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Regulatory Publications Branch
Division of Freedom of Information
and Publication Services, Office of
Administration, U.S. Nuclear Regulatory
Commission, Washington D.C 20555

Dear Sirs:

Hydro-Engineering of Casper, Wyoming, a consulting firm active in uranium mill tailings reclamation design has reviewed the Draft Staff Technical Position of the U.S. Nuclear Regulatory Commission (NRC) dated August 1989. This position paper concerns the "Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites". This letter presents comments pertaining to specific areas of concern in the Draft Staff Technical Position paper; however, detailed discussions of the technical aspects are deferred until a later time when a meeting may be arranged with NRC technical staff.

It is understood that the development of this position paper was to make more consistent both the approach to the design by operators and the evaluation by the NRC of designs for the reclamation of uranium mill tailing sites. It is indeed vital that the designers of tailings covers have a clear perception of what is acceptable and what is not acceptable to the NRC reviewers. It is also important however, that the engineer use his individual judgement as to which particular methods of design are appropriate. This judgement should be based on both the recognized industry standards for design and on a comparison of the applications in the reclamation and the environment under which the procedure was developed. Appendixes A, B, and D present specific design methods and procedures to be applied under, what appears to be, all design circumstances. The specific methods put forth in the Draft Staff Technical Position paper are procedures which should be used only in specific reclamation environments and are generally not industry standards for design. In addition, many of the methods and parameters described in this document such as the Horton method, the limiting shear values to use, the sacrificial slope equation, and the several riprap design methods are not adequately and technically justified. Justification in this paper is often based solely on the conservatism of the result when compared to other methods. A tailings cover design must be based on sound principles and correct procedures. To incorrectly apply a method during design on the rational that it yields a specific conservative result is not standard practice in engineering and can in fact lead to a unstable or inferior overall design. As an example, the design of very low slope angles, using the Horton equation, might yield a tailings cover surface in which surface drainage throughout the design life of the cover can not be assured.

Consequently, the use of specific procedures in all design circumstances, namely those given in Appendixes A, B and D, is contrary to the spirit and content of the Draft Staff Technical Position paper, particularly the statement on page 5 and 6 which reads:

> The design criteria applied to tailings reclamation design should reflect current standard engineering design practices. Examination of similar design situations can help in establishing the type and reasonableness of design criteria applied to tailings reclamation.

The appropriate degree of conservatism should also be used in the design of a tailings cover. The Summary 10 Management Position paper is quoted on Page 6 of the Draft Staff Technical Position that the appropriate conservatism can be evaluated with the following guideline:

> Given the general demographic and physiographic characteristics of mill tailings sites, the risk of tailings reclamation failure is not life threatening in the short term and is unlikely to be significantly greater over the long term. Therefore, the engineering criteria should be commensurate with this risk.

The above paragraph states that risk to lives is minimal from an erosional exposure of tailings. Indeed, a Uranium Mill Standard Tailing Study Panel of the National Academy of Sciences (NAS) concluded that:

> ...the risk posed by piles under such circumstances (eroded piles) is inconsequential compared with other impacts of such a catastrophic event...(PMF)

Therefore, based on the staff statements made by the NRC and the NAS, the appropriate degree of conservatism for the design of tailing covers would be moderate to low in many areas of the western United States when determined using biological and environmental risk factors.

It is clear from the NRC Draft Staff Position paper that the degree of conservatism should also be chosen based upon the requirement of no maintenance to the reclamation over its design life. It is stated that because of this requirement, and the uncertainty of recurrence intervals of very large magnitude storms, it is mandated that a (PMF) Probable Maximum Flood be used in design. The use of the PMF in design virtually assures that the design event will not be exceeded during a 1000 year period.

It is important to note that the design of a feature for a specific meteorologic event is to provide for no erosion during the storm. The design therefore would allow for a large number of events to occur without damage to the cover. Considering the low risks associated with even a large failure of the reclamation and considering the virtually zero probability of occurrence of a PMF, along with quotations above it indicates that the PMF is too high a magnitude event for a reasonable design.

An alternate, more reasonable storm option for using a 1000 year design is the standard project flood (SPF). The SPF is used by the Army Corps of Engineers (ACOE) in many areas where significant loss of life would occur from failure. The definition of a SPF is as follows:

> Estimates representing flood discharges that may be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the geographical region involved excluding extremely rare combinations.
> (EM1110-2-1411, page 4)

The SPF affords a protection where:

> ...some small degree of risk can be accepted but an unusually high degree of protection is justified by hazards to life and high property values within the area to be protected. (EM1110-2-1411, page 5)

As is seen in the definition, the SPF is the most extreme magnitude flood that can <u>reasonably</u> occur. Its probability of occurrence is very low and can be used in situations where a high loss of life and property would occur from failure. Considering this fact and recognized usage and the risks associated with a failure of a reclaimed tailings structure, it is more appropriate in remote areas to use a SPF for the 1000 year design. It must be emphasized that such a design would be capable of withstanding many SPF events without damage and during a PMF, such a design would experience only very minor erosion of the cover. Use of the SPF in the design should provide for reasonable assurance of long term stability of the reclaimed structure due to its very high magnitude and extremely rare occurrence.

Finally conservatism in design should be obtained by choosing a conservative design storm with the subsequent use of standard engineering procedures and parameters. As the Draft Staff Technical Position states on page 6:

> In evaluating the magnitude of a design basis event or the acceptability of a particular design criteria [sic], reasonable ranges and distributions of parameters should be used. ...Extreme values should not be used. In any case, there should be a reasonable and defensible technical basis for the choice of a design basis event or design criteria parameter, with consideration given to phenomena which can be reasonably expected to occur during the period for which the design is required to perform.

Discussion of specific areas where this principle should be applied in the design of tailings covers but is not in the Draft Staff Technical Position paper will be presented herein under the review of each appendix.

The NRC modified Horton Stable slope equation presented in Appendix A yields overly conservative slope designs as a result of several factors. A full evaluation of the Horton method will not be presented in this letter. Instead, only the major concerns will be discussed herein.

First, the addition of a concentration factor without the addition of a rainfall abstraction factor models two slopes of different and opposed character. If the flat slope is modelled to be irregular in its surface so as to concentrate flows, one must also assume that storage due to the same irregularities would occur. A rainfall abstraction volume would likely be significant for any stable slope which concentrates flow 2-3 times. The addition of one factor, namely the concentration factor, without the addition of the abstraction or runoff coefficient is inappropriate.

Secondly, the incorporation of the rational formula within the Horton Stable Slope equation also results in overly conservative slope designs. The rational formula will inherently yield overly high discharges for a unit slope as it is intended to model nearly circular basins. The use of the rational formula to predict discharges along a unit strip of land effectively results in an additional concentration of flow.

Third, the shear stress incorporated in the Horton equation significantly over-predicts shear that a surface would experience. This is a result of two factors. First, the shear of flowing water on a surface is significantly decreased by the roughness that is created from raindrop impact upon the surface of the flow. Raindrop impact upon the surface of the water during high intensity storms has been shown to result in a very significant increase in roughness experienced by the flow. This increase in roughness does not originate from the bed but yet reduces the flow velocity which in turn significantly decreases shear on the bed. The shear stress equation is incapable of correctly predicting shear upon the bed under these conditions since it assumes all roughness originates from the bed. In addition, the shear stress equation is a laminar flow equation. The depth of flow in the Horton equation however, is predicted by the Manning equation which is for turbulent flow and yields depths greater than would be experienced in a laminar flow condition. The flow depth is a function of resistance from the bed; however, it is also a function of energy losses from turbulence, air entrainment and raindrop impact. In the shear stress equation, it is assumed that all shear energy which causes there to be a depth of flow is expended by the bed. The use of an equation which determined depth of flow assuming the turbulent conditions in conjunction with an equation to predict shear that assumes laminar flow, results in an over prediction of the shear upon the bed.

The fourth concern of Hydro-Engineering, of using the Horton equation, is that the limiting shear values as obtained from Temple (1987) are excessively low. It has been shown that shear stress is only useful to determine the threshold of movement of bed material. It can not be used in sediment transport analysis'. The problem with using shear as the limiting value is that often values of shear significantly in excess of the limiting values may be experienced before a tangible amount of transport actually occurs. This may largely be the cause for the disparity between laboratory derived values of limiting shear and those determined through years of practical application in the design of hydraulic structures.

Overall, the results of the theoretically derived Horton Stable Slope method yields cover slopes which are excessively low or short. This is compounded by the application of extremely conservative parameters used in its application. The results of the Horton equation are incongruous with Hydro-Engineering's practical experience with slopes in the Western United States.

Appendix B presents a sacrificial slope calculation. It is stated in the Draft Staff Technical Position paper, on page 16, that sacrificial slopes may only be considered if a 200 year design life is defended. Hydro-Engineering feels that such a limitation should not be imposed under many types of design.

The design of a tailings reclamation structure must account for individual stability needs of features relative to their position in reference to the cover and to their hydrologic significance to the reclamation plan. Features that are adjacent to the tailings area but do not receive runoff from covered tailings can be designed to allow for some erosion during the design storm as long as the erosion is less than that required to directly affect the integrity of the cover over the 1000 years. In the case of the clay dam outslope, where there is a drainage divide along the crest of the dam, significant erosion is acceptable with a design life of 1000 years. The presence of a divide along the top of the slope inhibits a significant depth of gullying down the length of the slope. Many gully erosion studies are focussed on slopes which have contributing drainage above the steeper slope segment of interest. The prediction of gully depth based upon these type of studies yields too high a gully depth. Experience with numerous spoil slopes and tailings dam slopes of various ages indicate a substantial decrease in gully formation when headwater contribution is reduced even on relatively steep 2.5:1 to 5:1 slopes.

The process of gully erosion involves both dislodgement and transport down the throat of the gully and interrill sheet erosion. The erosion of a slope and formation of gullies involves a complex inter-relationship between these two processes. When contributing drainage occurs from a low slope area above the slope in question, the erosion dynamics and morphology are drastically changed. Gully erosion therefore is over-predicted in this method and is also over emphasized as to its significance in jeopardizing the stability of the tailings cover. Finally, the correction for a fine grained material using the Horton Stable Slope method is inadequate since fine grained slopes, where there is cohesion, erode more slowly. Therefore, the corrections to this method for fine grain soils only partially addresses Hydro-Engineering's concerns.

Appendix C presents an outline of the process to be followed for justifying a design life of 200 years. This appendix contains highly subjective language and outlines a procedure which is very costly for the operator. The data requirements needed for such a process would be very difficult if not impossible to obtain. Finally, numerous transmittals to and from the NRC would be most likely required in order to execute such a procedure. This could result in an protracted period of time to occur until there could be a decision regarding the appropriate design life.

Appendix D presents guidelines and instructions for the design of riprapped structures. The selection of a riprap design method based upon its conservatism is inappropriate. Riprap design methods are often very specific to particular applications. In most cases of ephemeral channels and in all overland flow applications, the use of safety factor method is inadvisable. The Stephenson method is acceptable in many of the conditions specified in the Draft Staff Position paper; however, in past NUREGs it is incorrectly presented. Modifications to the Stephenson method by NRC technical consultants are theoretically unjustified, as they confuse the definition of threshold and failure discharges, and subsequently result in erroneous corrections for angular versus rounded rock. The modifications to the method are significant and are completely divergent with the original Stephenson method. The method presented in the original Stephenson document must be presented correctly and used unaltered. The three riprap design methods mentioned (Abt, Stephenson and Safety Factor) are all developed from laboratory experiments contrary to that which is implied on page D-2 of the Draft Staff Technical Position paper, namely: that the Abt method alone is derived in the laboratory. The Laboratory conditions used to determine the Geesler's function, which is incorporated in the Safety Factor method is much less relevant to the proposed application on tailing cover slopes than the Abt method. Finally, the decision to use a specific method must be reserved for the design Engineer and be based on sound engineering principles. The degree of conservatism from the use of a method should not be the primary consideration in the selection of the correct method.

The use of the shear stress in riprap design for channels is recognized to be inappropriate under many design circumstances. Engineering judgement must be applied to the selection of the appropriate conveyance parameter to be used in design.

The rainfall distribution of a storm should be that which is recognized as appropriate for a given magnitude or recurrence interval storm. The selection of a rainfall distribution which yields the most conservative outflow as stated on page D-11 is arbitrary and inconsistent with standard engineering practices.

In addition, within one reclamation plan, many different distributions would be needed depending on individual basin sizes shapes and hydrograph combination schemes. Such an approach in storm runoff determination is unreasonable and unsound.

The degree of riprap oversizing of 40% for round rock as presented in Appendix D on page D-4 is very much higher than accepted oversizing procedures and based upon too little data and improper reasoning.

Rock durability of channels draining small basins in many cases, should be for occasionally saturated conditions as directed on page 91 of NUREG CR/4620. In addition the durability and oversizing criteria overlap in some areas which would possibly cause one to conclude that the riprap would need oversizing even though it is actually very durable.

Finally the method of placement of riprap (by hand 8" or larger, page 19), should be evaluated based upon a performance specification basis and not be dependent upon procedure.

Hydro-Engineering's concerns can be summarized into three categories. These are namely: 1) preserving an engineers judgement in design, 2) incorporating conservatisms based on risk and in such a way as to not escalate the conservatism of the overall design, and 3) the use of sound engineering and geomorphic principles relative to specific applications. We believe that when the principles presented above are incorporated appropriately in the design of a tailings cover, reasonable assurance of the 1000 year design life can be attained.

This document is intended to express our concern over specific items presented in the Draft Staff Technical Position paper, August 1989. It was not intended however to present full technical arguments in defense of our concerns. Specific supporting references were not presented within this document in keeping with the intended scope and detail of our replies. Hydro-Engineering encourages questions regarding the content of this letter. Questions may be directly addressed to me at 770 East Magnolia Street, Casper, WY 82604.

Sincerely,

Stuart Dykstra

Stuart Dykstra
Hydrologist

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