CENTER for SCIENCE in PUBLIC PARTICIPATION
224 North Church Avenue, Bozeman, MT 59715
Phone (406) 585-9854 / Fax (406) 585-2260 / web: www.csp2.org / e-mail: csp2@csp2.org
"Technical Support for Grassroots Public Interest Groups"

May 20, 2009

Bobbie Lacklen
Kootenai National Forest
31374 U.S. 2 West
Libby MT 59923-3022
r1_montanore@fs.fed.us

Montana DEQ
PO Box 200901
Helena, MT 59620-0901
deqmontanoreEIS@mt.gov

RE: Draft Montanore Project EIS – Review of the Seismic Safety Considerations for the Montanore Tailings Dam

The Center for Science in Public Participation provides technical advice to public interest groups, non-governmental organizations, regulatory agencies, mining companies, and indigenous communities on the environmental impacts of mining. CSP2 specializes in mining, especially with those issues related to water quality impacts and reclamation bonding.

Summary of Conclusions:

1. The choice of the earthquake event corresponding to the Maximum Credible Earthquake (MCE) is not the most conservative choice for the MCE, as reflected in the data presented in the technical reports. The random local earthquake M 6.5, cited under the minesite at a depth of 5 km, should be used as the Maximum Credible Earthquake (MCE) for calculation of peak acceleration, rather than a M 7.0 earthquake on the Bull Lake Fault.
2. Even based on the choice of the MCE as a M 7.0 earthquake on the Bull Lake Fault by the designers of the tailings dams, the design horizontal acceleration due to the MCE of 0.22 g was not used as the design seismic event for dam stability analysis. It appears that a value of 0.11 g, or only half the horizontal acceleration of the MCE event, was utilized for seismic safety analysis.
3. Although a similar level of dam safety analysis has not been performed for the Poorman Tailings Impoundment Site location, it appears that similar safety concerns (seismic stability related to glaciolacustrine clay sediments) would exist at this site too.
4. Given the numerous assumptions about dam stability, including that the dam drains will work properly in perpituity, and that the tailings material used for dam construction will remain fully unsaturated in perpituity, there is still a finite but unquantifiable risk that an unanticipated failure could occur in the glaciolacustrine clay sediments that underlie the main tailings dam and the diversion dam.
5. Cycloning sands from sulfide ore deposits for tailings dam construction has led to the concentration of pyrite in the course fraction of the cycloned sands at the Thompson Creek mine in Idaho. It is not clear that a geochemical analysis of the cycloned tailings dam sands has been performed to insure that this will not be an issue for the proposed Montanore dam.

Section-Specific Comments:

2.5 Alternative 3—Agency Mitigated Poorman Impoundment Alternative

2.5.3.5.2 Final Design Process

The analysis of the Poorman impoundment design considerations are only at a conceptual stage, as opposed to the level of analysis available for the Little Cherry Creek proposal. It is noted in the DEIS:

> "… a preliminary design of the Alternative 3 site would be completed to confirm the site layout and design/operation feasibility. The second field exploration program would be completed to collect data and material samples necessary for the final design of the facility." (DEIS, p. 103)

and;

> "Technical review of the final design would be made by a technical review panel established by the lead agencies. … The lead agencies would review and approve the final design prior to construction." (DEIS, p. 103)

The fundamental approach in proposing and preliminary analyzing this alternative are sound. However, more detail would be needed in order to properly evaluate and critique this alternative, as is stated in the DEIS. The DEIS states that lead agencies would review and approve the final design of this alternative, with the implication being that the public would not be offered the opportunity to evaluate and comment on the proposal (probably because it would require additional time).

This impoundment location, and the design of the tailings dam, is not without risk, as it apparent from information presented in the DEIS. It is important that the public be offered an opportunity to review and comment on this important proposal, should it become the preferred alternative in the EIS.

Recommendation: The results of the Poorman Impoundment Alternative evaluation final design process, if this is selected as the preferred alternative, should be disclosed to the public, probably thorough an SEIS process.

3.8 Geology

3.8.1 Analysis Area and Methods

It is stated in the DEIS:

> "The leaching of nitrate from blasting residues on ore, waste rock, and tailings is also a short-term concern."

It should be noted that nitrate levels from waste rock, heap leach material, and the pits at the Zortman-Landusky mines are still leaching in significant amounts over 10 years after the cessation of mining.

Recommendation: This statement is misleading unless "short term" is more clearly defined. This should be clarified in the EIS.

3.9 Geotechnical Engineering

3.9.2.2 Seismicity and Seismic Hazard

In describing the potential seismic hazard to the minesite, it is stated that:

> "The site is located in a moderately active seismic area. The design maximum credible earthquake (MCE) is a potential Magnitude 7.0 earthquake on the Bull Lake Fault, which results in a peak ground acceleration of 0.22 g." (DEIS, p. 395)

There are two issues to be discussed with regard to the choice of the Maximum Credible Earthquake (MCE); first, the choice of the MCE event; and, second, the use of the MCE in calculating the seismic safety of the tailings dams.

(1) Choice of the MCE Event

The Maximum Credible Earthquake (MCE) is defined as the largest rationally conceivable seismic event that could occur in the tectonic environment in which the project is located (Seed, 1982).[1]

The size of the MCE is usually estimated based on the seismic history of the fault, and the characteristics of the fault under consideration compared to similar fault systems. The International Commission on Large Dams (ICOLD) has published guidance on estimating the safety factors to be used in calculating seismic risk for dams, including tailings dams.

> "According to the current ICOLD guidelines, large dams have to be able to withstand the effects of the so-called maximum credible earthquake (MCE). This is the strongest ground motion that could occur at a dam site. In practice, the MCE is considered to have a return period of several thousand years (typically 10,000 years in countries of moderate to low seismicity)."[2]

The choice of the "return period" is important because the longer the return period, the larger the earthquake that might be expected. The larger the earthquake, the more energy, and the longer the period of shaking that will take place at the site under consideration.

The research for the MCE for the Montanore Project was largely done by Morrison-Knudsen Engineers, and checked by Klohn-Crippen. Morrison-Knudsen summarized its findings on earthquake research for the Montanore area in Table 4.2 of its 2005 report:

---

[1] Seed. H.B., "The Selection of Design Earthquakes for Critical Structures," Bulletin of the Seismological Society of America, Vol. 72, No.6, December 1982.
[2] "Earthquake Safety of Existing Dams for Irrigation and Water Supply in Rural Areas", Dr. Martin Wieland, Chairman, Committee on Seismic Aspects of Dam Design; International Commission on Large Dams (ICOLD), December 2001

TABLE 4.2
PEAK GROUND ACCELERATION FOR VARIOUS SOURCE MAXIMUM CREDIBLE EARTHQUAKES

Earthquake Source	Site Distance (km)	Fault Length[1] (km)	MCE Magnitude	Mean Peak Ground Acceleration (g) C[2]	J + B[3]	I[4]	Average
Bull Lake Fault	20	30.6	6.8	0.18	0.19	0.21	0.20
Rainy Creek Fault	24	23.3	6.7	0.15	0.15	0.17	0.16
Flathead Zone	65	---	7.3[6]	0.09	0.06	0.09	0.08
Random Local	15	---	6.5[5]	0.19	0.21	0.23	0.21

Notes:

(1) Fault lengths are scaled from map shown in Witkind (1977).

(2) Campbell (1981) attenuation.

(3) Joyner and Boore (1982) attenuation

(4) Idriss (1985) attenuation

(5) Algermissen et al. (1982)

Of note in Table 4.2 is that the random earthquake MCE generates a larger peak ground acceleration than the M 6.8 MCE on the Bull Lake Fault. However, Morrison-Knudsen chose as the final MCE for the Montanore minesite a M 7.0 earthquake on the Bull Lake Fault at a distance of 20 km. The rationale behind this choice is explained by Morrison-Knudsen:

> "Table 4.2 summarizes the MCE magnitudes, source distances, and resulting rock accelerations. As shown in Table 4.2, a random, local earthquake gives the largest estimate of peak acceleration. However, although the MCE on the Bull Lake fault yields an acceleration 5% lower than that from a local source, because of its larger magnitude, it could produce shaking of longer duration (i.e. more significant number of stress cycles). For purposes of the design earthquake, rounding the Bull Lake HCE to magnitude 7.0 is appropriate. Thus, the design mean peak rock acceleration produced by an MCE of magnitude 7.0 is 0.22g."[3]

However, also in Table 4.2 it should be noted that Morrison-Knudsen chose to site the "Random Local" earthquake at a distance of 15 km from the Montanore minesite. There is no explanation given by Morrison-Knudsen for this choice of 15 km distance.

[3] Morrison-Knudsen Engineers, Mar90, pp. 4-5,4-6

In the discussion of its choice of the random local earthquake Morrison-Knudsen notes:

> "… uncertainties in knowledge of fault activity and a rather short historical earthquake record led Algermissen et al.[4] (1982) to select a maximum earthquake of magnitude 6.5 for the area, which is greater than the largest observed event (M-5.0). This earthquake is not assigned to any specific fault."[5]

The usual, and conservative, choice of distance for a random earthquake (sometimes called a floating earthquake since it is not associated with a known fault) is to site it directly under the site in question. It is not clear why Morrison-Knudsen chose to site this earthquake 15 km from the minesite, but one result of siting this earthquake event 15 km from the minesite, as opposed to under the minesite, is that the maximum horizontal acceleration associated with the random event is significantly decreased. To be conservative in evaluating the potential impacts on a random local earthquake, the event should be sited under the minesite, for example at a depth of 5 km.

Recommendation: The random local earthquake M 6.5, cited under the minesite at a depth of 5 km, should be used as the Maximum Credible Earthquake (MCE) for calculation of peak acceleration.

(2) Use of the MCE in Calculating Seismic Safety

The Maximum Credible Earthquake (MCE) should be use in calculating how much movement a tailings dam can withstand without deforming to the point that the dam will fail. As mentioned in Section 3.9.2.2 in the DEIS, the peak ground acceleration due the MCE is 0.22 g.

It is also stated in Montanore Tailings Facility Updated Design Aspects, Klohn Crippen Berger, 9Jul07, that:

> "The seismicity assessment carried out by MKE was reviewed and updated for the Design Report. The controlling seismic event is the maximum credible earthquake (MCE), on the potentially active Bull Lake Fault (magnitude M7.0 and PGA of 0.22 g)."[6]

However, in the original Design Report from Klohn Crippen Consultants, 2005, in both Section 6.3.3 and in Appendix IV – Stability Analysis, it is stated:

> "Dynamic stability analyses were carried out using pseudo-static and post-earthquake liquefaction analyses. For the pseudo-static case, a horizontal seismic load of 0.11g was applied to the centroid of each slice of the modeled slip surface. Seed (1979) suggested that deformations would be acceptably small for earth dams constructed from ductile soils when the FOS was at least 1.15 for pseudo-static accelerations of 0.10 g (M6.5) to 0.15 g (M8.25). In addition, Hynes-Griffin and Franklin (1984) concluded that earth dams with pseudo-static FOS values greater than 1.0 using a pseudo-static acceleration of 50% of the peak ground acceleration would not develop "dangerously large" deformations. Accordingly, a pseudo-static acceleration of 0.11 g has been used for the seismic stability determination."[7] (emphasis added)

This statement appears to be saying that instead of using 0.22 g as the maximum horizontal ground acceleration, 0.11 g has been used as the design basis earthquake for the tailings dams. This is only one-half the acceleration of the maximum credible earthquake.

---

[4] Algermissen. S.T., Perkins, D.M., Thenhaus, P.C., Hanson, S.L. and Bender, B.I., Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States: U.S. Geological Survey Open-File Report 82-1033, 1982.

[5] Morrison-Knudsen Engineers, Inc., Montanore Project Geotechnical Report, Tailings Impoundment Site, March 1990, p. 4-3

[6] Klohn Crippen Berger. 2007, Montanore Tailings Facility Updated Design Aspects, 9Jul07, p. 11.

[7] Klohn Crippen Consultants Ltd. 2005. Draft Tailings Technical Design Report. Submitted to the KNF and the DEQ, page 86, and Appendix IV – Stability Analysis, page IV-4

The assumption of 0.11 g as the maximum acceleration as opposed to 0.22 g has huge implications for the design safety of the tailings dams. As the g acceleration increases, the amount of energy increases logarithmically. This assumption appears to be made on the basis of "professional judgment." The conservative choice, and the choice that is usually made in making seismic safety calculations for tailings dams, is to use the acceleration associated with the MCE.

The Factor of Safety calculated for the main tailings dam using 0.11 g as the design event is 1.17.[8] The target FOS is 1.15.[9] If 0.22 g is used as the design basis earthquake, it will have significant implications for the dam, and could make the dam infeasible in this location. On the other hand, the fact that it probably takes such an assumption to make the dam feasible both from a stability and cost perspective in this location, raises concern for the assumption.

The situation at the Diversion Dam is actually worse than that at the main dam. Using 0.11 g as the design event, the FOS is 1.09, i.e. less than the target FOS of 1.15.[10] If 0.22 g is used at the design event, then the FOS would likely be considerably lower than the target FOS of 1.15.

Recommendation: The acceleration associated with the MCE (the acceleration associated with a M6.5 earthquake located under the minesite, or 0.22 g, whichever is larger) should be used in calculating the seismic safety of the tailings dams.

Morrison-Knudsen also recommended using 0.22 g as the MCE, and design event, for analyzing seismic stability:

> "Dynamic Response and Deformation Analyses - The peak bedrock acceleration (0.22g) determined for permit application studies (Ref. 4)[11] will be used in the dynamic response and deformation analysis."[12]

The choice of 0.11 g as a design event by Klohn-Crippen for the Montanore tailings dams appears to be highly unusual, and should be carefully reviewed.

3.9.3.2 Impoundment Stability

One of the primary concerns that surfaced in previous analyses of the tailings dam design was the presence of saturated glaciolacustrine clay underneath the main and diversion tailings dam sites. Under seismic loading the glaciolacustrine clay has the potential to destabilize the foundation upon which these dams would be built, and could lead to dam failure. These concerns are summarized in a statement from Klohn Crippen Consultants, 2005:

> "A liquefaction analysis was conducted on the SPT results from the 1989 to 1990 geotechnical investigations and the results are presented in Appendix II. The analysis showed that the glacial outwash and till sediments under the Main Dam are sufficiently dense that liquefaction during a large earthquake is unlikely in these materials. The glaciolacustrine clay, however, classified as stiff to very stiff based on the field blow count results, could experience a reduction in shear strength during a

[8] Klohn Crippen Consultants Ltd. 2005, Table 6.2 Stability Analyses Results, p. 88
[9] Klohn Crippen Consultants Ltd. 2005, Table 5.1 Design Criteria for FOS, p. 73
[10] Klohn Crippen Consultants Ltd. 2005, p. 118
[11] Morrison-Knudsen Engineers, Inc., Montana Project Sanders and Lincoln County, Montana, Tailings Impoundment Preliminary Engineering Report, February 1989
[12] Morrison-Knudsen Engineers, Mar90, Appendix A – Design Basis Memorandum, p. 15. This same conclusion is stated in Morrison Knudsen Corporation, San Francisco, Montanore Project Interim Tailings Impoundment Engineering Report, July 90, Appendix A – Design Basis Memorandum, p. 15

> large earthquake due to cyclic pore pressures, or due to the development of excess pore pressures during construction."[13] (emphasis added)

Klohn Crippen Berger, in a 2008 letter to Mines Management Inc. cited in the DEIS, have suggested a series of mitigating steps that they are confident will provide long term protection from seismic risk for the tailings dams. (DEIS, p. 405)

However, there are still a number of significant uncertainties associated with the Klohn Crippen Berger assumptions. For example, Klohn Crippen Consultants, 2005, noted:

> "A lacustrine clay layer has been identified under a portion of the Main dam. The spatial distribution of the clay should be further confirmed with a program of penetration holes and geophysics. The strength of the clay should also be further confirmed with the penetration holes, sampling and laboratory testing. This work will allow final definition of the extent of clay excavation required to meet the stability criteria for the dam."[14]

Given the numerous assumptions about dam stability, including that the dam drains will work properly in perpituity, and that the tailings material used for dam construction will remain fully unsaturated in perpituity, there is a finite but unquantifiable risk that an unanticipated failure could occur in the glaciolacustrine clay sediments that underlie the main tailings dam and the diversion dam.

Pyrite Concentration in the Tailings Dam Construction Material

An issue that has not been addressed in the DEIS is the possibility of concentrating acid generating materials (primarily pyrite) in the coarse fraction of sands that will be used as the primary construction material for the main tailings dam. This has been a significant issue at the Thompson Creek tailings dam in Idaho.

The plan for the main tailings dam construction is to use cycloned tailings for construction of the majority of the dam (after construction of the starter dam). The cycloning process separates a large and fine fraction of the tailings. The large fraction is used for dam construction, because it is able to drain any interstitial water, and therefore prevent pore pressures from destabilizing the dam, either under static or seismic loading. The fine fraction, often termed the slimes, which will reading retain interstitial water, is placed in the tailings pond.

At the Thompson Creek mine this same procedure was used for tailings dam construction. There is pyrite in the tailings at Thompson Creek, and the cycloning selectively concentrated the pyrite in the large fraction that was then used for dam construction. As a result, the tailings dam itself is generating acid mine drainage.

While it is not clear that this would happen at Montanore, it is still a possibility that should be investigated. It is not apparent that the potential for this to happen has been evaluated.

Recommendation: ***Cycloning sands from sulfide ore deposits for tailings dam construction has led to the concentration of pyrite in the course fraction of the cycloned sands at the Thompson Creek mine in Idaho. Geochemical analysis of the cycloned tailings dam sands should be performed to insure that this will not be an issue for the proposed Montanore dam.***

#####

[13] Klohn Crippen Consultants Ltd. 2005, pp. 83-84
[14] Klohn Crippen Consultants Ltd. 2005, p. 144