surface of the material is:

$$DR = 6.99E-11 \frac{mrem/hr}{pCi/m^2} \text{ X } 8.10E7\ pCi/m^2$$

$$= 0.0056 \text{ m rem/hr.}$$

This dose rate assumes no shielding whatsoever. The placement of a person upon an earth moving machine will further reduce the dose rate by one or two orders of magnitude. Limits on radiation exposures to workers are specified in Title 10, CFR, Part 20, Section 101, paragraph (a) as 1.25E3 m rem per calendar quarter. A calendar quarter is 520 working hours. The statutory limit therefore, averages to 2.40 m rem/hr. which is more than four hundred times higher than the maximum expected dose rate of 0.00E5 m rem/hrs. Workers in the area will be required to follow the standard badging and safety procedure of the high radiation areas of the mill and to wear respirators, and

5. the final concentration and volume of H_2SO_4 in the evaporation ponds is determined according to:

a. From Figure 10.1 of the Discharge Plan:

H_2SO_4 to tailings = 40 tons/day

Liquid (including H_2SO_4) to tailings = 2685 tons/day

Weight %, concentration H_2SO_4 to tailings = 40/2685 = 1.49%,

b. From Designers Memorandum #8, 33% of the liquid to tailings will be retained by the solids in the disposal trenches:

(40 tons/day) (0.67) = 26.7 tons/day H_2SO_4 to evaporation ponds,

c. Weight of H_2SO_4 to evaporation ponds over the twenty years:
(26.7 tons/day) (2000 lbs./ton) (365 days/year) (20 years)
$= 3.89 \times 10^8$ lbs. H_2SO_4,

d. Volume H_2SO_4 to evaporation ponds:
From CRC, specific gravity $H_2SO_4 = 1.72$
Bulk density = (1.72) (62.4 lbs./ft.^{3}) = 107 lbs./ft.^{3}

$$\text{Vol. } H_2SO_4 \text{ in 20 years} = \frac{3.89 \times 10^8 \text{ lbs.}}{107 \text{ lbs./ft.}^3}$$

$= 3.64 \times 10^6$ ft.^{3}
= 83.5 acre-feet,

e. Total weight of evaporation system with 83.5 ac-ft. of H_2SO_4
(700 ac-ft. - 83.5 ac-ft.) (43560 ft.^{3}/ac-ft.) (67.4 lbs./ft.^{3})
$= 1.68 \times 10^9$ lbs. H_2O
(83.5 ac-ft.) (43560 ft.^{3}/ac-ft.) (107 lbs./ft.^{3})
$= 3.89 \times 10^8$ lbs. H_2SO_4

Wt. % H_2SO_4 @ 20 years
$= [3.89 \times 10^8 / (1.68 \times 10^9 + 3.89 \times 10^8)] \times 100$
= 18.8%

Thus, in 20 years ponds will be 18.8% with a volume of 700 ac-ft, and

6. the limiting H_2SO_4 concentration for H_2O evaporation from the ponds is determined from and based upon the following:

a. the attached figure 1 (see item 7 for discussion) represents an experimental evaporation test conducted by W. A. Wahler and associates on a sulfuric acid/uranium raffinate solution. The curve indicates that the 2% raffinate solution evaporates at the same rate as distilled water up to an H_2SO_4 concentration of 10% by weight. At that point, the raffinate evaporation rate is reduced by 50% (i.e., slope change from 1:1.2 to 1:0.6) up to an acid concentration of approximately 20%. This indicates that when the evaporation acid concentration reaches 10 to 20%

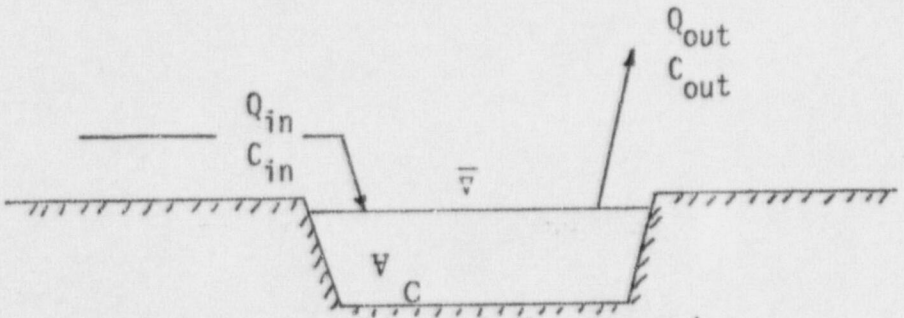
6. (Cont'd.). the following measures or combinations of these measures will be necessary:

   (1.) Neutralize pond acid with lime or caustic in a continuous or batch treatment process, and/or

   (2.) increase the evaporation pond acreage and/or volume, and

b. When will the evaporation ponds reach 10% acid concentration?:

The following diagram represents the evaporation pond system:



Where: Q_{in} = liquid inflow to ponds

= (2685 tons/day) (0.66) (2000 lbs/ton) (1 ft.^{3}/62.4 lbs.) (1 ac-ft./43560 ft.^{3})

= 1.30 ac-ft./day

C_{in} = concentration of acid to evaporation pond in wt. % = 1.49%

$\forall$ = Pond volume = 700 ac-ft.

C = Pond acid concentration in wt. % = ?

Q_{out} = Evaporation outflow = inflow = 1.30 ac-ft./day

C_{out} = concentration of acid in evaporation = 0

The following differential equation describes the mass balance of the evaporation system:

$$\frac{d(cv)}{dt} = Q_{in}\, C_{in} - Q_{out}\, C_{out}$$

Because $C_{out} = 0$, we have:

$$\frac{d(cv)}{dt} = Q_{in} C_{in}$$

or,

$$c\,\frac{dv}{dt} + \frac{dc}{dt} = Q_{in}\, C_{in}$$

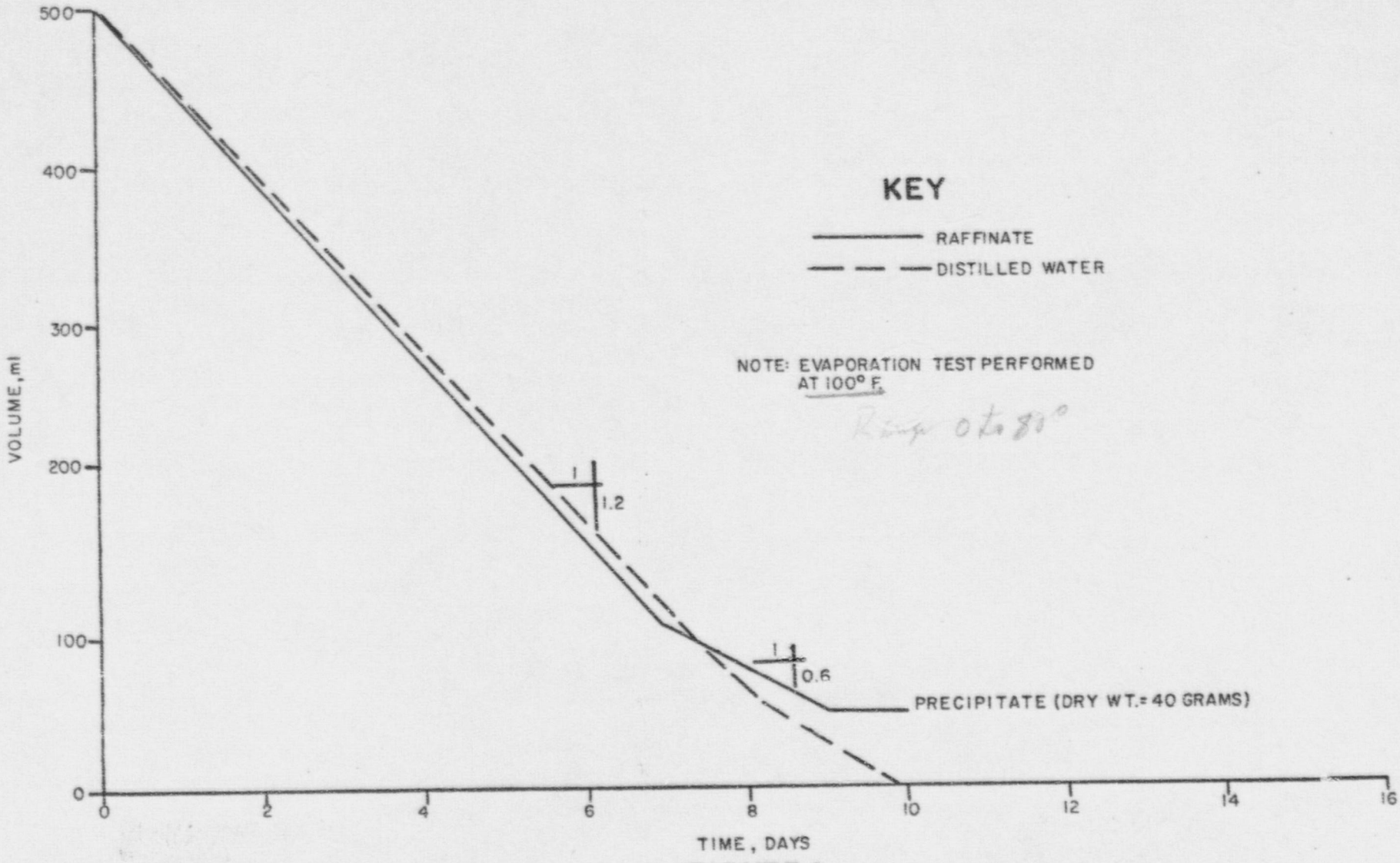

500
400
300
200
100
0
VOLUME, ml
0
2
4
6
8
10
12
14
16
TIME, DAYS
KEY
RAFFINATE
DISTILLED WATER
NOTE: EVAPORATION TEST PERFORMED AT 100° F.
Range 0 to 80°
1
1.2
1
1
0.6
PRECIPITATE (DRY WT.= 40 GRAMS)

FIGURE 1

Because the pond volume remains essentially constant (i.e., dv/dt = o), we have:

$$V \frac{dc}{dt} = Q_{in} C_{in}$$

Separating and integrating with the limiting boundary condition that $C = C_{in}$ at $t = t_o = 0$

$$\int_{c}^{c_{in}} dc = \frac{Q_{in}}{V} C_{in} \int_{t}^{t_o} dt$$

or,

$$C = \frac{Q_{in}}{V} C_{in} t + C_{in}$$

Solving for t, for C = 10%, Q_{in} = 1.30 ac-ft./day, C_{in} = 1.49%

t = 3075 days = 8.4 years, and

7. Samples of 500 milliliters each of acid raffinate and distilled water were placed in an oven set at 100°F. The loss due to evaporation was determined daily until the distilled water totaly evaporated and the raffinate crystalized after 95 percent evaporation. The oven dry weight of the crystalized sediment was 40 grams. A plot of evaporation versus time appears on Figure 1. Laboratory testing of the raffinate samples was performed to determine the rate of evaporation as the concentration of dissolved solids in increased (Figure 1). This curve of evaporation versus time shows that the rate of evaporation is constant and nearly the same as clean water until the concentration of dissolved solids reaches approximately 400,000 mg/l. At this point, the rate of evaporation decreases rapidly to near zero and dissolved solids start coming out of solution and forming a precipitate. For design purposes it was assumed that the evaporation rate of the pond liquor is 90% clean water until the concentration of dissolved solids reaches 400,000 mg/l, and

8. Handling of sulfuric acid in concentrations up to 25% by weight is accomplished by using available equipment as follows: "Requires equipment utilizing PVC, teflon, rubber and other standard materials and equipment available from commercial suppliers."

   (Personal communication w/Mr. Jan Acrea - Vice President, Chemical Marketing Services, Denver, Colo. - Reg. Professional Engineer, State of Texas, No. 23084)

and

Fasullo, O.J. Sulfuric Acid Use and Handling, McGraw-Hill, 1965.

Regarding the comments presented by Stephen Wells we commit to:

1. slope measurements will be made in the tailings area to define existing surface conditions, in both the evaporation pond and trench areas. This data in addition to other baseline date (i.e. Marquez Channel survey) will be provided to the EID. Present slopes are variable as will be the slopes at different locations on the reclaimed tailings area. In fact, the slopes in certain reclaimed areas may be steeper than the original subjacent slopes.

2. It would be expected that soil constituents on a reclaimed surface are variable. Just as with the existing undisturbed soil which shows a substantial variation in constituents from one location to another. Additionally, as with the existing surface you would expect differential erosion to occur, we are not saying that the reclaimed surface will contain a uniform distribution of constituents, thus implying uniform erosion. Differential erosion will occur, and

3. as site specific reclamation data on soil and vegetation conditions for undisturbed surfaces is gathered, it will be presented to the EID. The reclamation program will be modified to respond to those individual characteristics of each location and data on individual soil types, texture, thickness and other physical properties, type of vegetation, plus necessary data on root/soil density will be accumulated and presented to the EID for review prior to finalizing site specific reclamation plans, and

4. the recommendations presented in DM #5, will be included in the finalized reclamation plans. Specifically, land surface configurations as discussed on pages 3 & 4 of the DM, and

5. collection basins will be designed and located according to the necessity for optimizing runoff protection. Final design and locations will be presented to the EID prior to commencing their construction, and

6. as a point of clarification, the reclaimed surfaces will be designed to a 1:8 or 1:10 (v:h) slope. This is in agreement with the statement made in DM #5, pg. 4, para. 3, " . . . shaping is recommended to be at least 1v:2h.". The statement made on pg. 87 is intended to convey that those recommendations in DM #5 will be followed plus the addition of even more conservative geomorphic controls by creating shallow (1:8, 1:10) slopes, and

7. survey will be completed on the present Marquez channel configuration within 12 months after mill startup. This baseline data along with the assessment of channel parameters defined on page 2 will restore Marquez to its original course and greatly minimize any post-operational readjustment of this channel.

In regard to the letter from Physicians for Social Responsibility, dated November 25, 1979, we submit:

1. the current plan does present sufficient technical information, both in graphical and narrative form, to document the tailings disposal plan, and

2. the descriptive narrative discusses various hydrologic aspects of this disposal plan. Specifically, Section II, III, IV and V plus Designer's Memorandum #1, Appendix E.

Concerning the letter of November 26, 1979, from Constance Atkins, we submit:

1. that questions on the content of this plan have been responded to previously.

Regarding the letter of November 23, 1979, from both Victoria Cross and Anne Kirschner, we submit:

1. as previously stated information concerning the contents of this plan are discussed above, and

2. hydrologic discussion are presented in various sections of the plan and are discussed above, and

3. the topic of fluid levels in the trenches is previously discussed in response to recommendations by Donald Runnells.

Concerning the letter from Mary Kiseley and Patricia French dated November 26, 1979, we submit:

1. the contents of this discharge plan are discussed above, and

2. the topic of alternative sites is discussed above, and

3. the topic of bonding is discussed above, and

4. the hydrologic aspects of this plan are discussed above. The ground water regime and specifically, the stratigraphy at this site, are not the same as the conditions at Church Rock. Refer to previous discussion for specific details.

Regarding the letter from Mr. Danny Buck dated November 25, 1979, we submit:

1. specific details on trench and pond locations are presented in the plan and reiterated above, and

2. hydrologic discussions specifically fluid levels in trenches, are presented above.

This concludes our responses to these questions. If you have any questions after reviewing this presentation, please call me.

Very truly yours,
BOKUM RESOURCES CORPORATION

Raymond R. Waggoner
Environmental Manager

RRW:ks

cc: Dr. Gale Billings, SAI

7 Xerox cpys made
1 Bruce Gallichio 6 Dec 79
1 Calvin Clayton 7 Dec 79
1 NRC by Pamela 10 Dec 79
1 Johnny Nelson 10 Dec 79