REVIEW OF THE MARLINE/UMETCO TECHNICAL SUMMARY AND SUPPORTING MEMORANDA FOR THE SWANSON URANIUM PROJECT, PITTSYLVANIA COUNTY, VIRGINIA

ROGERS, GOLDEN & HALPERN

SEPTEMBER 5, 1984

RG&H

September 5, 1984

Mr. Richard Collins
Institute for Environmental Negotiation
Campbell Hall, University of Virginia
Charlottesville, VA 22903

RE: Transmittal of Rogers, Golden & Halpern Final Report on Marline/Umetco Technical Summary and Supporting Memoranda

Dear Mr. Collins:

Enclosed are three (3) copies of RGH's review of Marline/Umetco's technical summary for the Swanson Uranium Project. This review incorporates the status of all items in which Rogers, Golden & Halpern has a review role. Our review is generally in line with the draft version submitted to you on August 24, 1984 and discussed with you, Bruce Dotson, and Tim Mealy by telephone call on August 29. We have attempted to reflect your comments in the content and format of our final report.

Our report is organized to provide background context for the 1984 consultant studies and to clearly define our scope of work. We have included the memoranda produced under this contract as Appendix A, as requested by Tim Mealy.

It is our understanding that IEN will be preparing a document integrating the reports of all the Commonwealth's consultants and we have considered this in preparing our final report.

Rogers, Golden & Halpern looks forward to our meeting on Thursday, September 6 and to presenting our findings on September 7 in Richmond.

Sincerely yours,

Jack A. Halpern

Jack A. Halpern

Enclosures

cc: Dr. Bernard Caton (2)

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September 5, 1984

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FOREWORD

Rogers, Golden & Halpern (RGH) is a participant on behalf of the Commonwealth of Virginia in the "technical mediation" process for the Swanson Uranium Project in Pittsylvania County. The process was initiated by the Uranium Task Force (UTF) between Marline/Umetco[1] and the Commonwealth. It was intended to reduce informational uncertainties from 1983 studies and reviews by October 1984.

RGH attended the initial negotiation meeting of this process in Charlottesville, Virginia on April 11 and 12, 1984. The purpose of this meeting was to define any outstanding issues regarding the proposed project. For this meeting a comprehensive, ten-page list of issues or topics that needed further discussion was prepared by the Institute for Environmental Negotiation (IEN). This document was compiled from prior years' studies, reports, and discussions. Assignments and scope of work definitions for Rogers, Golden & Halpern and other state consultants were developed by IEN as a result of this meeting. IEN coordinated the work of all state consultants and their interactions with Marline/Umetco.

Rogers, Golden & Halpern's scope of work within the process was limited to a review of:

1. Methods of analysis for and chemical characteristics of uranium ore, mineralized rock, waste rock and their leachates,

2. Clay quantity, mechanical, and chemical studies,

3. The tailings and waste rock management concept,

4. Input parameters for the PABLM computer model (waterborne radionuclide pathways analysis), and

5. Adequacy of other site-specific uranium studies.

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[1]The joint venture of the Marline Uranium Corporation and Umetco, a subsidiary of the Union Carbide Corporation, that has proposed the Swanson Project.

As part of its scope of work, RGH attended several meetings in Danville, Charlottesville, and Richmond, Virginia. On April 24, 1984 a meeting was held in Danville to review the protocol for composite sampling of ore, sub-grade rock, and barren crystalline and Triassic rock. Analytical methods were also specified at this meeting. RGH attended a meeting in Richmond on May 2 to further review previous comments on the tailings facility. RGH also participated in a meeting regarding the socioeconomic effects and cost-benefit aspects of the project on May 21, 1984 in Charlottesville. Pursuant to this meeting RGH provided a memorandum (6/8/84) regarding these considerations to IEN and the Tayloe Murphy Institute.

Rogers, Golden & Halpern has reviewed all material within its scope of work that has been submitted by Marline/Umetco and its consultants. RGH has discussed this material in a number of conference calls as well as the following memoranda:

Date	Title
5/22/84	Available Clay Volumes at Banister River
5/22/84	Chemical and Radiological Properties of Ore and Waste Rock
5/22/84	Review of CSMRI (Colorado School of Mines Research Institute) Leachability Testing
6/08/84	Response to the May 21 Meeting in Charlottesville Concerning the Gibbs & Hill Socioeconomic Report
6/19/84	Response to June 15, 1984 Conference Call Regarding PABLM Inputs
6/21/84	Chemical Analyses of Swanson Rock Materials
6/21/84	Swanson Tailings Management Area - Clay Issues
7/03/84	Response to June 29, 1984 Conference Call Regarding PABLM Inputs
7/09/84	Telephone Log of Notary/Kennedy Discussion of Evaporation and Seepage
7/10/84	Response to Jack Parker's Clay Memo
7/11/84	Response to July 9, 1984 Conference Call Regarding PABLM Inputs

These memoranda are included as Appendix A of this report.

RGH's review of the technical summary and memoranda, included in this report, and presentation of our findings complete this contract.

INTRODUCTION

This report is the Rogers, Golden & Halpern review of the Marline/Umetco Technical Summary and 1984 Supplement with Supporting Technical Memoranda, FINAL DRAFT, August 1984. In the three-volume summary document, Marline/Umetco presents clarifications and modifications to its October 1983 development plan for the Swanson Uranium Project. Before proceeding to the review, it is very important that the reader understand the Swanson Project features as proposed by Marline/Umetco. The project proposals have evolved gradually, in a way intended to eliminate undesirable environmental impacts. Table 1 listing the specifications of the Swanson Project as currently proposed is necessary to understanding the RGH comments on the Marline/ Umetco technical summary.

The analysis presented by Marline/Umetco assumes that these specifications will essentially be met. As detailed engineering designs are developed changes to these specifications may occur.

Developing the project in accordance with different specifications will necessitate reexamination of the Swanson Project impacts that are presented in the technical summary document. In cases where the specification has to do with the scale of the project, changes in impact proportionate to changes in scale are to be expected. Where the proposed technology changes, a new analysis would be warranted. Changes in the more critical items in the list in Table 1 directly affect the environmental acceptability and/or economic feasibility of the project.

An example of a critical assumption, which Marline/Umetco has indicated might change, is the milling process. Many of Marline/Umetco's comments regarding ways in which it would mitigate impacts of the project are based on the carbonate leaching process. Marline/Umetco and its consultants have acknowledged that the acid leaching process is an entirely different situation. Thus, it would be reasonable to require a re-evaluation of the impacts of the project if the milling process were changed.

Table 1

Current Specifications of the Swanson Uranium Project

Mine

- The open pit method will be used to mine the ore.
- The mine will result in a single pit.
- The mine pit will be a maximum of 850 feet deep.
- The mine pit will occupy 110 acres at the surface.
- The volume of the pit will be approximately 65 million cubic yards.
- 135 acres are required for the mine and support activities.
- The operational life of the mine is 13 years.
- Anticipated ground water inflow to the mine is 92 gallons per minute.

Mill

- The mill feed will have an average concentration of 0.1 percent U_3O_8.
- The ore will be milled with the carbonate leach process.
- There will be no point-source discharge from the milling process.
- The mill will have one lined pond with a surface area of 4 acres.
- 200 acres are required for the mill and the ore stockpile.
- The mill will process 3,000 tons per day of ore for a 350-day production year or 1.05 million tons per year for 13 years.

Tailings and waste rock management

- Approximately 13.5 million tons of tailings solids will be produced over the life of the project.
- 191 acres are required for the tailings pile at an average depth of 33 feet.
- The tailings will be encapsulated with from 25 to 40 feet of mine overburden and waste rock.
- The tailings will be dewatered by a belt filter press to a water content of 25 percent by weight.
- A maximum of 10 acres of tailings will be uncovered at any time.
- There will be no standing water between the tailings and the temporary clay dams.
- The tailings pile will have at least an 18-inch thick clay liner with a permeability of no more than 10^{-7} centimeters per second (.1 foot/year). (Marline/Umetco believes a permeability of 10^{-8} centimeters per second is achievable with local clays.)
- The tailings pile will be covered with a reclamation cap consisting of 12 inches of clay (permeability 10^{-7} centimeters per second), an eight-inch gravel drain and at least eight feet of random fill.
- All mineralized waste rock will be covered by barren waste rock.
- Waste rock areas will not be lined.
- The waste rock piles will be located only in Whitethorn Creek and Mill Creek drainage basins.
- Approximately 930 acres are required for the mine overburden and waste rock storage areas (including the rock over the tailings management area).
- Mill Creek will be diverted around the tailings/waste rock area.
- Marline/Umetco will control access to and use of water along the length of the Mill Creek diversion to its confluence with Whitethorn Creek.
- Marline/Umetco will control ground water access between tailings/waste rock areas and streams to eliminate potable well water pathways.
- Sufficient clay with suitable properties for the entire facility is available locally.

TECHNICAL SUMMARY REVIEW

Since April 1984, RGH has been involved in discussions with Marline/Umetco and its consultants regarding several aspects of the Swanson project within RGH's current scope of work. These discussions were coordinated by the staff of the Institute for Environmental Negotiation. While many of the issues that were raised have been resolved by these talks, several remain unresolved. RGH will address both resolved and unresolved issues in order to give a perspective on the changes in the project or the analysis on these particular items from 1983 to 1984 and the role of Rogers, Golden & Halpern.

Clay Issues

The presence of suitable -- low permeability and high geochemical attenuation capacity -- clays within the locale of the project is assumed by Marline/Umetco. The important uses of these clays are as liners, containment dams and reclamation caps for the tailings pile. These clays are intended to reduce the rate at which radionuclides and other pollutants in the tailings enter the environment. What have been called "clay issues" in this and other reviews by state consultants include:

1. Whether there is an adequate volume of clays present for the purposes intended,
2. The appropriate permeability of these clays to be used in the analysis of environmental effects,
3. The extent of attenuation of radionuclides that has been demonstrated to be achievable by these clays,
4. The suitability of these clays for the structural purposes proposed, and
5. The probable source of clays.

Clay Availability

Preliminary investigations by Marline/Umetco have shown that a sufficient volume of clay-sized material is locally available to construct an 18-inch liner and 12-inch reclamation cap for the tailings management area. Clay to build the temporary dams and berms was not included in this analysis, and neither was the quantity needed to line the facility's various ponds. In addition, no provision was made for clay lining any waste

rock areas, particularly areas containing sub-grade ore. The appropriateness of an 18-inch clay liner was questioned, as several government agencies, as well as the state's consultant on clay issues, recommend a liner on the order of three-feet thick. If a three-foot liner is constructed, it alone would require all of the demonstrated local clay reserves meeting permeability specifications.

The problem with the analyses presented to date is that there is not sufficient information to enable RGH to determine if the clay-sized materials encountered in the Banister River floodplain are of consistent and compatible mineralogy to perform both the permeability and geochemical attenuation functions as Marline/Umetco has proposed. The studies necessary to make this determination have not been performed to date, and will not be available within the current legislative session. The result of not having this information is that, while there may be sufficient clay-sized material in the proposed borrow areas, it may not be suitable for the liner as proposed. Further elaboration on these points is found in the subsections that follow.

Clay Permeability

Testing of the mechanical properties of the clays was conducted in a manner consistent with standard engineering laboratory practices to evaluate the permeability of clay materials. These tests show that the potential Banister River area borrow materials can be compacted to the general range of hydraulic conductivities proposed (3.7×10^{-8} centimeters per second under laboratory conditions). In our experience, the field excavation, placement, and compaction of such material takes place under considerably less controlled conditions than are possible in the laboratory. A recompacted permeability of 1×10^{-8} centimeters per second over several hundred acres would be difficult to guarantee during the life and post-closure period of the facility. On this basis it was resolved to use a higher permeability -- 10^{-7} centimeters per second -- for the analysis of waterborne radionuclide impacts from the tailings pile. The water balance and other references in the technical summary are based on the lower (10^{-8}) permeability but the 1984 PABLM analysis uses the agreed upon higher (10^{-7}) value.

Seepage Attenuation

As stated earlier, the characterization of the available clays has not been presented in sufficient detail to provide a reasonable estimate of their ability to contain

or attenuate fluids that may pass through them. Because of schedule constraints, the testing that could resolve these questions has not been performed. Presumably, these tests will occur in the future. In lieu of this testing, Marline/Umetco provided what it believes to be pertinent literature on the subject of uranium tailings management with clay liners. None of this literature deals with tailings from an alkaline leach process, and so is not directly applicable to the Swanson Project tailings.

As several of the state's consultants have stated in previous memos, the column tests reported in the October 1983 submittal by Marline/Umetco were of extremely limited value. The significant desorption of several cations from the clay has never been adequately addressed, and the method used to calculate the distribution coefficients was non-standard. These values should only be referenced with appropriate qualifications in the future.

To our knowledge, there has never been any mineralogic identification of these clays by Marline/Umetco. The mineralogy of the clays is very important in terms of how the clay will react with the contained waste. In the prediction of clay liner performance, mineralogy is one of the key considerations in determining whether there is comparability between any two samples of clay-sized material. Identifying the clay minerals present is as important as the size-distribution analyses and proper clay column testing for geochemical attenuation potential evaluation. It is essential in determining whether the local clay has the properties required to perform as stated, and ultimately whether sufficient volumes of acceptable material are available locally.

Because attenuation of the harmful constituents has not been clearly demonstrated, Marline/Umetco agreed to use raw, unattenuated tailings fluid in the PABLM radiologic pathways analysis. These values are a good, conservative representative of long-term conditions because attenuation merely slows down pollutant migration, but does not stop it. The PABLM model was also run with Marline/Umetco's estimated attenuation of radionuclides by the clay liner to evaluate a best case condition. However, RGH asserts that the unattenuated values are more appropriate at this time.

Clay Liner Integrity and Geotechnical Considerations

Rogers, Golden & Halpern, in responding to Technical Memorandum No. 3, Stability Evaluation of Tailings Facility, commented that the evaluation did not discuss the effect

of the clay liner on the overall stability of the facility nor the effect of the tailings and overburden on the integrity and possible differential settlement of the liner.

Technical Memorandum No. 6 and the references provided with it are the response of Marline/Umetco's geotechnical consultant to those comments. The response generically addresses the important geotechnical and construction concepts in the facility as proposed. The discussion provided and the consultant's assessment that there are no unusual conditions that cannot be accounted for in the design of the facility are reasonable assurances that this part of the project is feasible. Without getting into design of the facility it would be difficult to go further at this time.

The tailings management proposal seems feasible partly because the tailings are not to be used in the construction of the containment dam. The dam is apparently an earth or rockfill dam, which can be designed to meet the conditions anticipated at the site. The proposed tailings management plan does not depend on the stability of hydraulically deposited, fine tailings as is typical in many "tailings ponds" or "tailings dams." An important caveat here is that the proposal must be reexamined if the tailings are not to be dewatered or are to be used in construction.

Other important considerations that must be incorporated within the design of the facility will be 1) settlement of the liner, 2) integrity of the liner under extreme earthquake conditions, and 3) support of the rock fill by the tailings. This work is appropriate for future, more detailed design stages.

Clay Borrow Area

At the present time and with the present clay volume requirements, approximately 200 acres adjacent to and in the floodplain of the Banister River would be disturbed by the clay borrow operation. The impact of this disturbance has not been assessed.

Characeristics of Swanson Rock Materials

Several composites of Swanson ore grade material have been prepared by Marline/Umetco. The analyses of these composites correlate very well and show the Swanson ore to contain relatively small amounts of the trace metal contaminants found in other uranium ores.

Limited analyses have also been presented for a sub-grade ore composite, barren crystalline rock, and barren Triassic rock. These analyses have shown that these rock types are not significantly enriched with any trace chemical constituents that could cause problems if leached from piles of these materials. However, radiological analysis of the sub-grade ore composite has shown this material to contain elevated concentrations of several radionuclides, particularly radium-226 and thorium-230. The high concentrations of these nuclides will cause this material to emit significant quantities of radon-222. Due to the diffuse nature of the Swanson deposit, the potential exists for production of large quantities of the sub-grade ore. A recent EPA report titled Potential Health and Environmental Hazards of Uranium Mine Wastes states that the accumulation rate of sub-grade ore at uranium mines equals the ore production rate (EPA, 1983). Marline/Umetco does not currently plan to segregate this material, while most other uranium mines do. In addition, it should be noted that the barren crystalline rock contains 5.9 +/-0.4 pCi/g of radium-226. EPA has suggested that materials containing more than 5 pCi/g of radium-226 be treated as hazardous waste. It may thus be inappropriate to dispose of this material in unlined piles along with the barren waste.

Waste Rock Handling

The final technical summary has indicated that the waste rock area that was previously located partly in the Georges Creek drainage basin will now be constructed entirely in the Whitethorn Creek basin. The revised site map shows a hand-drawn area of irregular shape and approximately 260 acres partially overlapping the original location of the waste pile. The location and shape of this area have not been presented before. While it is recognized that the analysis is presented at an early stage so that this configuration is not necessarily final, it is further understood that Marline/Umetco will locate this waste rock area wholly within the Whitethorn Creek surface and ground watershed to limit potential impacts to the streams for which impacts have been analyzed.

The technical summary also states that all sub-grade ore will be covered by barren Triassic and crystalline rock in the final configuration of the waste pile. If this is the case, some method of separately stockpiling the different materials becomes necessary. Marline/Umetco has not provided any indication as to how this will be accomplished. A large pile of exposed sub-grade ore will emit a quantity of radon approaching (within an

order of magnitude) that of an equivalent pile of ore. This quantity should be included in the dose calculations for airborne pathways (MILDOS).

Access to the Mill Creek Diversion

The location of the tailings management area requires Mill Creek to be re-routed. The technical summary lists three possible ways to accomplish this. As stated previously, the location of the Mill Creek diversion is very important when assessing the environmental impacts of the project. It is also of primary importance in the pathways analysis. The Mill Creek receptor has been dropped from the 1984 PABLM analysis on the assumption that Marline/Umetco will control access along the entire length of the diversion. Marline/Umetco should make a committment that this will also be the case if an alternate route is chosen. The Mill Creek receptor was previously the critical receptor and a comparable location would be expected to have a much higher calculated dose under the 1984 PABLM assumptions. This receptor would be of concern unless activities and pathways can be precluded.

PABLM

The PABLM computer code was used in the 1983 Marline report to assess the radiological dose from surface water pathways. It was agreed as part of the mediation process to rerun PABLM in 1984 with such additional scenarios and different input parameters as resulted from discussions with the Commonwealth's consultants. These 1984 runs were completed as presented in the technical summary after many of the issues regarding PABLM inputs were resolved. Issues relevant to PABLM are discussed below.

Justification

The computer code PABLM was originally developed by Battelle Pacific Northwest Laboratories for the Office of Nuclear Waste Isolation to be used in assessing potential geologic nuclear waste repositories and nuclear power plants. The code has never been validated or verified, nor has a sensitivity analysis been conducted. The Nuclear Regulatory Commission is currently conducting a benchmark study of the model (Mills, personal communication, 1984). RGH has been unable to locate any reference to a site where PABLM has been used to assess the radiological dose to man, although portions of

PABLM and its predecessors have apparently been used for a study in British Columbia. In terms of justifying the use of PABLM for this project, RGH has not found unequivocal evidence that would support the use of this model for this application. RGH's primary reservation is that PABLM has not been used for a similar project at a specific site. This reservation also applies to PATH1/DOSHEM, BIODOSE, and other computer codes for surface water radiological assessment. On this basis PABLM is as appropriate as other available models **at this time.** Specific problems with PABLM that we are aware of are:

1. It uses older method and factors for calculated dose, and
2. The time period is inflexibly one year, which does not allow for handling short-term releases well.

Regarding the first problem, modifications to the dose factor tables to incorporate more recent, but not the most recent, International Commission on Radiological Projection (ICRP) standard models were made in the 1984 PABLM runs. RGH cannot comment authoritatively on the effect of using different ICRP standards in PABLM, including ICRP-30 now pending, except that these differences must be better explained vis-a-vis the 1984 PABLM results in order for there to be an understanding of the effect that the currently proposed standard would have on the predicted outcome.

Input Parameters

1. Treated mine water radionuclide concentrations - The PABLM inputs include a **dissolved** radium-226 concentration of 3.0 picocuries per liter in the treated mine water discharge. This is based on EPA's maximum allowable 30-day average concentration. However, EPA permits up to 10.0 picocuries per liter (30-day average) total radium-226. RGH feels that the highest allowable concentration should have been run in PABLM because any users of this water could receive the higher dose. We had not made this comment prior to the 1984 PABLM runs. This change can be accounted for by using linear multipliers with the 1984 PABLM inputs as discussed in Technical Memorandum No. 13.

2. Saprolite ground water - RGH has recommended that the shallow ground water intercepted at the perimeter of the mine pit and discharged to Mill Creek be included both as a source of radiation in the dose calculations and as a discharge in the project water balance. It has never been included in either. This discharge is significant

in comparison to the treated mine water discharge both in terms of quantity (140 gallons per minute vs. 166 gallons per minute) and radionuclide content.

A letter to RGH from Dravo Engineers, Inc., dated August 8, 1984, which was requested by IEN, addresses the quality of this shallow ground water. The letter and the previous tests it references demonstrate adequately that this water would not have to be treated and could be directly discharged. RGH agrees with this conclusion. It was never RGH's contention that this water would require treatment. However, RGH still maintains that this is a discharge that should have been included in the project water balance.

Regarding its inclusion in PABLM, we understand that this water is normally part of the base flow of Mill Creek. As such it would be part of background radiation dose, which is not included in PABLM. We have not been able to confirm that background dose measurements and estimates for this project include the contribution of surface water at measured radionuclide concentrations via all pathways including irrigation.

3. Pond breach - The original purpose of the inclusion of a "pond breach" scenario was to represent a worst case scenario of a tailings dam failure. A breach in the temporary dam or permanent containment of the tailings could result in a release of solids and a modification of the dose calculations. The pond breach now modeled is a limited failure of the **mill** pond with a release of about one foot of water. This is not even the entire volume of the pond (which has not been specified). As acute (short-term) releases are handled in PABLM this volume is so diluted that it is not likely to contribute significantly to dose. Reviewers of the technical summary should be aware that the effects of a catastrophic tailings dam failure are not included in PABLM as run. The effects of such a release are probably better estimated outside of PABLM and then combined with other doses.

4. Flow rates - RGH agrees in principle that annual flow rates should be used to model chronic conditions in PABLM. The average annual flow rates (Q_{avg}) are appropriate for the long-term (50-year) dose committment calculations. However, for the short-term dose, the one-year flow will be lower than the average over a long time period. An estimate of annual low flows for various return periods is necessary to determine appropriate flow rates to consider in a sensitivity analysis of the results for a

short-term (one-year) dose. Seepage rates are also potentially lower in a dry year but a worst case assessment would only consider less dilution and corresponding higher dose.

The flow rates used in PABLM were calculated flows based on drainage basin area, however, and not actually measured. Differences between the calculated and actual flow rates would affect the dose calculations. For example, the average annual flow measured for the Banister River at Halifax is 506 cubic feet per second vs. 550 calculated. For the lower flow, doses would increase by about 9%.

RGH agreed to an average annual flow of 30 cubic feet per second for Whitethorn Creek at its confluence with Mill Creek. The technical summary adds to this flow the 10.5 cubic feet per second average flow of Mill Creek to calculate PABLM inputs. Marline/Umetco should justify this value as it decreases dosage proportionately.

5. Evapotranspiration and seepage rates - The 1984 supplement includes seepage from mine overburden and waste rock storage areas as radionuclide sources not included in the 1983 PABLM analysis. In response to Technical Memorandum No. 5, which calculated seepage rates proposed to be used in PABLM, RGH commented that evaporation rates from unvegetated overburden and unvegetated tailings covered with waste rock were higher than would normally be expected from rock piles. Higher evaporation estimates would lead to correspondingly lower seepage rates. RGH had recommended that either no evaporation from these areas be considered as a worst case estimate of seepage or that, at most, 25 percent of the area be assumed to have enough gravel or finer material at the surface to result in evaporation rates as estimated by Marline/Umetco's consultant.

Subsequently, Technical Memorandum No. 11, Supporting Data on Evaporation from Rock Fills, was prepared by Dravo Engineers, Inc. to make a case for the evaporation rates proposed in Technical Memorandum No. 5. Although the Minnesota mine waste data presented seem to support an evaporation rate comparable to that used, RGH would question whether the rockfill particle size distribution for this project will be comparable, particularly when the first step of the milling process is screening rock through a grizzly with 36-inch square openings. The CANMET data provided seem to indicate that only 24 percent of typical waste rock is finer than gravel. Depending on distribution throughout the surface of the rock pile, the 25 percent of the area having significant evaporation RGH suggested is a reasonable compromise value.

In any case, the increase in predicted seepage assuming no evaporation from these areas (1.056 vs. .814 cfs from waste rock and overburden) is not out of line to use in a worst case analysis for short-term (one-year) dose. For the long-term (50-year) dose commitment, the seepage rates used by Marline/Umetco consultants in PABLM are conservative, because the tailings and waste rock areas will be unvegetated for only about one year.

An additional issue regarding the seepage rates from the tailings pile is the effect of assuming a liner with a higher permeability (10^{-7} vs. 10^{-8} centimeters per second) as suggested by the state's consultants. Dravo provided calculations (Technical Memorandum No. 12) to show that with the higher permeability liner, the level of saturation in the tailings and hence the seepage rate decreases over time. In either case of liner permeability, the seepage will eventually stabilize at an equilibrium rate. RGH accepts this reasoning and the proposed average seepage rate, although RGH does not completely agree with the calculations provided.

6. Tobacco uptake pathway - Previous studies (Harley et al., 1978; Athalye et al., 1972) have shown the uptake of radionuclides by tobacco. No attempt has been made to model this possible pathway at the Swanson site or the effect of the project on the tobacco crop.

If the specifications in table 1 are met, other PABLM inputs have been treated as recommended and as agreed in conference calls and follow-up memoranda.

PABLM Inputs/Computer Printout

Rogers, Golden & Halpern requested that the inputs to the PABLM computer program be provided in the form that they are actually to be input to the program, including supporting calculations for any conversions or other changes to the input parameters provided. The validity of insisting on this is clearly demonstrated by Volume 3 of the technical summary. Although most readers of the summary will bypass this document or leave it to the state's consultants, the information presented should be clear and correct to any reviewer. This is also important in terms of RGH's review because its scope is limited to PABLM inputs; RGH assumes that if the PABLM inputs are correct, the model results will be correct.

Specific problems with the printouts, as listed in Appendix B, have been pointed out to IEN. These are not concerns that will be meaningful to the typical reviewer. Their impact on the results cannot be evaluated without clarification from Marline/Umetco.

1984 PABLM Results

Although Marline/Umetco has done an excellent job of summarizing the differences between the 1983 and 1984 PABLM results, the real question as to which assessments are meaningful is left unanswered. From our perspective, the 1984 runs should be more significant because of their more comprehensive scope and additional data and only they should be considered as representative. However, unfortunately, because of the detailed description of the 1983 inputs and results in the technical summary and because the 1983 runs are in the nine-volume report, these results will undoubtedly be considered. RGH asserts that there is no way to compare the 1983 and 1984 results because of the number and types of changes and that this should be clearly pointed out to reviewers. The 1984 PABLM results are really a replacement for, instead of a supplement to, the original work with one important exception: only the 1983 PABLM results consider the Mill Creek receptor. They therefore present the only data that gives an approximation of the importance of Marline/Umetco controlling activities near the Mill Creek diversion. Otherwise, the 1983 results should be ignored.

SUMMARY

Marline/Umetco has responded to a number of issues raised by Virginia's consultants during the 1984 technical mediation process. Not all of these issues have been resolved. The question that remains is the significance of these unresolved issues to the impact analyses that have been presented and ultimately to the regulatory process that may occur. It is RGH's professional judgement that any decisions to be made based on the analysis must bear in mind the following:

1. The dose from tobacco pathways and its impacts on the crop have not been considered.

2. No radiological dose calculations have been performed for acid leaching processes or mill discharges.

3. A receptor similar to the 1983 "Mill Creek receptor" is most likely to be the maximally affected individual in terms of radiologic dose unless Marline/Umetco can guarantee control of enough property to prevent access to and use of water from whatever diversion of Mill Creek is ultimately proposed. The revised (1984) PABLM analysis has not been performed for such a receptor.

4. Marline/Umetco must control access to ground water so that no potable water wells withdraw water seeping from the tailings pile and waste rock area before it enters adjacent streams.

5. The effects of a catastrophic tailings release have not been analyzed.

6. Short-term (one-year) radiological doses would be higher than those presented in the PABLM results for what RGH would consider a reasonable worst case analysis because of more seepage, lower flows, and higher radium-226 concentration.

7. Liner and reclamation cap clays must meet the permeability specifications proposed (even if they have to be imported from considerable distance) if the dose estimates are to be realistic.

8. The tailings must be dewatered for the tailings management and encapsulation plan to work as proposed.

9. The PABLM dose calculations estimate only incremental dose from the project and do not include background.

10. Interpretation of the PABLM outputs in terms of exposure standards and background dose is within the scope of other state consultants and RGH's comments should be considered in light of their review of the technical summary.

REFERENCES

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APPENDIX A

RGH Memoranda

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Jack Halpern, RG&H

DATE: May 22, 1984

RE: Available Clay Volumes at Banister River

Rogers, Golden & Halpern has reviewed PRELIMINARY TECHNICAL MEMORANDUM NUMBER 1 by Dravo Engineers, Inc. dated May 9, 1984. This memorandum addresses the Volumes of Available Clay in the Banister River Valley Alluvium. We reviewed the logs of the borings located on the map attached to the memorandum and the mechanical and chemical tests which we could attribute to clays taken from these borings. Our effort was concentrated on evaluating only the consistency of the materials discussed, and not on the mechanical or chemical characteristics which will be considered in other parts of our efforts this year.

Dravo's memorandum indicates that their borings A-21 through A-26 are representative of an area of 300 acres which should be capable of providing 2 million cubic yards of this type of material from a borrow area of 138 acres with an average excavation of 9 feet of clay. They have also indicated that there are other local sources of similar material available to the proponents.

We concur with the material presented with respect to the issue of VOLUMES OF COVER MATERIAL AVAILABLE. We reserve our evaluation of the suitability of those materials available to provide the necessary geotechnical (permeability, etc.) and chemical properties needed to manage the tailings until the specific questions raised in these areas are answered. If these properties are not found to be adequate, alternative sources of adequate material must be demonstrated.

cc: John Yellich, Marline Uranium Corporation
Don Gorber, SENES

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Jack Halpern, RG&H

DATE: May 22, 1984

RE: Chemical and Radiological Properties of Ore and Waste Rock

We have received and reviewed Stan Johnson's report to the Uranium Administrative Group Task Force dated May 3, 1984 on the assembling and analyses of an ore grade composite of the Swanson Project. It is our feeling that the sample preparation used is capable of producing a representative composite of both the ore-grade material and the mineralized waste. When compared to our compilation of whole rock analyses from the Swanson Project, the 0.05% and 0.01% U_3O_8 upper limits for mineralized waste and barren rock, respectively, seem reasonable. The changes made in the core holes and intervals that were sampled for the ore-grade composite and the few revised analytical detection limits are also acceptable.

We have also reviewed all of the new chemical and radiological data provided by Marline and have compiled this information with previous data in our files to allow a quick turnaround on the review of the new lab test data.

cc: John Yellich, Marline Uranium Corporation
Don Gorber, SENES
Stan Johnson, Division of Mineral Resources

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Phil Hopkins and Jack Halpern, RG&H

DATE: June 8, 1984

RE: The May 21 Meeting in Charlottesville concerning the Gibbs & Hill Socioeconomic Report

We have the following thoughts concerning our participation in the meeting in Charlottesville on May 21 that discussed the socioeconomic impacts of the Pittsylvania County Uranium Project. The meeting was very useful to RG&H and we were glad to be able to lend our expertise and our background that we have obtained over the preceding two years concerning the project. In particular, we feel our socioeconomic expertise was especially useful in helping the Institute to begin to consider the types of impacts and what needs to be addressed in the study that the Tayloe Murphy Institute is performing. Presented below are some of the observations that we made during the meeting and list for your consideration:

1. Our overall concern is the structure of the benefit/cost analysis and how it will utilize the results of the socioeconomic study. We feel from the meeting that John Knapp and the people at Tayloe Murphy have a very good handle on how to proceed. However, we do feel that the environmental impacts should be included to the extent possible with all consideration of their potential risks or probability of their occurrence. As noted in the meeting, it would be desirable to include a range of probabilities of occurrence for the significant environmental impacts and attach to those some potential dollar figure of loss or benefit. In essence, a Bayesian analysis should be considered and some of the recent cost-benefit literature can be consulted in seeing how to include this in the study. We would be very concerned if the environmental impacts were included only in a qualitative manner as we feel that would not give a potential indication of their probability of occurrence or magnitude to readers of the report. It would not allow the environmental impacts to be properly considered in the study.

2. We agree with the comments from Tayloe Murphy and the Piedmont Environmental Council that potential changes in the magnitude and duration of the uranium mining and milling operation need to be specifically included in the report. In particular, fluctuations in the national and international uranium markets could cause the mining and milling operation to cease if the price of uranium on the long-term contract markets fell below that figure needed to make the mine a viable operation. In such cases, locally employed people could be laid off for significant amounts of time and this would have the attendant socioeconomic impacts. In addition, this would have impacts on such things as unemployment contribution made by the firm to the State of Virginia and the payments by the State of Virginia to those people who become unemployed. It is our recommendation that, wherever possible, boundaries should be described that would describe the feasible fluctuations of the uranium milling and mining operation.

3. We feel that Bruce Dotson's write-up that defines the various benefit and cost terms that would be used in the study was a very good first step in providing some overall guidance to the benefit/cost analysis itself. Our concern is that benefit/cost analysis can mean a lot of different things to a lot of different people. The case of this particular study is much broader than the conventional cost/benefit analysis as normally performed by organizations like the Army Corps of Engineers. In this case, you have a mixture of economic, social and environmental impacts that are both qualitative and quantitative in nature. It is always very difficult to incorporate these to a very meaningful cost/benefit framework such that you have a valid comparison between all these different types of impacts. Once again, a survey of recent environmental and cost/benefit literature should aid Tayloe Murphy in formulating the overall approach to this problem.

4. We would like to reiterate that a potentially significant impact that needs to be addressed is the temporary decline in demand for locally produced agricultural commodities due to the presence of the uranium mining and milling operation. The presence of the uranium operation could lead to perceived radiological impacts such that the purchasers decrease their demands for Pittsylvania County agricultural products - (i.e., tobacco). We realize that literature is sparse in this area with regard to what actual decline in demand for agricultural commodities has occurred where farming areas are located adjacent to projects having radiological characteristics. However, we do feel this should be addressed to the extent the literature supports such an analysis.

5. It was evident during the meeting that the local fiscal impacts were not defined to the detail that we would like to see them. We feel confident that given their knowledge of local and Virginia fiscal and tax collection systems that Tayloe Murphy will be able to address this in much more detail than the Gibbs & Hill people were able to do. One area that needs more study is the generation of local and state

tax revenues and the disbursement of local and state outlays for the necessary governmental services.

6. One concern that we would like to re-emphasize is the potential use of the site of the disposal site and tailing site once the mining and milling operation ceases. We realize that the configuration of this site may make it very difficult to do much other than passive recreational use. However, we were impressed by the fact that Marline is now planning to install a much thicker cap on top of the waste rock and tailings than was originally planned. The report should include a discussion of what the present uses of this site are and should incorporate John Yellich's analysis as to the proportion of the 1265 acre mining, mill and tailings area which is currently in agricultural use as opposed to that which is woodlands or undeveloped. Assuming the latter two conditions prevail, the opportunity cost of letting this site lie relatively unused over a long period of time may not be that great.

7. One issue that did not receive any discussion during the May 21 meeting was the potential liability of Marline and Union Carbide should unplanned environmental impacts occur such as the pollution of local groundwater. More specifically, the issue is the availability of funds to compensate the state and local citizens for health impacts or losses of natural resources. As USEPA has in fact realized through its regulations and has also occurred for low level radioactive waste disposal sites, it is important that a company's assets be available or reachable by a State or local government when such damages could occur. RCRA and 10 CFR 61 have very specific regulations that may be used as a model for setting up trust funds or bonding arrangements to ensure than funds are available for closure and post-operational monitoring activities. Arrangements should be made to ensure that the company's assets can be attached in order to cover any resulting environmental damages. This was very apparent in previous years' discussions with State of Texas staff.

8. It was clear from the discussion at the meeting that there was a lot of confusion as to how the RIMS model is used and applied. At the same time it was noted that the output from the RIMS or any other economic model is only dependent on the assumptions that go into determining which expenditures will occur locally and within the State of Virginia, and those that will occur outside the state. More definitive breakdown in the methodology and assumptions as to why expenditures would occur within Pittsylvania County or Halifax County should be included in the report.

9. It would be useful to have a discussion in the report where appropriate about the financial and technical qualifications of Union Carbide to carry out the operation. This would serve to assure the people of Virginia that Union Carbide has the experience and the longevity so that they will be involved for the full duration of the project. In addition, what is the current role of Union Carbide versus Umetco.

10. The discussion of the proportion of the labor supply that will come from within the Pittsylvania and Halifax County areas was adequate within the Gibbs & Hill report. Marline's plan to establish a local vocational training program indicates that issue could use more detail. We recognize that one of the primary selling points of this particular project is its positive economic benefit in Pittsylvania County and this is generally perceived through employment. Therefore, it is advisable to be as definitive as possible in terms of the number and the composition of skills of those local residents that will be hired to work on the project.

We would like to reemphasize that, in order to continue to provide the kind of expertise we have been doing throughout this project, we would very much like to review the Tayloe Murphy study when it becomes available. We feel that we can function very effectively as highly qualified technical reviewers who also are able to function as independent and unbiased in this particular case. We are looking forward to seeing the results of their study. I would like to emphasize that being sent under separate cover to John Knapp is the material that I promised him from the Bureau of Labor Statistics concerning the annual number of hours that can be assumed for mine and mill operating personnel. As I noted in the meeting, this material is based on contract construction figures from the Bureau of Labor Statistics and may not in all cases be applicable to this situation. But it may serve to give John and Beverly guidance in making the proper assumptions as to the amount of labor inputs that will be required on an annual basis.

Please forward copies to those you feel appropriate.

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Rogers, Golden & Halpern

DATE: June 19, 1984

RE: June 15, 1984 Conference Call Regarding PABLM Inputs

A conference telephone conversation initiated by IEN was held on the afternoon of June 15, 1984. Persons participating in the conference were as follows:

IEN -- Richard Collins, Tim Mealy
MUC -- John Yellich, Noel Savignac (consultant)
RG&H -- Jack Halpern, Roger Moose, Ron Kaiserman, Bill Garland, Pat Kennedy
SENES -- Doug Chambers, Don Gorber
Dravo -- Alan Notary, Bill Lynott (joined conference in progress)
Gibbs & Hill -- Ed Baker

This memorandum reflects RG&H's understanding of the key points discussed during the conference. Different scenarios and inputs to be used in the PABLM computer runs, the Swanson Project water balance and the modified tailings management plan were the main topics covered.

1. PABLM is proposed by Marline to calculate the incremental radiation dose from water sources, created by this project. Justification has still not been presented for its use. Dosage is to be calculated for an average individual stipulated to be a typical local Southern Virginian. In order to more realistically reflect the percentage of local consumption of produce, fish, etc., Bill Garland suggested that a survey of local residents and food markets be taken.

2. It was agreed to ratio dosage values (PABLM outputs) for average individuals to estimate effects on individuals with different characteristics (exposure) since doses are directly proportional to sources. Since typical receptor is adult male, Rich Collins wanted some attempt to extrapolate results to other age groups, particularly children. Since it is impossible to use ratios to extrapolate where zero values have been used for exposure pathway, low nominal values will be used for possible pathways instead of zero. Doug Chambers identified specific pathways where this should be done.

3. Rich wanted it made clear in description of model runs what average individual is and that assumptions are conservative. He also wants text accompanying computer runs to explain model results to laymen.

4. It was agreed that average annual stream flows are appropriate for modeling chronic conditions in PABLM because the model deals with dosages on a yearly basis. Actual average flows for streams of interest have not been reviewed or agreed. Low flows should be used for modeling acute conditions.

5. Regarding other discharges or pathways that should be considered, RG&H identified three: discharge of water intercepted at the perimeter of the mine, seepage/runoff from waste rock and mill discharge. RG&H feels that water intercepted at the rim of the mine may be mineralized and should be included as a discharge in PABLM and the final water balance to determine a total discharge. Marline disagrees on the basis that it is a natural, existing discharge. Alan Notary indicated that they don't envision a large mill discharge per 440 CFR; however, Jack Halpern noted that MUC had reserved the right for a mill discharge at a previous meeting.

6. Items promised week of June 18 per Alan Notary:

   - content of mine water discharge and leaching tests of ore, sub-grade ore and barren rock from Colorado School of Mines Research Institute

   - further radionuclide analysis (not sure what this is)

   - updated water balance, which will justify PABLM inputs.

7. Jack Halpern asked about status of "tailings memo" reflecting meeting on changes in tailings management. Alan Notary indicated assumptions will be part of modified water balance.

8. RG&H raised issue of changes in waste rock area location. John Yellich indicated it will be entirely in Whitethorn Creek drainage. RG&H asked for modified drawing to document change.

9. A question was raised whether dam break scenario should include tailings (solids) flow. MUC response was that dam is actually for a surge pond and is not a tailings containment dam. "Dam break" is more accurately a "pond overflow." This change in tailings management will be reflected in new assumptions and reviewed by RG&H.

10. Marline volunteered that PABLM would be run considering tailings liquid seepage with and without attenuation by clay liner.

11. Roger Moose commented about PABLM predicting incremental dosage (i.e., effect above background) and not total dose. Doug Chambers indicated that radiation protection standards 1) do not use a threshold dose concept, 2) assume response is linear with respect to dose, and 3) are set as dosage above background.

12. Ron Kaiserman questioned use of mass spectrometry in the single analysis of mineralized and barren waste rock because of its +40% accuracy. Marline responded that Stan Johnson had agreed to this. (A re-review of his May 3, 1984 report to UAG Task Force failed to locate a method of analysis for these rock types.) All values based on this test data will be increased by 40% to assess the worst case situation.

13. Pat Kennedy requested that calculations of actual inputs to PABLM and numbers actually input be provided. This is because of difficulty in understanding computer runs submitted with original study. For example, where does dilution flow of 1,120 cfs (1.120E+03) come from? This has no relation to the flow values supposedly used. Also, are sources really in Ci/yr?

14. RG&H feels that 40 ppm uranium in the tailings solution is consistent with solutions of operating and inactive uranium mills, and that very little dilution will take place during the washing procedures.

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Rogers, Golden & Halpern

DATE: June 21, 1984

RE: Chemical Analyses of Swanson Rock Materials

Rogers, Golden & Halpern has reviewed the chemical analyses of the ore grade composite prepared by Stan Johnson. The method of preparation is described in his memo to the Uranium Administrative Group Task Force dated May 3, 1984. With few exceptions, the chemical and radiochemical profiles of all the splits are remarkably similar, attesting to the efficacy of the sample preparation procedure. Notable exceptions to this homogeneity are in the values for vanadium and fluorine. Vanadium ranges from less than 10 ppm (samples JC-3 and JC-7, Blue Ridge Analytical Lab) to 450 ppm (sample JC-4, Accu-Lab), and fluorine ranges from 203 ppm (sample JC-7, Blue Ridge Analytical Lab) to approximately 5000 ppm (sample JC-8, Accu-Lab). All in all, these analyses correlate very well with our compilation of previous analyses of the ore grade samples and their composites.

We have also reviewed the single chemical and radiologic analyses presented for the mineralized waste composite, barren crystalline, and barren Triassic. Because the chemical results were reported with an error of $\pm$40%, it was agreed during the conference call of June 15, 1984 that all concentrations could be increased by 40% in order to assess the worst case situation. Even with this increase most of the constituents are within the normal range of values for crustal rocks. Notable exceptions to this are in the values for barium and uranium, which are well above crustal averages. However, for the radiochemistry, the mineralized waste exhibits extremely elevated values for several radionuclides, particularly radium-226 and thorium-230. The high concentrations of these nuclides will cause this material to emit significant quantities of radon-222. Due to the diffuse nature of the Swanson ore body, the potential exists for the production of large quantities of this mineralized waste. Several recent studies suggest that the accumulation rate of sub-grade ore at surface uranium mines equals the ore production rate. We are not aware of any plans to segregate this material, and feel that it may be inappropriate to dispose of it in unlined piles along with the barren rock. Additional clay may be required for this waste area. This material represents a source of radionuclide contamination similar to the tailings piles. In addition, the barren crystalline rock contains 5.9 $\pm$ 0.4 pCi/g of radium-226. EPA has suggested that materials containing more than 5 pCi/g be treated as hazardous waste.

cc: Jack Parker, VPI

RG&H

June 26, 1984

Professor John Knapp
Tayloe Murphy Institute
University of Virginia
Colgate Darden Graduate School
of Business Administration
Dynamics Building, 4th Floor
2015 Ivy Road
Charlottesville, VA 22903

Dear Professor Knapp:

After much digging and phone calling I have finally located the references on labor inputs into construction that I mentioned during our meeting in Charlottesville. The Industry Productivity and Technology section of the U.S. Bureau of Labor Statistics has conducted studies on the indirect economic impacts of construction expenditures. These studies have attempted to quantify the indirect employment created by expenditures for non-labor inputs (e.g., raw materials, supplies, equipment, etc.) per $1,000 of construction contracts. As a result, these studies have had to answer the question of how many hours of labor input are required per $1,000 of construction contracts in order to separate out the economic impacts of disposable construction income expenditures. The BLS has used a figure of 1800 hours for a person year of construction labor in these studies.

The contact person for these studies is Mr. Robert Ball at (202) 523-9321. He is sending me the most recent material he has on labor inputs into construction. He noted during our recent phone conversation that BLS has not updated their figures on annual labor inputs in construction since 1980 or 1981. In addition, he was not aware of any other groups within BLS or the Department of Commerce that regularly survey the labor inputs into construction. Mr. Ball did note that recent Bureau work has indicated a figure of closer to 1200 hours per year as being the typical annual labor input per skilled construction trade worker. As you noted during our meeting in Charlottesville, it is likely that the annual labor hours assumptions for skilled construction trade workers may not be applicable for workers in an open pit uranium mine.

Mr. Ball is sending me a copy of the most recent figures that BLS has on construction labor inputs. I will send these along as soon as I get them. He mentioned that the most recent discussion of his work is presented in the December, 1981 Monthly Labor Review, in an article titled "Employment Created by Construction Expenditures".

I hope the above information will be useful in present or future Tayloe-Murphy studies. Best of luck on the Marline study and I look forward to seeing a copy upon its completion.

Sincerely yours,

Phil Hopkins

Phil Hopkins
Economic Planner

PH/ba

cc: Jack Halpern
Rich Collins

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Rogers, Golden & Halpern

DATE: June 21, 1984

RE: Swanson Tailings Management Area - Clay Issues

This memorandum addresses the clay issues associated with the tailings management area proposed by MUC at the Swanson Project. The material reviewed includes MUC's October 15, 1983 submission to the Uranium Administrative Group, MUC's November 29, 1983 response to the November 14, 1983 review of that submission, Dravo Engineers' PRELIMINARY Technical Memorandum Number 2, dated May 31, 1984, and the Chen and Associates June 1, 1984 letter to Dravo Engineers. In addition, we have reviewed many of the publications cited by the recent Dravo memorandum and have further researched the available technical literature independently of the Dravo work. All of the clay studies cited in Dravo's Technical Memorandum Number 2 dealt with tailings from an acid leach process, which are not directly applicable to the proposed Swanson mill with its alkaline leach circuit. None of the publications viewed by us to date have addressed the alkaline leach process tailings except to note that it is not in general use by the industry.

As we have stated earlier, the characterization of the available clay is not done in sufficient detail to provide a reasonable estimate of its ability to contain or attenuate fluids that may pass through it. Because of the constraints of schedule, no further testing has been done that could have resolved these remaining questions. Therefore, MUC has provided a summary of available literature as a major portion of this technical memorandum. Further elaboration of their interpretation of the existing data was also included in this memorandum.

Our remaining outstanding concerns on the clay issue lie mainly in the following five areas:

- o hydrogeologic properties
- o chemical properties
- o mineralogical properties

- o structural foundation properties
- o conceptual design of the tailings management area reflecting these properties.

First, the mechanical properties of the clays are important to the design of the tailings management area because they are being called upon to contain the waste and segregate it from the environment. The tests provided were conducted in a manner consistent with standard engineering laboratory testing practices to evaluate the permeability of cohesive (clay) materials. These tests show that the potential Banister River area borrow materials can be compacted to the general range of hydraulic conductivities (within an order of magnitude higher than that to which MUC has committed itself) under laboratory conditions. In our experience, the field excavation, placement, and compaction of such cohesive materials takes place under considerably less controlled conditions than are possible in the laboratory. Thus, the low permeabilities described are unlikely to be achieved during construction of the project. Seasonal variations in atmospheric conditions introduce the potential for additional deviations in recompacted permeabilities, most of which are likely to increase the values even more.

With respect to the chemical properties of the clay that would be used for construction of liners and caps, we have stated before that the column tests reported in October were of very limited value. The significant desorption of several cations reported in the data has still not been adequately addressed, and the use of the time averaged effluent concentrations to calculate distribution coefficients for the various dissolved ions is non-standard. Thus, there is no sound basis to compare the MUC reported values to values found in the literature. In the scientific literature, effluent concentrations from column experiments are usually examined as a function of time, and the experiments are run until an equilibrium condition is attained. The bulk of the literature reviewed and cited by MUC dealt with clay considerations associated with the acid leaching process. This is primarily due to the fact that the bulk (approx. 86%) of the industry experience is with the acid process. For ores with a limestone content of 12 percent or less (which includes the Swanson deposit ore), the acid process is almost always chosen. This is probably why the literature is deficient in descriptions of alkaline leach tailings. Industry experience with acid process tailings interactions with clay liners is not directly applicable to the MUC proposal of a mill process with the alkaline circuit. Because of these experimental defects, no attenuation of effluents has been proven, and calculations involving seepage of tailings fluids should use raw tailings fluid concentrations.

Mineralogical properties of the clays to be utilized in any waste containment facility are very important in terms of how the individual clay minerals may react with the contained wastes. In the prediction of clay liner performance, this is one of the key considerations in determining whether there is any comparability between any two samples of clay-sized materials. There has never been any mineralogical identification offered by the proponent. This identification is as important as the size distribution analyses and proper clay column testing that have or should be provided in determining whether the clay deposits identified have the properties required to perform as MUC states they will, and whether sufficient volumes of these clays are available locally.

Structural (foundation) considerations including bearing capacity, static stability, and seismic stability are discussed but not fully addressed in Chen and Associates memorandum. In short, their memorandum describes the types of analyses to be done prior to and in conjunction with design of the tailings management facility. Discussion is limited to conditions significant to the overall stability of the tailings/waste rock pile. There is no discussion of the clay liner, its proper bedding requirements, the potential for differential settlement or loss of integrity under tailings and waste rock loads or its contribution to the stability of the structure overall. It is difficult to consider the stability of the tailings area under various intermediate construction stages prior to closure since the staging scheme including temporary dams and interior dams has not been completely described or considered. Seismic design considerations for the long-term integrity of the liner system are not considered. This is particularly important where the liner joins clay "starter" dikes at the perimeter of the impoundment(s).

The conceptual design of the tailings management area is highly dependent upon the properties of the materials that would be utilized in constructing it. It has been demonstrated here that there are significant gaps in the basic information provided to date, and there is no assurance that can be given that all of the missing information, if provided, would be favorable to the tailings management concept as proposed. Most important, there can be no assurance that the facility could achieve any attenuation or containment of effluents. Therefore, on the basis of information provided, the possible exposure of nearby residents to radiological doses should be computed as though the facility released the raw mill water contained in the dewatered tailings directly to surface and/or ground waters of the Commonwealth.

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Rogers, Golden & Halpern

DATE: July 3, 1984

RE: June 29, 1984 Conference Call on PABLM Inputs

RG&H participated in a conference call on Friday, June 29 to discuss final inputs to the PABLM model. Other participants were Bruce Dotson and Rich Collins (IEN), John Yellich (MUC), Noel Savignac, Don Gorber (SENES), Al Notary (Dravo), and Jack Parker (VPI). Suggested inputs were outlined in a memo from Dravo Engineers dated June 26 entitled Summary of PABLM Input Parameters. We made the point at the outset that we had received the memo less than two days before the call and received the technical summary, which provides back-up for some numbers, less than two hours before the call. Lacking sufficient time to properly review the document, we were only able to comment in a very general way. Our comments, some of which were still unresolved from previous calls, included:

- The shallow ground water intercepted at the perimeter of the mine pit is still not included in the PABLM run. Since an attempt is being made to quantify the total radiation dose, we feel that this water should be included.

- A mill discharge is not included in the PABLM run. Because a discharge would probably be allowed under current regulations, and because a discharge has not been specifically ruled out, we feel that a discharge should be included as a possibility.

- RG&H would like to see some documentation indicating why PABLM is a suitable model for this type of situation.

- The unattenuated values for seepage through the clay liner should be used in the model.

- RG&H has been unable to locate any references dealing specifically with tailings from the carbonate leach process.

- The time span for which the model is being run has not been specified.

- The permeability used to calculate seepage through the clay liner may not be achievable under field conditions. Seepage volume as reported may be too low.

- The tailings piles as designed may not be licensable under current EPA regulations due to a higher permeability in the cap than in the bottom liner.

- PABLM inputs have not been provided as they will be input to the model.

- The use of a flood with a two-year recurrence interval may not be appropriate in an assessment of the worst case situation. We requested some back-up for the decision to use this event in the model instead of the PMP event.

- The PABLM input document is confusing with respect to the dam break. It is unclear which dam will fail (mill pond or surge pond) and whether surges can accumulate behind the temporary dike.

- It may be necessary to include a release of tailings along with liquid in the dam break scenario. If PABLM cannot handle a solid release, another way should be found to include this dose.

- The Mill Creek Receptor has been deleted from the model run. We question whether MUC will be able to control Mill Creek and its diversion to the extent they claim. Therefore, since this is the critical receptor, it should be included in the model run.

In the follow-up discussion RG&H stated that it would not participate in the conference call regarding clays scheduled for 3:30 that afternoon because several key individuals would not be available.

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Jack Halpern, Rogers, Golden & Halpern

DATE: July 10, 1984

RE: Revision of Jack Parker's Clay Memo

We have reviewed the revision of Jack Parker's clay memo dated July 3, 1984. The fact that his conclusions were unchanged even when taking kinetics into consideration strongly supports the use of unattenuated fluids in the PABLM run. We agree completely with Jack's conclusions, and feel that we have nothing to add to them. Therefore, we will not be participating in the conference call scheduled to discuss this revised document.

RG&H

MEMORANDUM

TO: Richard Collins, Institute for Environmental Negotiation

FROM: Rogers, Golden & Halpern

DATE: July 11, 1984

RE: July 9, 1984 Conference Call Finalizing PABLM Inputs

RG&H participated in a conference call on July 9, 1984 to finalize the inputs to the PABLM model. Other participants were Rich Collins and Tim Mealy (IEN), John Yellich (MUC), Noel Savignac, Doug Chambers and Don Gorber (SENES), Ed Baker and Al Notary (Dravo), Jim Rouse (Envirologic), and Jack Parker (VPI). It was agreed upon at the beginning of the call that RG&H would comment on the June 29, 1984 Summary of PABLM Input Parameters from Dravo on a page-by-page basis. Our comments, some of which referred to the Technical Summary from MUC, included:

1. The Technical Summary still refers to the original PABLM runs and input parameters. We feel that it should reflect the updated values. Also, it is not a summary in the strictest sense because much new information is presented.

2. RG&H was unsure whether the critical receptor was one individual or a homogeneous group as stated in the document. It was explained that the critical receptor is a representative member of a larger group of maximally exposed individuals.

3. The Technical Summary states that Mill Creek may be diverted to any one of three places. We feel that one option should be specified and adhered to.

4. MUC should provide support that they control access to and use of the Mill Creek diversion.

5. There are several inconsistencies among the carbonate leach process flow sheet, material balance, and preliminary project water balance (figure II-12) in the Technical Summary. We feel that these inconsistencies should be checked. An example is the plant makeup water (Stream #51).

6. The shallow ground water intercepted at the perimeter of the mine pit should be included in the background dose. The radionuclide content of

Mill Creek and other creeks should also be included in the background calculations.

7. RG&H feels that a mill discharge has still not been specifically ruled out and should be included in PABLM.

8. MUC reserves the option to use the acid leach process. We pointed out that a larger tailings area would result from this process (+20%) and should be used in PABLM.

9. A waste rock area is still in the Georges Creek drainage basin. Therefore, this stream should be included in PABLM. We have not received any documentation indicating that this area will be moved. (John Yellich stated that there will be no waste rock area in the Georges Creek basin in the final technical summary.)

10. IEN should verify the values from the survey of local residents conducted by MUC concerning local food and water consumption.

11. The volumes contained in the facility's various ponds should be specified.

12. Based on the stream hydrograph separation supplied by MUC, we feel that eight (8) inches should be used as a conservative value for percolation through vegetated, reclaimed areas.

13. Differences in PABLM inputs can be examined via a sensitivity analysis only if the model is amenable to simple ratioing. This should be verified. SENES and Noel Savignac felt this was the case.

14. A permeability greater than that suggested should be used for the lower clay liner. It was agreed that a permeability of 10 to the -7 cm/sec would be used in PABLM.

15. Our independent calculations do not agree with the suggested values for evaporation and seepage from unvegetated, uncovered overburden. New Numbers were presented; however, it was agreed that Pat Kennedy and Al Notary try to agree on the numbers to be used in a separate phone call. This comment also applies to ore stockpile but this would not be significant to PABLM.

16. Runoff (20.3 in/yr) from exposed tailings does not allow for seepage from this area. Seepage from the exposed slope of the tailings is not estimated. A question was raised as to whether there would be an impoundment (free water surface) between the advancing tailings and the temporary dike. Al Notary indicated that this is a diversion with only a small amount of water temporarily impounded at any time.

17. We feel that the HELP model should be re-run with new permeability for the liner and higher percolation. If this model cannot accommodate the configuration and initial water content of the tailings pile, another method should be found.

18. The vegetation assumptions should be specified.

19. RG&H has still not received the CSMRI report on the leaching experiments conducted on Swanson rock materials.

20. RG&H cannot independently verify the reported ratio of Triassic : mineralized crystalline : barren crystalline rock that was used to calculate radionuclide content of leachates.

21. It is still unclear which pond will be breached in the dam break scenario. We have suggested that there be a failure of all retention structures. We have not yet received the back-up for using the two-year flood from Dravo, but Al Notary said that he would send it.

22. RG&H questioned whether PABLM can accurately model the effect of the slug from the dam break. We are also unsure whether the assumed 50% dilution of the slug is valid. We feel that it would be better to leave the dam break to hand calculations or the sensitivity analysis. Doug Chambers clarified that it is better to think of PABLM as dealing with radionuclide loadings rather than concentrations.

23. RG&H feels that several sources are missing from the scenarios section; e.g., shallow ground water and mill discharge. For the Halifax scenario, seepage should have been included. Noel Savignac commented that this was a typing error, and seepage is included in this scenario.

24. RG&H would like to receive copies of the actual PABLM printouts. Noel Savignac replied that he will provide copies to all consultants.

Notes of the telephone conversation between Al Notary and Pat Kennedy referred to above are attached.

RG&H

RECORD OF TELEPHONE CONVERSATION

Date: July 9, 1984

Job Number: 176.08

Recorded by: PAK

Client: Virginia UAG

Talked with: Alan Notary, Dravo Engineers, Inc.; Don Gorber, SENES

Copies to: JAH, RK, RM

RE: Resolution of PABLM seepage rates as agreed at conference call earlier today

1. There were two unresolved items regarding seepage rates to be used in PABLM that were to be settled via conference between Pat Kennedy and Al Notary in which Don Gorber asked to participate. These two items are 1) appropriate evaporation rate (and corresponding seepage) from unvegetated waste rock/overburden storage areas (and ore stockpile), and 2) seepage rates through vegetated waste rock/overburden.

2. Rogers, Golden & Halpern feels that evaporation rate from unvegetated overburden calculated by Dravo (19.7 in/yr) is unrealistically high because large-size blasted and crushed rock with little or no evaporation is a major part of these areas. Evaporation calculated by Dravo is realistic for gravel representative of "fines" in these areas. RG&H suggests that a weighted average evaporation assuming 25% of area has fines predominant near the surface and rest of area has no appreciable evaporation be used. Al Notary feels that existing calculation is conservative in that four-inch evaporative depth was used. Al also feels that there will be some evaporation from wetted surface of larger rocks. Evaporation calculation currently assumes coarse sand or well-graded gravels over entire area. He wants to stay with their number and wants RG&H to provide reference for lower evaporation. We indicated that our basis is the mixture of rock and gravel or finer materials and we felt that larger rock is predominant.

3. There was an impass on this item. Don Gorber suggested that RG&H provide numbers it thinks should be run and that Al Notary get us some information on distribution of size gradations of rock. Marline will run PABLM with Dravo numbers at this time although RG&H does not agree with number.

4. RG&H has concerns over who will do sensitivity analysis and how it will be presented in comparison to model runs. Sensitivity analysis and discussion are apparently responsibility of IEN plus consultants. This is not completely resolved yet.

5. Regarding second RG&H concern -- 6.1 to 6.7 inches of seepage versus 8 inches in regional water balance -- Al Notary indicated that regional water balance is based on hydrograph separation that gaging station data is primarily for Pre-Cambrian geology. Triassic area water balance is more likely closer to vegetated, covered overburden. Also regional water balance is for mixed cover types and soils and not for cover specifically designed to minimize infiltration. These arguments seem reasonable. RG&H will consider them in recommending numbers to be used in sensitivity analysis. The existing numbers will be run in PABLM.

6. There was some discussion regarding dam-break dilution calculations to be provided by Al Notary. Apparently his calculations consider dilution downstream of dam and effect on radionuclide concentrations for various storm events. Don noted that, based on discussion between Doug Chambers and Pat Kennedy this morning, the important parameter for PABLM is the loading of each radionuclide and therefore only the dilution within the dam prior to the break is significant.

7. We confirmed that the PABLM runs would use a recalculated seepage through the liner based on a permability of 10 to the -7 cm/sec.

The attached table shows suggested seepage values to be used in the sensitivity analysis of the PABLM runs. Seepage from the tailings management area is based on Darcy's law calculation with 10 to the -7 cm/sec permeability of liner. This number may change if Dravo reruns the HELP model with lower permeability. Seepage rate for unvegetated overburden assumes 25% gravel with 19.7 in/yr evaporation and remainder of overburden area with no evaporation. Basic seepage rate for vegetated overburden is 8 in/yr. Seepage of 1.6 in/yr through clay cap in tailings management area leaves 6.4 in/yr for lateral drains.

SUGGESTED SEEPAGE RATES FOR PABLM COMPUTER MODEL

SOURCE: Tailings Management Area

	Vegetated, covered tailings	Unvegetated, covered tailings	Exposed tailings	TOTAL
Area (ac)	144.8	36.2	10.0	191.0
Seepage				
inches	21.0	21.0	21.0	63.0
gpm/ac	1.085	1.085	1.085	3.255
gpm	157.10	39.27	10.85	207.22
cfs	0.350	0.088	0.024	0.462

SOURCE: Overburden/Waste Rock Storage Area — Tailings Management Area via lateral drains

	Vegetated	Unvegetated	Vegetated	Unvegetated	TOTAL
Area (ac)	651.6	72.4	144.8	36.2	905.0
Seepage					
inches	8.0	36.9	6.4	35.1	
gpm/ac	0.413	1.904	0.331	1.812	4.460
gpm	269.31	137.83	47.88	65.60	520.62
cfs	0.600	0.307	0.107	0.146	1.160

APPENDIX B

Specific Problems with PABLM Computer Printouts

1. For all runs, input data labeled NUCLIDE RELEASE (CI/YR) is actually the diluted concentration in picocuries per liter (pCi/l). These numbers appear on the first page of each run. This would confuse even people familiar with PABLM.

2. There is not sufficient information to review the relative contributions of U-234, U-235, and U-238 to dose. In particular, how can the activity of U-234 be higher than that of U-238, assuming equilibrium?

3. COOLANT FLOW RATE shown (1.120E+03) is merely a conversion factor to allow concentrations rather than total annual releases to be used. It is not the receiving stream flow. This approach is really a quirk of the model that is not well documented.

4. COOLANT MAKEUP FLOW is ignored by the code for Model 3 (that is, no reconcentration), so this number is insignificant. What is Model 0?

5. An irrigation rate of 60 liters/square meter/month is equivalent to .6 feet in three months. Does PABLM use the actual rate during irrigation season or the annual amount spread over twelve months? Irrigation rate in input summary (1983 vs. 1984) should indicate the appropriate application rate and duration, i.e., .6 feet in three months. (From comparing 1983 and 1984 computer input printouts, it appears that 1983 irrigation rate input is lower by a factor of 10 than the rate supposedly used. This decreases dose estimates from this pathway substantially.)

6. Po-210 concentration for the first case does not seem to match the agreed upon value. RGH has not checked all such computations.

7. RGH cannot confirm actual PABLM inputs for the pond breach scenario on the computer printout because calculations have not been provided. From

the PABLM documentation RGH understands that acute cases are handled as a one-time release in curies and not as a rate as apparently input. RGH does not understand the very low irrigation rates used in these runs.

8. In general, the computer printouts need improved annotation if they are to be useful.