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NOTE FOR : E. Grammer, ELD-R. Fonner, ELD D. Harmon, OSD H. Miller, WMUR K. Hamill, WMUR a: R.A. Scarono J.B. Martin FROM: D. Martin, WMUR SUBJ: Review Request, Mtg. Notice Attached are re-ducts of the 12 Criteria that I have prepared to recorporate changes resulting from public comment and other ideas. Plesse verien these in detail and be preparel to other comments/suggestions at a meeting to be held : Friday, March 14 9:00 AM ELD offices, MNBB* The re-drafted criteria contain many significant changes, both technically and organizationally, for various purposes. Therefore I and H. Miller are particularly interested in ELD's condid view of the extent to which we can make such changes without becoming vulnevable to any low-suit claiming that a ve-proposal with opportunity to comment should have occurred. This project urgently needs sound advice on this matter. A buiet summery at the nature and retionale for the proposed changes is also attached. * E. Grammer is securing 2 contenance 100m. B205100006 B20126

DEM 3/10/80

Summery of Changes and Rationale for Re-Dust's of 12 Cuiteria

General: Changes have been made to both the organization and content of the 12 critoriz in order to : 1) define applicability to existing sites 2) increase specificity and decrease potential tar wide varietions in interpretation 3) provide implementation detes and schedules 4) provide waiver potential, as appropriate 5) scrap ambiguous motherhood language The previous content has been retained, with only minor exceptions, but has been supplemented greatly in & number at press. These dreft revisions embody final scope and organization that I would propose, but many specific #'s and dates are incorporated only to suggest that these be specified.

Cuitevion 1 : This has been newly written to specify all lang-term performance objectives for final disposal cites. The idez is to define requirements in one place so existing sites will know what they have to satisfy to Paroid re-location. This Critorian now includes the minimum cover depth veguiroment and the Rn flux limit that were in #6 before, sembonkment slope requirements from old #4.

Criteria 2: Newly written to incorporate all requirements

SUMMERL -2 for alternatives analyses in support of original siting of final disposal sites. It identifies general objectives to be meximized (e.g., remoteness) and specifies alternatives that must be considered (e.g., below grade disposed) This alternatives enalysis would be required for new site relection for velocation of existing tails. Criterion 3: Identifies below-grade is prime option, as before, and veguives elternatives suchasis to consider potential below grede sites within certain distruces & areas. It requires adaption of below grede if practicable. Criterion 4: Requires special consideration for siting abore neturally impermeable goologic for metimes, to promote grandwater protection. This are is mostly new - zhawzace for disposed with grandwater contact has been dropped as that is al 'y contrary to EPA's proposed withera. Crituion 5: Re-unites Non-proliferation requirement that we in #1. Regurves this untess waired. Criterian 6: Incorporates accident prevention, conseguence mitigation requirements. Requirer siting where impoundment failure wald not impair surface water, or secondary catchment. Requires pipe-line failure alarms and control. Daily inspections are required under 64 that pipe-lines sud above grate anly.

Summery -3-Criterion 7: Contains previous "ALARA" veguivements. Yellowcake control malfunction has 24-hr limit. Criterion B: Monitoring requirements - not much changed. Critorian ?: Financial surety veguivaments have been suggested by E. Gremmer previously. Criterion 10: Long-term surreillance charges has been changed to allow increased charges for more trequent surreillance and any monitoring or maintenance needed (toreseen as needed). Criterian II: Land BPM Ownership transfer has been verised to allow exemptions under certain oir constances. Criterian 12: Lang-town servillance has been verised to include monitoring & maintenance, and allan Commission to veguire vemedial actions 2. it deems appropriate.

Final reclamation of all permanent tailings or other waste byproduct material disposal sites shall be accomplished by the provision of sufficient earth cover, but not less than a thickness of three meters, to limit the average surface exhalation of radon from such tailings or wastes to a maximum calculated value of two picocuries per square meter per second. The effects of any plastic or other synthetic caps shall not be taken into account in determining the calculated radon exhalation value. Applied cover materials shall not contain concentrations of radium Significantly above those of surrounding natural soils and shall not have an average radium content exceeding three picocuries per gram. The types, amounts, and distribution of applied cover materials shall be such as to provide a reasonable expectation that the actual surface radon exhalation from all disposed tailings and wastes will be limited to a maximum average value of two picocuries per square meter per second over at least many thousands of years. Provisions necessary to assure the required long-term stability of and appropriate physical isolation of reclaimed tailings or other waste materials include:

- a) No embankment slopes steeper than 3 horizontal to 1 vertical (3h:lv), all slopes steeper than 5h:lv protected by riprap, all slopes of steepness between 5h:lv and 10h:lv protected by rock cobble or stone mulch, and all other surface areas protected by rock cobble, stone mulch, or self-sustaining vegetation;
- b) A negligible potential, less than 10⁻⁷ per year, for seismic motion of greater magnitude, force, duration, or frequency
 than that which the impoundment could reasonably be expected to withstand without significant damage;
- c) A neglibible potential, less than 10⁻⁷ Per year, for significant damage to the impoundment from any and all non-seismic natural phenomena capable of causing catastrophic failure, including damage due to flood, hurricane, tornado, windstorm, prolonged

heavy rainfall, and other similar occurrences, as evaluated on the basis of present conditions and specifically not including potential glaciation; and

d) A negligible potential for significant long-term environmental impacts due continued migration of toxic or radioactive materials in groundwater, as would be the case in geographic areas of net evaporation or where there is, for other reasons, a similar lack of potential for significant groundwater transport of hazardous materials or resulting environmental impacts.

These requirements shall be met by all permanent tailings or other waste byproduct materials disposal sites, and shall govern the selection of all such future sites and all associated decisions with respect to the selection and execution of the complete tailings or waste management plan, including the selection of disposal mode.

Any existing tailings or wastes in any impoundment which cannot meet these requirements shall be moved to a new site which shall be determined in accordance with the procedures specified in Criterion 2 of this Appendix, and in accordance with all other requirements of this Appendix. All existing licensees, as of the effective date of this Appendix, shall have committed to a documented final reclamation plan, approved by the Commission and in accordance with all of the requirements of this Criterion, prior to November 8, 1982, or cease all operations. A fixed extension of this date, not to exceed one year beyond November 8, 1982, may be granted by the Commission if it is determined that movement of tailings or wastes to a new final disposal site is required.

- 2 -

The selection of a combination of site and disposal method for any proposed final disposal of tailings or other waste byproduct materials shall be based upon a complete and detailed analysis of all available and practicable alternatives, and reasonable combinations thereof, which shall be performed, documented, and published by the Commission. Such evaluation shall place primary emphasis on the prospects for long-term isolation and stabilization, in accordance with the requirements delineated under Criterion 1 of this Appendix. In so far as practicable, considering the combination of all environmental, economic, and other costs and benefits, the final combination of site and disposal method approved should:

- Maximize remoteness from people so as to minimize potential population exposures from any anticipated atmospheric emissions or potential groundwater migration of any hazardous materials;
- b) Minimize the potential for disruption and dispersion of tailings or wastes by natural forces so as to minimize the spread of contaminants by wind action or surface runoff of precipitation;
- Minimize the upstream rainfall catchment area so as to minimize the potential for flooding and erosion; and
- d) Minimize the consequences of any potential failure of the tailings or waste impoundment.

As part of the detailed alternatives analysis required for the approval of a combination of site and disposal method the Commission shall fully consider, as to availability, practicability, and all associated significant environmental, economic, and other costs and benefits, certain alternatives offerring enhanced environmental protection. These alternatives, if determined to be both practicable and cost-effective, shall be adopted

if available and if equivalent environmental protection is not provided otherwise. In some cases these alternatives may be mutually exclusive, in which case the final selection shall be based upon a weighing of the totality of circumstances. These alternatives generally offer optimum state-of-the-art performance in one respect or another and include the following:

- 2 -

- a) Deep mine disposal of some or all tailings or wastes;
- Below grade disposal of tailings or wastes in mined out pits or specially excavated pits;
- c) Disposal of tailings or wastes over naturally impermeable geological formations;
- e) Neutralization of tailings or wastes;
- f) In-situ dewatering with recycle of reclaimed liquids;
- g) Disposal of tailings or wastes in a series of small impoundments, pits, or cells, with progressive reclamation;
- h) Siting where there is virtually or actually no potential for contamination of any surface water resource, either by surface runoff, impoundment failure, or other mechanism; and
- i) Siting at locations distant from the ore source in order to utilize below grade disposal, achieve disposal over naturally impermeable formations, or to otherwise benefit from enhanced environmental protection.

#2

The "prime option" for final disposal of tailings or other waste byproduct materials is below grade burial, in order to minimize the long-term potential for uncovering of wastes by erosional processes. Protection from long-term erosion is essential to the sustainment of physical isolation over the long term, and should be maximized to the greatest extent reasonably achievable. Any evaluation of alternative disposal sites and methods performed by mill operators in support of their proposed tailings or waste disposal program, or performed by the Commsision in evaluating such programs, shall fully reflect this need. Furthermore, below grade burial shall be selected as the final approved disposal method unless this method is determined, in the required alternatives analysis, to be either impracticable or not beneficial in promoting the protection of public health, safety, and the environment. A particular site or area may have characteristics which make below grade burial unbeneficial or impracticable, such as a near-surface high quality groundwater formation, poor isolation from valuable groundwater resources, or bedrock formations sufficiently near the surface such that excavation could only be performed by blasting at excessive cost. Any above ground or partially above ground disposal program approved at such sites must be demonstrated to provide reasonably equivalent long-term protection from natural erosional forces. Additionally, no above ground or partially above ground disposal program shall be approved without making a reasonably complete survey and analysis of all potential below grade disposal sites within a distance of 20 kilometers from the proposed site, and over all areas less distant from the major ore source than the proposed site.

Groundwater resources shall be protected to the maximum extent reasonably achievable, practicable, and appropriate, considering the quality and potential for future use of any groundwater resources potentially affected by the proposed mill and/or waste disposal facilities. Such protection shall be afforded during construction, use, and reclamation, and over the long term, for any licensed facilities. The most effective and reliable method of affording such protection is to site tailings or other waste retention systems in locations providing natural protection, where naturally impermeable formations provide an effective and enduring natural barrier to the migration of toxic or radioactive materials. This fact, and the need for such protection, shall be reflected in any analysis of alternative sites and disposal methods prepared either by the mill operator or the Commission. Such alternative analyses, which result in either the proposal or approval of any site not affording such natural protection of groundwater resources, shall include a reasonably complete survey and analysis of all alternative sites within a distance of 20 kilometers of the proposed site, and within all other areas less distant from the major ore source than the proposed site. Any approved disposal site not including such natural protection of groundwater resources shall afford reasonably equivalent protection by other mechanisms, including engineered safeguards and/or mandatory operating procedures or requirements as necessary. Appropriate synthetic, clay, or other bottom liners, or combinations of these shall be required as needed. In-place dewatering of tailings or other waste materials to reduce hydrostatic pressure and seepage, and neutralization to promote immobilization of toxic or radioactive materials, shall be considered. Sufficient monitoring shall be performed so as to ensure detection of any significant migration of toxic substances in groundwater beyond the immediate vicinity of the disposal area, at distances not to exceed 200 meters or the site boundary, whichever is closer. If any such migration is detected, remedial actions shall be required and taken as necessary to minimize any potential significant adverse environmental impacts.

#4

With respect to any evaluation of long-term protection of groundwater resources, no reliance shall be placed on any installed bottom liners. For sites in areas not having a proven condition of net evaporation, on an annual average basis, neutralization of tailings to immobilize toxic and radioactive materials shall be required.

- 2 -

In order to avoid unnecessary proliferation of small tailings or other waste byproduct material disposal sites, byproduct materials from insitu extraction operations and wastes from small above ground extraction operations shall be finally disposed either by consolidation with tailings or wastes generated by large conventional mills or by transport to a licensed low-level burial facility. This requirement may be waived, if requested, and if, upon consideration of all relevant costs and environmental impacts, such relocation is deemed by the Commission to be impracticable or unnecessary for protection of public health, safety, and the environment. Such waivers may not be granted without a prior finding by the Commission that the proposed final disposal site and reclamation plan is in conformance with all applicable requirements of this Appendix.

Severe environmental impacts can result from loss of integrity of above ground impoundments or slurry pipelines during mill operation. In the case of impoundment failure, extremely large quantities of solid and liquid wastes can be released in a very short time, with little or no opportunity for prompt control. Slurry pipeline failure releases, however, are proportional to the time during which pumping is continued while the line is in a failed condition. Therefore, slurry pipelines shall incorporate, by design feature, redundant automatic failure alarms in a location continuously manned during pipeline operation, and failureinduced automatic cessation of pumping at the head end and at all intermediate pumping stations. Above ground impoundments shall be designed and operated so as not to fail under the worst credible conditions induced by any and all potential natural phenomena, either singly or in possible combinations, and shall be sited only where catastrophic failure would not lead to contamination of any substantial flowing watercourse or other valuable surface water resource, or shall rely on a secondary catchment of such design and capacity as to ensure the complete containment of all waste materials released in the event of a maximum credible failure.

Criterion 6(A)

Daily visual inspections of all portions of all above ground tailings or other waste retention systems, and all operational slurry pipelines, shall be conducted by qualified engineering professionals and documented. The Commission may reduce the required inspection frequency, to not less than weekly, for small above ground evaporation ponds if the Commission determines that more frequent inspections would not be appropriate in view of the potential for, and the consequences of, catastrophic or other failure. The appropriate NRC regional office as indicated in Appendix D of 10 CFR Part 20, or the Director, Office of Inspection and Enforcement, U. S. Nuclear Regulatory Commission, Washington, D.C. 20555, shall be immediately notified of any failure in a tailings or waste retention system which results in a release of tailings or waste and/or of any unusual conditions (conditions not contemplated in the design of the retention system) which if not corrected could lead to failure of the system and result in a release of tailings or wastes.

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Milling operations shall be conducted so that all off-site airborne effluent concentrations are reduced to as low as is reasonably achievable below the limits in 10 CFR Part 20. The primary means of accomplishing this should be by means of emission controls. Institutional controls, such as extending the site boundary and exclusion area, may be employed to ensure that offsite exposure limits are met, but only after efforts have been taken to control emissions to the maximum extent reasonably achievable. Notwithstanding the existence of individual dose standards, strict control of emissions is necessary to assure that population exposures are reduced to the maximum extent reasonably achievable and to avoid site contamination. The greatest potential sources of offsite radiation exposure (aside from radon exposure) are dusting from dry surfaces of the tailings disposal area not covered by tailings solution and emissions from yellowcake drying and packaging operations. Yellowcake drying and packaging operations shall cease when effluent control devices are inoperative or have not been working at their reasonably expected best performance levels for more than one day. To control dusting from tailings, that portion not covered by standing liquids shall be wetted Or chemically stabilized to prevent or minimize blowing and dusting to the maximum extent reasonably achievable. This requirement may be relaxed if tailings are effectively sheltered from wind, such as may be the case where they are disposed of below grade and the tailings surface is not exposed to wind. Consideration shall be given in planning tailings disposal programs to methods which would allow phased covering and reclamation of tailings impoundments since this will help in controlling particulate and radon emissions during operation. To control dusting from diffuse sources, such as tailings and ore pads where automatic controls do not apply, operators shall develop written operating procedures specifying the methods of control which will be utilized, frequency of application, and other relevant information and detail.

A preoperational monitoring program shall be conducted for an uninterrupted period of at least one full year, prior to any major site construction or other activity not necessary for site characterization or licensing analysis, to provide complete baseline data on a potential milling site and its environs. Throughout the construction, operational, and reclamation phases of the mill and disposal facilities, an operational monitoring program shall be conducted to demonstrate compliance with applicable standards and regulations; to evaluate performance of control systems and procedures; to evaluate environmental impacts of operation; and to detect potential long-term effects.

Financial surety arrangements shall be established by each licensee to assure that sufficient funds will be available to fulfill all decontamination, decommissioning, and reclamation requirements prior to license termination. The amount of funds to be ensured by such surety arrangements shall be determined by the Commission, based on cost estimates contained in a detailed plan, approved by the Commission, for accomplishing:

- decontamination and decommissioning of all mill buildings and facilities and the entire mill site (exclusive of areas devoted to final disposal of byproduct material), and any affected off-site structures or areas, to levels which would allow unrestricted use; and
- the reclamation of all tailings and/or waste disposal areas in accordance with the technical criteria delineated in Section I of this Appendix;

and shall also ensure the full payment of any charges for the costs of long-term surveillance or any other charges required by Criterion 10.

The Commission will accept financial sureties that have been consolidated with other financial or surety arrangements that have been established to meet any other government requirements for such decontamination, decommissioning, reclamation, or long-term site surveillance, provided such other financial or surety arrangements would be acceptable to the Commission.

All such financial surety arrangements as are required shall be in effect and approved by the Commission prior to:

- the production, storage, use, or transfer of any byproduct material pursuant to any license issued after the effective date of this Appendix; or
- renewal of any license in effect as of the effective date of this Appendix, or November 8, 1983, whichever comes first.

All such financial surety arrangements shall be reviewed by the Commission and revised by the licensee, as deemed necessary or appropriate by the Commission, prior to approval of any license amendment or other licensing action which would allow activities which could significantly alter the amount of funds required to be ensured for decontamination; decommissioning, reclamation, and/or long-term-site-surveillance-or other-purposes, and at least every five years. The required amount of surety liability shall be determined so as to be at lease equal, at any time prior to the conclusions of the next 5-5 review and revision, to the maximum total Capital, administrative, and other costs that would in incurred by the Commission if the Commission became responsible for performing all required decontamination, decommissioning, and reclamation, plus all long-term surveillance or other long-term needs. This will assure a surety liability sufficient to fund all required decommissioning, reclamation, and necessary long-term surveillance and other efforts should the operator abandon these responsibilities at any time.

Financial surety arrangements generally acceptable to the Commission must be open-ended and include:

- a) Surety bonds
- b) Cash deposits
- c) Certificates of deposit

- 2 -

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- d) Deposits of government securities
- e) Combinations of the above or such other types of arrangements as may be approved by the Commission

#9

Financial surety arrangements which are unacceptable are self-insurance or third-party insurance or other similar types of arrangements. The method or combination of methods used to establish surety, and/or the amounts of such sureties, may be revised at any time, providing the Commission has granted prior approval of such revisions. In revising required surety liability the Commission will consider all relevant circumstances bearing upon anticipated costs, including inflation, any covered efforts already performed by the licensee, and the proven degree of acceptability of such completed efforts. In this regard, the Commission shall require that surety liability in an appropriate amount be maintained until all decontamination, decommission, and reclamation has been completed and approved by the Commission, and all long-term surveillance and other charges have been paid.

- 3 -

A minimum charge of \$250,000 to cover the costs of long term surveillance shall be paid by each licensee to the general treasury of the United States or to an appropriate State agency prior to the termination of any license including a final disposal site for tailings or other waste byproduct material. If site surveillance or monitoring requirements are determined by the Commission to exceed those specified in Criterion 12, the Commission may specify a higher charge. Similiarly, the Commission may specify a higher charge if it determines that some maintenance will likely be necessary to maintain fencing and posting, to maintain vegetative cover, or for any other purposes. The total charge to cover all foreseeable costs of long-term surveillance, monitoring, and maintenance shall be such that, with an assumed 1 percent annual real interest rate, the collected funds will yield interest in an amount sufficient to cover the annual costs, of site surveillance. The charge will be adjusted annually to recognize inflation. The inflation rate to be used is that indicated by the change in the Consumer Price Index published by the U.S. Department of Labor, Bureau of Labor Statistics.

This requirement may be waived by the Commission, for final disposal sites involving only deep mine backfill or deep well injection of liquid wastes, if the Commission determines that there is no foreseeable need for long-term site surveillance.

- These criteria relating to ownership of tailings and their disposal Α. sites become effective on November 8, 1981, and apply to all licenses terminated, issued, or renewed after that date. The Commission may waive requirements delineated under [B] and [C] of this Criterion for sites where no permanent disposal of tailings or other waste byproduct materials is anticipated, or sites including permanent disposal only by deep well injection, or deep mine backfill. Such waiver shall be granted if and only if the Commission determines that no long-term surveillance, monitoring, or maintenance is likely to be needed. Such waiver as may be granted may be withdrawn by the Commission at any time prior to license termination, if the Commission determines that such withdrawal is either necessary or appropriate for protection of the public health, safety, or the environment. These criteria shall not apply to tailings or wastes disposed in licensed low level waste burial grounds.
 - B. Any uranjum or thorium milling license or tailings license shall contain such terms and conditions as the Commission determines necessary to assure that, prior to termination of the license, the licensee will comply with ownership requirements of this criterion for sites used for the permanent disposal of tailings or other waste byproduct materials.
- - D. If the Commission determines that use of the surface or subsurface estates, or both, of the land transferred to the United States or to a State will not endanger the public health, safety, welfare, or environment, the Commission will permit the use of the surface or subsurface estates, or both, of such land in a manner consistent with the provisions provided in these criteria. If the Commission permits such use of such land, it will provide the person who transferred such land with the right of first refusal with respect to such use of such land.

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E. In the case of any uranium or thorium milling license in effect on or - after November 8, 1981, the Commission may require, before the termination of such license, transfer of land and interests therein (including NEUI tailings) to the United States or a State in which such land is located NEW at the option of such State as may be necessary or appropriate to protect the public health, welfare, and the environment from any effects associated with byproduct material defined in this Part. In exercising this requirement, the Commission will take into consideration the status of the ownership of such land and interests therein (including tailings) and the ability of the licensee to transfer title and custody therof to the United States or a State. For licenses issued before November 8, 1981, the NRC will review an applicant's plans to effect arrangements to allow for transfer of site and tailings ownership prior to issuance of a license. Subsequent renewals shall not disqualify licensees otherwise eligible for such consideration under this criterion.

- F. Material and land transferred to the United States or a State in accordance with this Criterion shall be transferre without cost to the United States or a State other than administrative and legal costs incurred in carrying out such transfer.
- G. The provisions of this Part respecting transfer of title and custody to land and tailings and wastes shall not apply in the case of lands held in trust by the United States for any Indian tribe or lands owned by

such Indian tribe subject to a restriction against alienation imposed by the United States. In the case of such lands which are used for the disposal of byproduct material, as defined in this Part, the licensee shall enter into arrangements with the Commission as may be appropriate to assure the long-term surveillance of such lands by the United States.

The final reclamation of all permanent disposal sites of tailings or other waste byproduct materials shall be such that on-going active maintenance, other than occasional repair of fencing or posting, is not necessary to preserve complete physical isolation. As a minimum, annual inspections shall be conducted by owners of such sites to determine the need, if any, for monitoring and/or maintenance. Results of the inspection shall be reported to the Commission within 60 days following each inspection. The Commission may require more frequent site inspections if, on the basis of a site specific evaluation, such appears to be either necessary or appropriate due to the specific features of a particular tailing or waste disposal system or site. The Commission may, at any time, require the performance of any monitoring and/or maintenance that the Commission determines to be either necessary or appropriate for the protection of the public health, safety, or the environment.

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UNITED STATES NUCLEAR REGULATORY COMMISSION WASHINGTON, D. C. 20555

SEP 1 3 1979

Mr. Jeffrey Zimmerman Senior Counsel American Mining Congress Ring Building Washington, DC 20036

Dear Mr. Zimmerman:

1916094818

In April, 1978, the Nuclear Regulatory Commission (NRC) released a report entitled "Evaluation of Long-Term Stability of Uranium Mill Tailings Disposal Alternatives" which was prepared for the NRC through Argonne National Laboratories by an inter-disciplinary group from the Civil Engineering Department of Colorado State University (CSU). The group was headed by John D. Nelson and Thomas A. Shepherd. The CSU study was contracted to support preparation of the Generic Environmental Impact Statement (GEIS) on Uranium Milling (issued in draft form in NUREG-0511, dated April 1979).

By letter of June 27, 1979, you forwarded a document entitled "Report on Review and Critique of 'Final Report, Evaluation of Long-Term Stability of Uranium Mill Tailings Disposal Alternatives'" dated June, 1979, which was prepared by W. A. Wahler and Associates for the American Mining Congress. You indicated the Wahler report was prepared because of questions concerning the report and its use in NRC mill licensing which were raised by members of the industry.

We have reviewed the Wahler report and believe that concerns raised in its conclusions are ill-founded, being based primarily on a misunderstanding of what the purpose of the CSU report was and how it relates to the NRC's mill licensing program. The Wahler report does not challenge from a technical or factual point of view the evaluation of long-term stability of mill tailings disposal programs that was performed in the CSU report for NRC. Believing that the bases for our licensing policies and for proposed regulations (44 FR 50012) on uranium mill tailings should be fully understood by the public, and certainly by the uranium milling industry, we write this letter to attempt removing the misconceptions which led to the Wahler report conclusions.

In no way does the CSU report represent staff regulatory guidance, nor was it intended by itself to form the basis of NRC licensing policy. The report is a source document which was considered in conjunction with numerous other reports, studies, and perspectives in developing proposed regulatory requirements for uranium mill licensing. The resulting proposed staff regulatory position on tailings management and disposal, and the basis for it, is fully explained in the GEIS on uranium milling which has been circulated for public comment. Concern about NRC regulatory policies are, therefore, most appropriately focused on the GEIS.

Mr. Jeffrey Zimmerman

In conducting its review of alternative mill tailings disposal practices during preparation of the GEIS on uranium milling, the staff recognized that one of the most important aspects of the disposal problem which must be grappled with is the long-lived nature of the radiological hazards posed by the tailings. The staff felt it important to conduct a systematic study of information currently available on the various mechanisms which could over the long-term, disrupt a tailings isolation area, in order to help identify the kind of siting and design features that could be incorporated into tailings management programs to minimize or eliminate the potential for such disruption. The CSU report was the result of that study. It was not intended to be used by itself as licensing guidance, but was considered along with other reports in proposing tailings disposal requirements, the staff considered a wide range of factors in addition to the long-term stability of mill tailings disposal systems, for example, monetary costs. These factors are discussed fully in the GEIS.

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Attached are two enclosures containing more specific responses to comments made and conclusions stated in the Wahler report. The NRC staff responses are brief and address only the conclusions while the responses by Nelson and Shepherd address the entire critique. As indicated above and in the attached responses by the NRC staff, one of the most important factors influencing the staff proposed position on tailings disposal is the matter of long-term tailings stability and isolation (See Section 12.2 of the GEIS). We feel that the study of long-term stability considerations provided in the CSU report, notwithstanding the inherent limitations which are clearly acknowledged in the report, along with the numerous other factors considered and discussed in the GEIS, provide a sound basis for the proposed staff position on tailings management and disposal.

We look forward to your comments on the GEIS and trust that they will be invaluable in developing regulations for uranium mill tailings disposal which are fair and reasonable and which protect public health and safety and the environment.

Sincerely.

John B. Martin, Director Division of Waste Management

Enclosure: As stated

U. S. NUCLEAR REGULATORY COMMISSION RESPONSES TO CONCLUSIONS CONCERNING "EVALUATION OF LONG-TERM STABILITY OF URANIUM TAILINGS DISPOSAL ALTERNATIVES"

CONCLUSION NO. 1

The author's basic assumptions regarding time frame, geomorphology and climate do not provide a sound basis from which to evaluate uranium disposal alternatives for permitting purposes. In no other facet of our society today known to the reviewers are designs required to assure that a facility or any of its components will remain intact for the next 100,000 years. To do so would be to place an unrealistic burden on those who must provide for the needs of today and the foreseeable future. More realistic design requirements combined with monitoring and, if necessary, future maintenance may be an appropriate solution to this objection.

RESPONSE

There are two aspects to this conclusion. The first part relates to the approach taken in the CSU study. The second relates to NRC uranium mill licensing policy.

The radioactive hazard presented by mill tailings is a very long-lived one. The half-life of Thorium-230 is 80,000 years. Any honest evaluation of the problem of tailings disposal must deal with this fact. With this in mind, during preparation of the GEIS on uranium milling, the NRC staff commissioned a study by experts in geotechnical engineering and related fields to analyze the kinds of potential failure mechanisms that would operate over long periods of time to disrupt a tailings disposal area. The investigators were directed to consider a period of time as long as 100,000 years. The study was done (1) to identify the failure mechanisms which must be considered in evaluating, on a relative basis, the benefits of various tailings disposal alternatives, and (2) to identify specific siting and design features which could be incorporated into a tailings disposal program to eliminate or minimize the potential for failures. The second aspect of the Wahler conclusion Number 1 relates to the licensing policy of the NRC staff. This policy was formed only after considering a wide range of factors, including economic factors; the CSU report was but one of the reports considered in developing the GEIS and this policy. This policy was based upon the principle that future generations should not be saddled with a lingering obligation to care for wastes generated by operations from which they will receive only indirect benefits, if they receive any at all.

We disagree with the statement that design requirements that help ensure long-term isolation of tailings would "place an unrealistic burden on those who must provide for the needs of today and the foreseeable future." The cost of the uranium produced in the milling process should reflect the cost of waste disposal. The cost of good tailings management systems has been shown in the GEIS to amount to a small fraction (roughly 1-2 percent) of the value of yellowcake produced (with U_3O_8 at \$30/1b.). This small cost is reason enough to give further consideration only to systems that will not require active maintenance in the long term.

CONCLUSION NO. 2

If the report is to be used for any comparative purpose, the list of potential failure modes should be reconstituted and simplified so as (a) to eliminate some of the highly improbable modes and (b) to consider each natural phenomena only once in the list of events to be considered.

RESPONSE

In licensing, the staff has not required or suggested using the numerical ranking methodology described in the CSU report. The authors used this methodology to graphically illustrate how the many interrelated factors affecting long-term stab lity combine. The important thing, the thing we have emphasized in licensing and in the GEIS, is that the significant failure modes identified in the report be addressed in developing tailings disposal programs. Some failures are more likely and more significant than others; obviously they should get more attention in design. The areas of chief concern to NRC are addressed in the GEIS Sections 9.4.1 and 12.2. More specifically, the NRC staff has identified siting and design features which should be incorporated into tailings disposal programs to avoid potential failures.

CONCLUSION NO. 3

A "cookbook" type of approach as proposed by the authors should not be adopted for evaluation of alternative disposal schemes. A problem of this nature which is framed within such a nebulous time period and involves so many site-specific conditions, simply does not lend itself to solution by arbitrary assignment of numerical coefficients.

RESPONSE

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We agree that, with the exception of a few general principles and concerns as outlined in the GEIS, this problem is extremely site specific. It was never intended that an inflexible "cookbook" analysis be done. The comparative, ranking methodology presented by CSU in Section V of their report was illustrative of a technique the authors thought might be used in evaluating the relative merits of alternative disposal programs. In their own report, they used the ranking methodology as a way of illustrating how the various complicated and interrelated factors which affect the long term stability of tailings impoundments combine. The staff has not used this methodology in its licensing actions.

Staff evaluations of alternative tailings management plans give thorough consideration to factors which are specific to alternative sites and to alternative tailings management plans and do not rely on the arbitrary assignment of numerical coefficients, as is implied in the Wahler report. Tailings disposal requirements, as proposed by the staff in the GEIS, are designed to assure the potential failure mechanisms identified in the CSU report are taken into account in developing disposal programs. And, recognizing that the factors which affect the extent to which these failures can occur are highly site specific, the staff has proposed requirements which are primarily performance objectives in order to provide needed flexibility in design.

As the time period under consideration is essentially without end, the time period can be called nebulous, but this is an inescapable part of the problem and must be considered when evaluating alternatives.

CONCLUSION NO. 4

It is not clear how any solution to evaluation of tailings disposal alternatives can be satisfactory to both the regulatory agencies and the industry unless some means is provided to include economics in the overall evaluation.

RESPONSE

The regulatory policy of the NRC has been developed during preparation of the GEIS on uranium milling and does consider economic factors. The costs of acceptable tailings management alternatives have been studied by the NRC staff in detail. Although the costs between alternatives for a particular site may vary substantially, they have been found (GEIS) to be small in comparison with the value of the yellowcake produced.

CONCLUSION NO. 5

The authors' proposed methodology is not adequate for its intended use in that it involves the use of ranking factors which have been assigned by the authors on the basis of their judgment, without benefit of site-specific information which is required to adequately form such judgments. Furthermore, the manner in which the various constituent factors are assigned numerical values and combined within the methodology provides comparative evaluations which can be misleading in both relative ranking and importance of effects.

RESPONSE

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The CSU study was never intended for regulatory guidance. Please refer to the eariler staff responses to Conclusion No. 1 through Conclusion No. 4, above, and to the separately attached comments by Nelson and Shepherd concerning the review and critique.

CONCLUSION NO. 6

If the report were intended to serve as some sort of guideline or example for the industry, the example comparative evaluations performed by the authors should have been carried through to their conclusions, including all the judgments and considerations an outside investigator would have to use to perform a complete evaluation of this nature. A partially completed example is not very useful to anyone.

RESPONSE

As stated above, the specific ranking methodology in the CSU report was not intended as guidance to the industry. The important thing is that tailings disposal programs be developed taking into account the potential failure mechanisms identifed in the CSU report. NRC proposed regulatory requirements (summarized in Section 12.2 of the GEIS) are intended to assure this is done.

CONCLUSION NO. 7

If this report is to become an official guideline of the NRC, then that organization should make their position clear as to whether the conclusions from evaluations made by the proposed procedures would be accepted even if they conflicted with the NRC's current position favoring below ground disposal.

RESPONSE

As has been stated above, the CSU report was one of many documents prepared in support of work to prepare the GEIS, and is not part of the regulatory guidance of the NRC. The proposed tailings disposal requirements (Section 12.2 of the GEIS) provide flexibility in developing tailings disposal methods. Above-grade disposal, subject to incorporation of specific design and siting features, is considered potentially acceptable where below grade options have been thoroughly considered and found to be impracticable or precluded for environmental reasons, for example, when potential groundwater contamination problems might be created by this mode of disposal.

CONCLUSION NO. 8

Areas exist in the report text that are both confusing and misleading to a reader who is not expert in the technical fields encompassed by the report If regulatory agency personnel unknowingly form improper conclusions from the text's contents, it could be harmful to both the NRC and the industry, and thus to the nation. For this reason, the report should be carefully reviewed and edited by experts in the various technical fields before being used as any kind of technical reference.

RESPONSE

Sec. 55. 1.

The staff agrees that an interdisciplinary approach must be taken in evaluating tailings management systems. This is, in fact, the approach taken by the NRC staff. With respect to the CSU study, it was prepared by a five member team with considerable experience in the technical aspects of tailings impoundment systems. Capable consultants in other relevant, related scientific disciplines were utilized to assist in preparation of the report (see comments by Nelson and Shepherd concerning the review and critique).

To understand how the staff used the CSU report, one must read Section 9.4.1 of the GEIS. The staff did an independent analysis of the matter of long-term stability of mill tailings under natural forces, albeit drawing extensively from the CSU report. As seen in Section 9.4.1, other relevant sources were also considered in the staff evaluation of long-term stability. Final conclusions about tailings disposal were drawn by the staff in Section 12.2 considering all aspects of tailings disposal, including economic ones as summarized in Section 12.3 of the GEIS.

CONCLUSION NO. 9

Finally, it is concluded, for the various reasons cited above, that the report and the methodology which it proposes should not be adopted by the NRC or anyone else as an official regulatory guide. A far better approach would be for the NRC to develop a set of objectives related to disposal alternative considerations and goals to be met in the design of disposal facilities. From that point, they should then permit the regulatory flexibility to allow the best and highest use of the technical expertise available to develop and improve on methods of meeting those objectives. Unnecessary restriction of creative engineering by the imposed use of "cookbook" procedures would benefit neither the NRC nor the industry over the long term.

RESPONSE

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The staff agrees. As stated above, the CSU report was never intended to be used as a regulatory guide. Contrary to what is stated by Wahler in this conclusion, the staff issued interim tailings management system performance objectives on May 13, 1977, and these objectives have been addressed by industry in all tailings management system proposals since that time. The conclusions of the GEIS concerning tailings disposal are very similar to the interim performance objectives and should continue to allow the industry flexibility in developing proposals for tailings management systems.

COMMENTARY

on

Review and Critique for American Mining Congress

of

EVALUATION OF LONG-TERM STABILITY OF URANIUM MILL TAILINGS DISPOSAL ALTERNATIVES

Comments by John D. Nelson and Thomas A. Shepherd

The following comments relate to the review and critique of our report on Long-Term Stability of Uranium Mill Tailings Disposal. These comments are divided into two parts. The first part includes general comments regarding the overall review. The second part refers to particular sections and comments made in the review and critique. Some redundancy exists between the two parts, but it was not considered to be a worthwhile investment of time to attempt to remove that redundancy.

Before the following comments are presented, however, we would like to note that Thomas A. Shepherd's name was spelled incorrectly throughout the review. It is not clear whether that was a result of inadequate editing of the review and critique or just lack of attention to detail during the review.

I. GENERAL COMMENTS

A. Many of the reviewer's comments reflect a lack of understanding of many important points that were presented in our report. The reviewer has chosen to ignore much of the discussion which we presented to stress the limitations of the methodology. He has not appreciated the significance of our comments regarding the care which must be taken to avoid placing too much confidence in the numerical values obtained through the methodology.

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It is important to emphasize that care was taken in the development of the methodology so as not to infer a misleading degree of accuracy in the numerical results of the report. Throughout the report the readers are cautioned to not place too much importance on insignificant differences in the numerical results. Considerable discussion was devoted in our report to the fact that the numerical results are intended to only be a guide to decision making. It was emphasized that the results are, to a large extent, subjective and it was pointed out that the product of ordinal scales may not result in an ordinal result. The reviewer appears to not have grasped the significance of that discussion in our report.

B. The authors have respect for the overall qualifications and integrity of the W. A. Wahler and Associates organization. Nevertheless, we would have preferred that the reviewer of this report identify himself and present his qualifications. The information on page II-1 indicates that the reviewer was Mr. George Fink.

Also, throughout the report the reviewer is referred to in the singular, implying that only one person participated in the review. Of particular significance in this regard is the level of effort and number of people who participated in the preparation of our report. A project team of five personnel with experience both in the design, construction and practical operations of tailings impoundments, consulted and discursed all of the points in our report prior to their publication. In addition, a committee of four consultants representing a very wide range of technical expertise, including geomorphology, erosion control, nuclear engineering and radiation biology, reviewed the report in detail. Their comments and opinions were taken into account in the final report. In this way it was attempted to insure to the greatest extent possible that methods of analyses and aids borrowed from other investigators were used in the manner for which they were intended. In instances where the application of methods and aids were beyond that for which they were originally developed, care was taken to insure that the application in this report was reasonable. This was accomplished by consulting many high level experts in technical fields relating to the pertinent subject matter in the report. Those experts were not identified explicity in the report.

Consequently, we believe that many of the innuendos contained in the review are totally out of place. In particular we are referring to (among others) the statement on page V-8 of the review which states "... before any of these aids are applied to a specific problem their general applicability and the degree of precision to be expected from their use should be carefully evaluated ...".

C. Of particular importance is the misunderstanding on the part of Wahler and Associates, and perhaps the American Mining Congress, as to the purpose of our report. The reviewer has assumed that our report and methodology will be applied as a regulatory guideline to be used for determining the one particular acceptable disposal option. The reviewer states that the proposed methodology is "not adequate for its intended use" although they do not appear to understand what its intended use was. The reviewer states that the methodology presented in our report has been suggested for use or mandatorily imposed for evaluation of alternatives on one or more potential projects by the NRC. The reviewer,

however, is not aware of the manner in which the results of those evaluations were used.

It must be emphasized that our report was intended to be a source document for the Generic Environmental Impact Statement, and not a regulatory guideline.

D. The reviewer expresses concern that our report will be misinterpreted and misapplied by unqualified personnel. The report was written for personnel having adequate technical background to understand the comments made therein and to integrate the conclusions in a reasonable and judicious manner into the Generic Environmental Impact Statement. Furthermore, we were given the opportunity to review, and to discuss with the authors of the Generic Environmental Impact Statement, conclusions drawn on the basis of our report which Fertain to long-term stability. Thus, the report was not intended for lay personnel who could misinterpret the conclusions, as was inferred in the review.

E. The reviewer has misunderstood the purpose of our report. The purpose was to provide an initial review of the potential ion_-term problems associated with uranium mill tailings disposal plans. The methodology and example applications were intended to illustrate a procedure based on the model sites described in the Generic Environmental Impact Statement and is site specific for that particular application. The results of the example application of the methodology are not intended to be all-inclusive for all mill tailings sites and if it were to be applied to other sites, site-specific considerations would need to be taken into account.

F. The reviewer takes exception to the time-period considered in our report and continuously refers to it as a "nebulous time". In our report on page 316 it was noted that short long-term periods represent periods during which engineering design of the site would govern its performance. Long long-term periods represent periods during which natural geomorphological processes would govern the performance of the impoundment. The medium long-term period represents a transition from the "engineering dominance" phase to the "geomorphological "minance" phase. In our report it was noted that these time periods would probably represent periods on the order of several hundred years for the short longterm period, a few thousand years for the medium long-term period, and up to periods of about 100,000 years for the long long-term period. The latter time period was chosen because it is of the same order of magnitude as the half-life of thorium. To define these time periods in more detail in terms of numbers of years would be meaningless.

It has been recognized and discussed both in our report and in our paper presented in the *Proceedings of the Symposium on Uranium Mill Tailings Management*, that it is not reasonable to specify that tailings impoundments should be designed to withstand forces of nature for a period of 100,000 years. The period of design performance of the impoundment cannot be defined in explicit numbers of years and for each site, site-specific considerations as well as consideration of the surrounding area must be taken into account. This philosophy, I believe, has been reflected in the pertinent part of the Generic Environmental Impact Statement.

G. The reviewer states that many of the potential failure modes listed on page 10 of our report should be eliminated and not considered in future licensing applications. It was noted in our report that

many of those failure modes, particularly the natural phenomena, will have little or no influence on the long-term stability of tailings impoundments (for example, tornadoes or glaciation). However, as a source 'document, it is important that all failure modes be considered initially and then removed from future consideration where they are not applicable. Because our report included consideration of those failure modes and because it is not a regulatory guideline, it is necessary to include all failure modes in that table.

H. The reviewer appears to express the fear at many points throughout his review that the report will serve as a regulatory guideline for the industry. He has misunderstood the intent of the report and apparently is not aware of the use which has been made of this report by the Nuclear Regulatory Commission. It has been emphasized that our report was intended to serve as a source document for the Generic Environmental Impact Statement and is not a regulatory guideline.

II. SPECIFIC COMMENTS IN REVIEW

The following comments relate specifically to particular conclusions presented in the Wahler review.

A. In subparagraph III.1, the reviewer takes exception to our assumptions regarding the time frame and indicate that no other facility is required to be designed to assure that it will remain intact for the next 100,000 years. Not only was it never intended to imply that an impoundment should be designed for such a specific time period, but it was never stated as such in our report. This extended time frame was included to assure development of broad insight into the interaction of

natural phenomena and tailings impoundments. It was never assumed to provide a design-life requirement.

B. In subparagraph III.2, the reviewer states ". . . if the report is to be used for any comparative purpose the list of potential failure modes should be reconstituted and simplified . . .". The report is not intended to be used for comparative purposes in regulation. It was intended as a source document to provide an initial insight into the potential failure modes which must be considered in evaluation of long-term stability.

C. In subparagraph III.3, the reviewer states "a cookbook type of approach as proposed by the authors should not be adopted for evaluation of alternative disposal schemes." A cookbook type of approach was not proposed in our report. It was stressed throughout our report that caution must be exercised and interpretation of the numerical results and the results were to be used only as a guide for decision making. It was noted that the results are subjective and will vary with particular site specific conditions. The reviewer also makes reference to the "nebulous time period" concerned therein. The significane of these time periods are presented on page 316 of our report and was discussed previously in Section I.F of these comments.

D. In subparagraph III.4, the reviewer criticizes the lack of inclusion of economics in the overall evaluation. We were instructed specifically not to consider economics in the evaluation.

E. In subparagraph III.5, the reviewer states that ". . . proposed methodology is not adequate for its intended use . . .". Much of the criticism resulting in this conclusion is based on the fact that

site-specific information was not included to form such judgment for assignment of ranking factors. Again it must be emphasized that the methodology in our report is applied to the Model Site as described in 'the Generic Environmental Impact Statement and the example is not intended to represent other specific sites.

The degree of uncertainty of the ranking factors in our report was discussed and it was noted that these factors were subjective and could be modified at later times if necessary. The range of negative utility factors was maintained at a relatively narrow margin so as not to unduly bias the results. We would be happy to listen to and consider constructive suggestions regarding the use of that negative utility factor, but until then, we do not see this as a serious criticism. The example application of the methodology was intended to demonstrate a way by which the information developed might be used.

F. In subparagraph III.6, the reviewer states "if the report was intended to serve as some sort of guideline or example for the industry ...". It was not intended for that purpose.

G. With reference to subparagraph III.7, our report is not intended as an official guideline for the Nuclear Regulatory Commission.

H. With reference to subparagraph III.8, our report was not intended for personnel who are not technically qualified to utilize the results of the report. The reviewer notes that the report should be carefully reviewed and edited by experts in the various technical fields. That was the purpose of the panel of consultants which reviewed the report, the conferences with many high level experts, and the makeup of the project team which prepared the report.

I. We agree wholeheartedly with the conclusion presented in subparagraph III.9. A set of objectives related to disposal alternatives and goals to be met in the design of disposal facilities has been formulated and to date has formed the basis for regulation of uranium mill tailings impoundments. Those objectives are commonly referred to as The Nuclear Regulatory Commission Performance Objectives.

J. In paragraph IV.C.1, the reviewer takes exception to the use of a long long-term period extending to 100,000 years. He appears to have missed the importance of the three time periods considered in our report and does not appear to have been cognizant of the comments on page 316 in our report. In his paragraph IV.C.2, he suggests that the uncertainties in geomorphology and climatic changes could be overcome by defining the disposal goals and criteria over shorter term periods and stresses that severity must be considered from the standpoint of environmental damage. In order to quantify the potential environmental damage, our methodology attempted to define it on the basis of release of radioactive material.

K. In subparagraph IV.C.3, the reviewer considers that the list of failure modes is redundant between elemental failure modes and natural phenomena. We agree that the list of failure modes is redundant. It was intended to be complete for the initial consideration of longterm stability necessary in such a source document.

L. In paragraph IV.D.4, the reviewer takes exception to what he says is our attempt to develop a standardized technical approach to permit a "cookbook" solution to the evaluation of all alternative disposal schemes. The reviewer neglects the discussion which we presented

as to the use of these results. He does not consider our cautionary comments that they should be used not as explicit numerical results, but must be considered only as aids in decision making. Perhaps more careful reading of the report would alter the reviewer's opinion on this point.

M. On page IV-5, the reviewer criticized the report for not considering economics. In this report it was specified that economic considerations were absolutely not to be considered.

N. The following comments refer to Chapter V in the review concerning the methodology. The reviewer devotes considerable discussion to the use of the negative utility factors and the assignment of values between 0.25 and 2.0. Again it is emphasized that such factors were subjective. However, these values were selected on the basis of discussion with several investigators and are considered to be reasonable. A wide range was considered to be undesirable in that it could grossly distort the results. On page V-2, the reviewer notes that ". . . the author's engineering judgment without benefit of site specific information supercedes the analyzer's engineering judgment and the results can be grossly misleading or even incorrect." It is not sure what the reviewer means by that comment. However, it must be noted that site specific information is obviously necessary before any particular site can be reviewed. The methodology in the report was applied to the Model Site for the Generic Environmental Impact Statement. In that application the site specific information for the Model Site was used.

The reviewer takes particular exception to the assignment of a large value of negative utility for floods. His argument is that floods

would cause such wide dispersion of the tailings that the environmental damage by the radioactive material would be minimal. This may or may not be the case, but is irrelevant to this discussion. Our purpose was to evaluate the potential for release of radioactive material from the site itself, not the off-site impact. It was considered that dispersion over large areas would be detrimental to the environment and would be particularly difficult to clean up.

0. On page V-4, the reviewer takes exception to our statement that the values shown on Table 13 represent only the best estimates by the project team. He states that "such a weakly founded approach hardly seems to be one which should become a standard of alternative evaluations for the uranium mining industry." Again, we must emphasize that this report was intended as a source document for the Generic Environmental Impact Statement and not a standard to be used by the uranium milling industry.

P. On page V-4, the reviewer notes that only Step 1 in Figure 18 was actually accomplished in our example. Steps 2 and 3 in Figure 18 were intended only to indicate the manner in which the results could be utilized. The reviewer appears to be perplexed because we did not add the four values of severity developed for each instance. In the report it was stated clearly that four values of magnitude of failure were developed, one for each separate release mode discussed in Chapter V. The reason these values are not added should be obvious in that it is impossible to add attenuation of gamma radiation to release of dissolved or undissolved radionuclides or radon emanation. The severity factor was obtained by multiplying a scalar quantity (L_i) by a vector (M_i) and

another scalar (U_i) . The result will be a vector, S_i . It appears very clear in Figure 18, Step 2, that A_i is determined by adding values of S_i which are vectors. If the reader wishes to add the values of severity, it is no more complicated than adding any two vector quantities.

Q. On page V-6, the reviewer questions the outcome if our report differs in opinion from NRC's opinion, particularly with regard to below-grade disposal. It must be emphasized that our report is a source document for the Generic Environmental Impact Statement which was prepared by the Nuclear Regulatory Commission.

R. Table 1 in the review lists aids borrowed from others. This table lists methods of analyses that we utilized and which we considered to represent the state-of-the-art in those particular fields. The use of each reference was reviewed by technical personnel well qualified in that particular field. Those personnel were either members of the project team or the panel of consultants utilized in this project. In some instances, other experts on the Colorado State University staff were consulted. As such, particular care was taken to ensure that the analyses were applied in a reasonable fashion. On page V-8 of the review, the reviewer notes that it is impossible within his review to conduct a detailed review of the development, applicability and precision of each aid listed in Table 1. He notes that the general applicability and degree of precision to be expected from the use should be carefully evaluated. However, the project team and the consultants involved in the project did conduct a careful review of each aid and its application. The reviewer's comments in this regard, therefore, have little credibility.

S. With regard to Table 2 in the review, the comment is voiced concerning the mislabelling of the axis in Figure 2b of our report. The 2% figure shown on page 21 is the correct value and, in fact, is conservative. The reviewer questions how the division points of crack spacing were determined for the purposes of calculating expected magnitudes of failure shown in the graph. That is discussed on page 21 of our report. It was assumed that an area extending to five feet on either side of the crack would contribute to release of radon. Thus a magnitude of release was computed to be the ratio of a ten foot wide area for each crack relative to the overall area of the tailings impoundment.

T. In their Chapter VI, the reviewer spends considerable discussion on earthquakes which he said might be completely misleading to an "inexperienced evaluator". Again, this report was not intended for people who are not technically capable of reading and interpreting the results. On page VI-3 of the review, the reviewer notes that whether or not the tailings are saturated during such an event could have little or no effect on the potential release of tailings. The significance of the tailings being saturated is that partially saturated tailings have a very small probability of liquefying during an earthquake. Liquefaction of partially saturated tailings would require imposition of a very high blast loading of short rise term. It is not considered that unsaturated tailings could be liquified during an earthquake.

U. On page VI-4, the reviewer notes that ". . . technical exception could be taken to statements and implications made in other sections of the report . . . ". He notes that the Nuclear Regulatory Commission should ". . . have each section technically reviewed and edited by

someone with a high level of expertise in the particular technical field under discussion . . .". Where members of the project team did not possess the required "high level of expertise", other members of 'the staff and faculty at Colorado State University, and in particular members of the consultant committee, were consulted. The authors resent the implication that the report was prepared by persons with less than adequate expertise and that care was not taken to consult experts in the field on matters that were presented in the report. We realize that many points may be open for discussion and we would like the opportunity to discuss on a professional level many of the points presented in our report. Unfortunately, this review was not conducive to such discussion.