NATIONAL WILDLIFE FEDERATION
GREAT LAKES NATURAL RESOURCE CENTER
People and Nature: Our Future Is in the Balance

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December 18, 2008

Rebecca Harvey
Director, Region 5 UIC Branch
U.S. Environmental Protection Agency
77 W. Jackson Blvd.
Chicago, IL 60604-3507

Re: Kennecott Eagle Minerals mine in Marquette County, Michigan

Dear Ms. Harvey,

The National Wildlife Federation submits this letter and the documents on the enclosed CD in support of its position that under the EPA's Underground Injection Control (UIC) rules, the EPA must require an individual permit for the injection of wastewater into the proposed Kennecott Eagle Minerals mine in Marquette County, Michigan. As explained below, the EPA must require a permit for this Class V well because it has information that the well may result in the violation of primary drinking water regulations. To prevent a violation of drinking water standards, the permit requirements must address construction activities, and thus the decision to require a permit should be made before construction begins. This letter and the enclosed materials supplement earlier letters and documents submitted to the EPA on June 19, 2006 and May 15, 2008.

In addition, the EPA should require an individual permit in this case because the proposed mine will be located within the Lake Superior basin and threatens a tributary of Lake Superior, the Salmon Trout River. As one of the primary partners of the Lake Superior Binational Program and the Lakewide Management Plan, EPA has committed itself to zero discharge and habitat protection goals for the Lake Superior basin. These goals will never be met if federal partners do not use their authorities to ensure that major new industry and development projects are protective of the Lake Superior environment.

In our May 15, 2008 correspondence, we explained why the EPA is legally obligated to require a permit for this activity. Under the UIC regulations, if the EPA learns that a Class V well *may* result in the violation of primary drinking water regulations, the agency *must* require a permit or take other action to ensure that the violation does not occur. 40 C.F.R. § 144.12(c).

Construction of a UIC well is considered an injection activity that is prohibited if it may result in a violation of a primary drinking water regulation. 40 C.F.R. § 144.12(a). In this case, it is the mine

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construction that is likely to result in violations of drinking water standards. As the mine workings will ultimately be injected with fluids, construction of the mine *is* construction of a UIC well. The EPA should therefore require a permit prior to construction activities to meet the mandate of subsection 144.12(c).

We reiterate that there is no question that once the mine is constructed, the mine workings will become a UIC well. Upon construction of the mine, the subsequent injection of fluids is required by state permit. This is not a situation where an underground mine may be "converted" into a well in the future. The mine would not be permitted if the mine workings were not planned to be used as a UIC well.

Furthermore, Kennecott's mining plan includes injection of wastewater into the mine workings during the life of the mine. The state-issued permit allows the pumping of excess wastewater into the mine as a contingency measure in the event that surface storage is inadequate. This contingency measure is a critical condition of the permit, as adequate wastewater storage capacity at the surface is uncertain.

The primary purpose of this letter is to more fully explain our conclusion that construction of this Class V UIC well is likely to cause a violation of primary drinking water standards. A contested case hearing on the state mining and groundwater discharge permits was held over the past spring and summer. This letter attempts to summarize the relevant information presented in that hearing. The enclosed CD contains the transcripts and exhibits from the hearing that are referenced in this letter, with the exception of permit application and MDEQ documents that are already in EPA's possession or are easily accessible on the MDEQ website. We would be happy to provide you with any additional materials from the hearing that you feel would be helpful.

There are three potential situations relating to injection of water into the mine workings that may result in violations of the Safe Drinking Water Act (SWDA). All begin with water that violates drinking water standards being left in the mine workings. First, if water in the upper bedrock at the site of the mine currently meets the definition of an underground source of drinking water, water left in the mine that does not meet drinking water standards will in-and-of-itself violate the SWDA. The second and third potential situations would arise from contaminated water moving out of the mine cavity and into the alluvial aquifer. This could occur due solely to the existing hydrological regime at the site. And finally, water could (and likely will) move out of the mine cavity and into the alluvial aquifer due to subsidence.

Underlying all of NWF's concerns is an almost complete lack of information about the hydrological regime in the bedrock at the proposed mine site. Almost no work was done by the company to characterize the bedrock hydrology, and as a result virtually nothing is known about the potential for movement of groundwater out of the mine once it is reflooded. In addition to unknowns regarding hydraulic gradients and heads, Kennecott's lack of data regarding potential flow paths between the bedrock and the alluvial deposits calls into question the company's predictions about outflows from the mine.

NWF and its partners have retained Dr. Robert H. Prucha and Dr. Kenzi Karasaki to provide expertise in reviewing Kennecott's hydrogeological studies. Dr. Prucha is a professional engineer, hydrogeologist, and hydrologist and is a principal in Integrated Hydro Systems of Denver, Colorado. His primary area of expertise is developing and reviewing modeling of water systems, including the integration of surface water and groundwater systems. He is also experienced in reviewing and preparing hydrogeologic reports of both bedrock and unconsolidated aquifers; characterizing and modeling groundwater flow conditions; designing conceptual hydrogeologic models; and the calibration, validation, and uncertainty analyses that are required of such models.[1]

Dr. Karasaki is a staff scientist, Principal Investigator and Area Team Leader at Lawrence Berkeley National Laboratory, with primary expertise in fractured rock characterization and fractured rock hydrology. He has characterized and studied fractured rock hydrology in Sweden, Japan, Canada and the United States.[2] Although Dr. Prucha and Dr. Karasaki's efforts in this case have been geared toward assessing predictions of groundwater inflow into the mine during mining, many of their observations are also pertinent to assessing predictions of the behavior of water in the reflooded mine once mining ends.

I. Kennecott's conclusions regarding bedrock hydrology are unwarranted

Kennecott's permit applications conceptualize groundwater at the site as divided into water in the unconsolidated deposits above bedrock (the alluvial aquifer) and water that saturates the bedrock. Water in the alluvial aquifer meets all drinking water standards, as does water in the higher levels of bedrock. Water deep in the bedrock does not meet drinking water standards.[3] Kennecott's mine plan rests on the assumption that the three layers are discrete, with few or no connections between them and with little movement of the water in either layer of the bedrock. This assumption is completely unwarranted and unfounded due to the very scant amount of relevant data.

According to Dr. Prucha's testimony in the contested case hearing, the characterization of the hydrology of a bedrock system must account for dikes and faults, as these features can control water movement. A "dike" is an obtrusive body of material different from the surrounding rock, which extends up vertically through that rock. Dikes are usually of low permeability, but are likely to be surrounded by higher permeability "brecciated zones," or fractured zones, which allow water to move freely along the edges of the dike and preferentially route water along those edges.[4]

"Faults" are open spaces between two adjoining bodies of rock, and can be significant conductors of water. Faults generally align with rivers and often establish a connection with them;[5] this effect

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1 Enclosed CD, Tr 8: 1541-1547 (Prucha).

2 Enclosed CD, Tr 39: 8038-8039 (Karasaki).

3 Mining Permit Application Vol. 2, Appendix B-3 (Phase II Bedrock Hydrogeologic Investigation).

4 Enclosed CD, Tr. 8:1552-53, 1560-61 (Prucha).

5 *Id.* at 1554, 1561

was noted by Kennecott's geologists in the area of the proposed Eagle Mine.[6] Faults and dikes intersecting the mine would thus serve as major flow pathways.

Kennecott's investigation of dikes and faults has been entirely insufficient. For instance, Golder Associates (Kennecott's technical consultants) concluded that the six boreholes forming the basis of the preliminary conceptual model were likely to have intersected any faults, and that testing results from those boreholes supports the conclusion that only one limited fault exists.[7] This conclusion is completely unwarranted based both on the scarcity of the data and on the limited data that does exist.

Dr. Prucha detailed numerous faults and dikes that have been identified through various sources, but were not investigated or included in Kennecott's conceptualization of the bedrock groundwater system. Dikes and a fault zone in the immediate area of the ore body and mine access tunnels were identified in a study by J.S. Klasner. Other faults and dikes have been identified by Kennecott's own geologists. Figure 4 of Appendix B-1 to the Environmental Impacts Assessment (EIA) also details numerous faults and dikes in the area of the mine, some running for several miles in length. Figure 21 of Appendix B-8 to the EIA shows a dike that is in direct contact with the Salmon Trout River and surrounding wetlands, which could offer a direct conduit between the overlying surface water and the underlying bedrock through brecciated zones surrounding the dike. The evidence indicates that several faults extend between the upper and lower bedrock, which is inconsistent with Kennecott's characterization of a strict division between them.[8]

Dr. Prucha has prepared an illustration depicting documented faults and dikes in the vicinity of the mine, along with surface topography, surface water features and drainage patterns, and groundwater wells.[9] The exhibit demonstrates that the Klasner faults and dikes are consistent with the surface drainage features in the area. These features were largely ignored in Kennecott's hydraulic testing – only one test was performed in the entire Klasner fault zone, and none were performed in a structurally complex area to the southeast.[10] MDEQ's expert Dr. David Sainsbury also criticized Kennecott for not considering the effect of a "discrete sub-vertical fault plane that intersects the Eagle deposit" on mine stability and subsidence.[11]

Kennecott's plan, which has gained MDEQ's approval, is to wait until going underground to conduct more studies of these potential flow paths. But according to Dr. Karasaki, for purposes of assessing hydraulic connections it is standard practice and absolutely essential to characterize

6 Mining Permit Application Vol. 2, Appendix C-1, p. 12.

7 *Id.*, p. 16-17.

8 Enclosed CD, Tr 8: 1550-53, 1558-68, 1597-1598, 1620-21 (Prucha); Tr 40: 8289-8291; (Prucha).

9 Enclosed CD, Prucha_Klasner_mapped_dikes.

10 Enclosed CD, Tr 40: 8311-8313 (Prucha).

11 Enclosed CD, Sainsbury May 5 2006 Report p. 11-12.

fractures from aboveground, rather than waiting until underground access is obtained. In fact, characterization once underground "won't help you much at all."[12]

In the state contested case hearing, Dr. Karasaki explained several factors that are critical to the study of hydrology in fractured bedrock that were ignored in the state permitting proceeding. First, the range of hydraulic permeability in fractured rock is extremely heterogeneous; the difference in permeability can be up to a factor of 10 million. The essential point is that because of the large range of permeabilities, a single pump test is not adequate to determine the permeability of a given area of rock. Kennecott's bedrock testing using a single long-term pump test is acutely inadequate in light of this principle.[13]

Second, a fault generally has dual properties; the core, or middle zone that is clogged with rock dust, is generally low permeability, but the fractured zones alongside the core are higher permeability. Therefore, it is difficult for water to cross a fault, but very easy for it to flow along the fault on both sides of the core.[14] Kennecott's conclusions regarding the nonexistence of faults based on its limited testing ignore this principle.

Third, fracture hydrology is dominated by the larger features or "killer fractures" in a system. As the area covered by a study increases and more high permeability features are included, the composite permeability of the area also increases.[15] Kennecott's testing of a very localized small set of boreholes is not sufficient to draw any conclusions about the hydraulic conductivity of the bedrock.

Fourth, during a pump test, a low response in another well does not necessarily mean the area between the pump test and the other well is of low permeability. In fact, the drawdown response in an observation well can be nearly identical regardless of whether the permeability of an intervening fault is low or high.[16]

Fifth, as Dr. Prucha also testified, "quick and dirty" slug tests only test a small radius, tend to underestimate permeability, and are prone to give incorrect readings. While slug tests in a homogenous medium tend to be more accurate, they underestimate permeability in heterogeneous media such as fractured bedrock.[17] Kennecott's characterization of bedrock hydrology relied almost exclusively on slug tests.

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12 Enclosed CD Tr 39: 8121, 8131 (Karasaki).

13 Enclosed CD, Karasaki Slides, Slide 6; Tr 39: 8048, 8054-56 (Karasaki).

14 *Id.* Slide 10; Tr 39: 8048-8049, 8067-8069.

15 *Id.* Slide 7; Tr 39: Tr 39:8049-51, 8056-58.

16 *Id.* Slides 10, 11; Tr 39: 8051-52, 8070-72.

17 *Id.* Slides 8, 9; Tr 39: 8052-53, 8064-67.

Sixth, long term pump tests at as many locations as one can afford are crucial to understanding a fracture system.[18] Kennecott's investigation included only a single long-term pump test, and even that was of relatively short duration (7 days versus a recommended duration of months).

Dr. Prucha also testified that when conducting any groundwater investigation, it is important to have a sufficient number and spacing of test wells. The number and spacing in this case were wholly inadequate to provide accurate information about groundwater flow, or accurate predictions of groundwater behavior under future conditions. Dr. Prucha testified that not only more testing in the area of the mine but also testing of the larger surrounding area is necessary to properly characterize the bedrock system, including investigation along identified dikes and fault zones.[19]

Dr. Karasaki testified that Golder's single pump test is inadequate to identify the zones of higher hydraulic conductivity in the bedrock. At other sites, he has conducted between 50 and 4,000 tests; there is no set number, but "the more the better." The single seven-day test is "acutely inadequate;" existence of a highly conductive fracture network cannot be ruled out based on the testing performed, and more tests are necessary, in more wells, covering a period of months. Moreover, the pump tests should not be limited to existing holes, but should also specifically target areas where faults are suspected.[20]

Dr. Karasaki also testified that some of the holes that were merely flow logged indicated inflows, and should have been long-term pump tested. Furthermore, the short-term pump testing that apparently was conducted on certain holes for heat-pulse flow meter purposes is "nowhere near" equivalent to long-term pump testing, and was not analyzed for time versus pressure or drawdown as a long-term test would be.[21]

Finally, Kennecott failed to utilize pertinent information that it could easily have obtained. During the drilling in the Klasner fault zone referenced by Kennecott's Mr. Ware, no flow metering, hydraulic conductivity, or hydraulic reactivity or resistivity testing whatsoever was performed.[22] This is in contrast to the testimony of Dr. Karasaki, who repeatedly emphasized that long-term hydraulic pump testing is absolutely necessary to evaluate the existence of major water-conductive features in an area.[23] Dr. Prucha also testified that no conclusions can be made about potential water conductive features in the Klasner fault zone without hydraulic testing.[24] Without

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18 *Id.* Tr 39: 8053-8054.

19 Enclosed CD, Tr 8: 1555-1558, 1569-1571, 1574 (Prucha).

20 Enclosed CD, Karasaki Slides, Slides 36, 37; Tr 39: 8074-75, 8113-16, 8120 (Karasaki).

21 *Id.* Slides 15, 16; Tr 39:8075-78, 8158.

22 Enclosed CD, Tr: 15: 3134 (Ware).

23 Enclosed CD, Tr: 39: 8074-8075, 8113-8116 (Karasaki).

24 Enclosed CD, Tr: 40: 8285-8286 (Prucha).

this information, Kennecott's conclusions as to the existence of conductive faults simply are not scientifically valid.

II. Water left in the mine workings is likely to violate primary drinking water standards.

During the public review period for the state mining permit, NWF's contractual expert Dr. Ann Maest and Dr. John Coleman of the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) each independently reviewed Kennecott's work to characterize the water quality to be expected in the mine after mine closure. Both came to the conclusion that Kennecott's work was based on data that did not reflect actual conditions. In some instances, Kennecott represented in its permit application text that it did use the appropriate numbers in its modeling, but modeling spreadsheets show that it did not. When these errors are corrected, modeling indicates that water in the mine will violate national primary drinking water standards.

It is completely unclear to what level these contaminants would or could be cleaned up by the pump-and-treat system following mine closure. Assumptions that at some point the pump-and-treat system will result in permanent attainment of drinking water standards in the alluvial aquifer are thus far completely unsupported.

Dr. Ann Maest earned an undergraduate degree in geology from Boston University, a Masters degree in sedimentology and geochemistry from Princeton, and a Ph.D. in geochemistry and water resources from Princeton in 1983. Her dissertation focused on the study of state and transport of chemicals and geochemical modeling. Dr. Maest held a postdoctoral fellowship at the National Research Council with the United States Geological Survey's (USGS) national research program, and worked as a project chief at the USGS for six years. Dr. Maest has been elected to four National Academy of Science committee study groups, including Committees on the Bureau of Mines Research, Hard Rock Mining on Federal Lands and Technologies for the Mining Industries. She currently serves on the National Academy of Sciences Committee on Earth Resources, which oversees all Academy studies related to mining and oil and gas extraction. Dr. Maest is employed by Stratus Consulting in Boulder Colorado, where she manages studies related to the effect of hard rock mines on water quality, natural resource damage assessments, and natural resource restoration and remediation. The majority of Dr. Maest's work is for state and federal governments.[25]

Dr. John Coleman earned an undergraduate degree in Wildlife and Forestry from the University of Maine, a Master's degree in Wildlife Science and Fisheries from Virginia Polytechnic Institute and State University, and a Ph.D. from the University of Wisconsin in Wildlife Ecology and Statistics. His M.S. and Ph.D. research focused on resource distribution and modeling using existing software and developing programs in Fortran, Pascal and Basic. Dr. Coleman has developed 15 to 20 models, some in partnership with EPA, throughout his years of experience. His work for GLIFWC has included extensive reviews of modeling and the development of models for review of permit applications for the Crandon Mine.[26]

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25 Enclosed CD, Tr 9:1838-47 (Maest).

26 Enclosed CD, Tr 13: 2743-2754 (Coleman).

A. Kennecott's estimates of mine water quality are based on several erroneous factors.

Kennecott's model predicts mine water quality by predicting the leaching of contaminants from the walls and the development rock in the mine, and then accounting for dilution by inflowing groundwater. In his review of Kennecott's work, Dr. Coleman discovered that the predictions are based on data that conflict with data presented in other parts of the state permit application.

First, the volume of rock used to calculate water quality in the reflooded mine is 5.2 to 5.3 times less than the volume referenced in the application text. The amount of development rock left in the mine is an important factor in calculating water quality, because it provides a primary source of contaminants that will dissolve into the water. According to the permit application, the volume of development rock in the mine at closure will be 663,000 tonnes. But the amount of development rock used in the model for calculating final water quality was only 125,600 tonnes. *Id.* at 2772-73. Having over five times the development rock in the mine than was used in the model suggests a significantly greater amount of constituents available to leach into the water.[27]

Second, the permit application indicates that the "best guess" for mine inflow is 75 gallons per minute (gpm). At the hearing, Kennecott revised the inflow estimate to even lower at 60 gpm. But the input used for the model is 180 gpm. This discrepancy is important because the more water flowing into the mine, the greater the dilution and the lower the concentrations of constituents in the reflooded mine water. The volume of water in which to dissolve constituents is a primary component in calculating water quality.[28]

Third, the permit application states that a variety of particle sizes of development rock in the backfilled and reflooded mine were used in calculating water quality. But the input data files for the model indicate that only one size, ten centimeters, was actually used in the model. Particle size is important in calculating the surface area of rock compared to the mass. *Id.* The smallest pieces of rock (down to powder size) contribute the greatest surface area for reactions per mass. The literature indicates particle size distributions ranging from a little above ten centimeters down to one times ten to the negative six meters, almost dust. The use of a larger average particle size than will actually be present results in a significant underestimation of the amount of constituents that are likely to leach from the rock into the water.[29]

Fourth, the permit application misstates the levels of nickel and sulfate used in modeling. Appendix D-5, Table 1 purports to contain the data inputs that were used for the model to calculate water quality in the reflooded mine. The text states that data from the final weeks of the column-leach tests were used in the model, but the model spreadsheet shows that data from

27 Enclosed CD, Tr 13:2770-74 (Coleman). Mining Permit Application Table 4.4 and Appendix D-2, p. 39.

28 Enclosed CD, Tr 13: 2775-76 (Coleman). Mining Permit Application p. 30.

29 Enclosed CD Tr 13: 2777-80 (Coleman); Coleman GLIFWC_10-10-2007[1]. Mining Permit Application Appendix D-3, p. 3.

weeks 20-25 were used. The nickel and sulfate levels used in the model are much lower than those referenced in the application.[30]

In addition to these four factors, Kennecott failed to adjust its predictions to account for the thickening of the crown pillar required by the state permit. In the contested case hearing, Dr. Maest pointed out that before this change was made, very little ore was to be left underground, but as permitted, a good deal of ore will remain in the crown pillar. Every sample taken of the crown pillar rock has shown the rock to be acid generating. Rain and snow melt can be expected to infiltrate the crown pillar and leach contaminants into the mine; this factor has not been accounted for in any of the modeling.[31]

B. When these factors are corrected, estimates of mine water quality are far worse.

Dr. Coleman re-ran Kennecott's model using the input data that was described in the permit application for the first four factors described above. The results show contaminant levels significantly higher than Kennecott's predictions. For instance, concentrations of sulfate went from Kennecott's prediction of 29 milligrams per liter to 9,307 milligrams per liter. Copper concentrations jumped from .002 milligrams per liter to 93.9 milligrams per liter. The corrected values are at least one to two orders of magnitude higher than those obtained by Kennecott.[32] Although the additional step of solubility modeling would need to be employed before actual predictions of water quality could be made, the results do indicate how far off Kennecott's predictions are. Furthermore, *Dr. Coleman's results are sufficient indication that National Primary Drinking Water Standards will be violated for antimony, arsenic, beryllium, selenium, and thallium.*[33]

Dr. Maest also modeled Kennecott's predicted water quality in the mine at the end of mining, and obtained results that are uniformly higher than Kennecott's. For aluminum, Dr. Maest's predictions are three orders of magnitude higher than Kennecott's. Copper, which is present in high concentrations in the country rock, was predicted by Kennecott at 2.1 micrograms per liter; Dr. Maest predicts 11 micrograms per liter. Kennecott's sulfate prediction is very low, as low as background sulfate concentrations in much of the groundwater in the United States. Dr. Maest predicts sulfate concentrations of almost 400 milligrams per liter, which exceeds Michigan standards.[34]

Dr. Maest's modeling predicts that the mine water will violate the national primary drinking water standard for cadmium. The cadmium standard is 0.005 mg/L; Dr. Maest predicts a

30 Enclosed CD, Tr 13: 2783-84 (Coleman); 75a_HCT_analysis_NewPad3(1); 75c_HCT_analysis_UGplusDR(1). Mining Permit Application Appendix D-5, p. 3.

31 Enclosed CD, Tr 10:1918-19 (Maest).

32 Enclosed CD, Tr 13: 2787-89 (Coleman); Coleman GLIFWC_10-10-2007[1] p. 6.

33 *Compare id. and* 40 C.F.R. 141.62(b).

34 Enclosed CD, Tr 10:1932-34 (Maest).

cadmium level of 0.012 mg/L, more than twice the standard.[35] Copper and lead levels are also likely to be drastically higher than the EPA Maximum Contaminant Level (MCL) goal, with a predicted lead level of 135 mg/L versus an MCL goal of 0 mg/L, and a predicted copper level of 11.4 mg/L versus an MCL goal of 1.3 mg/L.[36]

Dr. Maest also developed water quality predictions based on an estimated inflow through the crown pillar. The results indicate a pH of 5.75, aluminum of .6 mg per liter, *copper at 1.3 mg per liter*, nickel at 57 mg per liter and sulfate at 337 mg per liter.[37] Thus the water flowing into the mine through the crown pillar prior to any leaching of copper from material in the mine itself is likely to be as high as the EPA's Maximum Contaminant Level Goal. This water quality would supplant water coming into the mine that Kennecott's models assumed would be much cleaner, and thus would contribute to even higher levels of contamination than those predicted by Dr. Maest and Dr. Coleman.

Finally, neither Kennecott nor NWF's experts accounted for disseminated ore left in the mine in their water quality predictions. Because the disseminated ore has such a high sulfur content, it will contribute significantly to acid mine drainage and the leaching of metals if it is left in the mine. In his testimony for Kennecott, Mark Logsden admitted that it is still uncertain whether the disseminated ore will be mined.[38] If it is not, the mine walls will be more highly mineralized than has been accounted for in any modeling, and the water quality will eclipse either party's predictions.

C. *Kennecott has a history of underestimating contamination in reflooded mines*

Kennecott's Flambeau Mine in Ladysmith, Wisconsin used a similar backfill system as that planned for the Eagle Mine (development rock and reflooding). A number of water quality parameters at the Flambeau Mine are well above groundwater standards. These parameters are also significantly higher than predicted by Kennecott when the mine was first permitted. Before the Flambeau Mine was permitted, Kennecott predicted that the maximum sulfate levels in the reflooded mine would be 1360 mg/L. Instead, sulfate levels range up to 1700 mg/L. At the Flambeau Mine, Kennecott predicted a copper level in the reflooded mine water of 0.014 mg/L. Instead, copper levels have stabilized around 0.5 mg/L.[39]

Although manganese is not expected to be as great an issue at the Eagle Mine, the manganese situation at the Flambeau Mine is illustrative of the degree of error that can be expected from Kennecott's predictions. Prior to permitting, Kennecott predicted that the manganese level in the

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35 40 C.F.R. § 141.62(b)(4). Enclosed CD, Tr 10:1933-34 (Maest); Maest exhibit p.15.

36 40 C.F.R. § 141.51(b). Enclosed CD, Tr 10:1933-34 (Maest); Maest exhibit p. 15.

37 Enclosed CD, Tr 10:1941 (Maest).

38 Enclosed CD, Tr 20:4144 (Logsdon).

39 Enclosed CD, Tr 13: 2788-93 (Coleman); 70_Flambeau_2005_Annual_Report; Coleman flamb06-table[1].

reflooded mine would be 0.522 mg/L; it has been recorded as high as 37 mg/L.[40] These errors in Kennecott's work in the past lend additional credibility to Dr. Maest and Dr. Coleman's conclusions that Kennecott is significantly underestimating constituent levels in the mine water.

Dr. Maest and her colleague Jim Kuipers recently conducted a study that indicates that the mining industry regularly underestimates the degree of water contamination that a sulfide mine will cause.[41] For instance, the study found that of 25 mines studied, 13 caused groundwater standard exceedences, and in 10 of those 13 cases, the mining company had significantly under-predicted the mine's impact on groundwater.[42]

And where, as at the Eagle Mine, the mine is in close proximity to water and has high acid drainage or contaminant leaching potential, mining companies almost always under-predict impacts. According the Kuipers/Maest report, "Of the 15 mines with close proximity to groundwater and high acid drainage or contaminant leaching potential, all but one (93%) have had mining-related impacts to groundwater, seeps, springs or admit water." *The mining companies significantly under-predicted groundwater impacts for twelve out of fourteen of these high-risk mines.*[43]

Finally, a review of the reasons for these faulty predictions mirrors the errors that Maest and Coleman have found in this case. According to the report, faulty predictions stemmed from overestimations of dilution, a lack of hydrological characterization, an overestimate of the amount of discharge, an underestimate of the size of storms, lack of geochemical characterization, and the use of too small or an unrepresentative sample size.[44] *Every single one of these factors is relevant to Kennecott's work for the Eagle Mine.*

D. Kennecott's groundwater monitoring is not designed to detect contaminants

As the UIC regulations reflect, monitoring groundwater quality is critical for ensuring that drinking water standards are met. In this case, the state-required monitoring around the reflooded mine is wholly inadequate. Only three compliance wells are planned for the alluvial aquifer; not one is planned for the bedrock aquifer. Furthermore, the three wells that are planned are not downgradient from the mine and are not as close to the mine as they should be.[45] EPA involvement is needed to ensure that any groundwater contamination that does occur will be detected.

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40 Enclosed CD, Coleman flamb06-table[1].

41 Enclosed CD, CamparisonsReportFinal.

42 *Id.* at ES-8 and Table ES-6.

43 *Id.* at ES-11-12 and Table ES-9.

44 *Id.* at ES-13.

45 Enclosed CD, Tr 13: 2800-03 (Coleman). Mining Permit Application Fig. 7-3 (map of monitoring and compliance wells).

E. Kennecott's mine water quality predictions are based on insufficient testing

Adding to the problems of Kennecott's water quality predictions for the reflooded mine is the inadequate testing that produced the numbers that went into the models. These are numbers that (of necessity) were used by NWF's experts as well as Kennecott's, because they were the only numbers available. Due to the uncertainty inherent in such truncated testing, even Dr. Coleman and Dr. Maest's predictions cannot be considered as "worst case" scenarios.

In all of its preparation for mining, Kennecott has conducted only *one* kinetic test on the semi-massive sulfide unit, and only *two* kinetic tests on the massive sulfide unit. Dr. Maest has stated very strongly that more tests are needed to adequately characterize the rock.[46]

Generally speaking, the number of tests needed to accurately characterize rock is based on the total volume of rock that will be mined. MDEQ consultant Ted Eary based MDEQ's number of required tests on the 675,000 metric tons of development rock that will be taken out of the mine. This is not an appropriate number, because it does not include the 4.05 million tons of ore. According to Dr. Maest, the sample amount is simply too low to determine the whole rock composition or how acid-generating the rock will be. Based on recommendations by regulators in Canada and British Columbia, between 26 and 80 samples should be required.[47]

F. The testing that was done shows high levels of contaminants and very acidic water

The potential for acid drainage and the leaching of heavy metals at this mine is particularly acute because of the extremely high levels of sulfate in the host rock and ore. In the testing that Kennecott did do, the massive sulfide unit produced sulfate-rich water virtually as soon as the test began. The pH immediately dropped down to 4.0 and remained there throughout the duration of the test. Kennecott stopped measuring sulfate in this test at week 20. This test also showed very high nickel concentrations that would exceed standards by 1000 times.[48]

In the semi-massive sulfide unit, high sulfate concentrations developed right away and continued to rise. The pH continued to drop to between 4.0 and 5.0, and remained even lower throughout the test. This rock also generated high nickel leachate.[49]

In the peridotite, sulfate concentrations continued to increase throughout the life of a 50-week test. The nickel concentrations climbed to 800 micrograms per liter. In testing the country rock the sulfates spiked right away, and trended upward. The pH was down to 4.0 after about 30

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46 Enclosed CD, Tr 9: 1881 (Maest).

47 Enclosed CD, Tr 10: 1910-13 (Maest).

48 Enclosed CD, Tr 9: 1885-87 (Maest); Maest Exhibit p. 8.

49 *Id.* Tr 9: 1888; Maest Exhibit p. 9.

weeks of testing. *Id.* Copper levels were also high. These concentrations were from filtered samples, so the total concentrations for copper and nickel are probably actually quite a bit higher.[50]

G. The state permit does not include adequate provisions to ensure drinking water standards will be achieved.

Kennecott's plan to ensure that groundwater standards are met in the alluvial aquifer is to institute a pump-and-treat system at the close of mining. Water will be pumped out of the mine, treated, and injected back into the mine workings. Although Kennecott plans to remove the wastewater treatment plant five years after closure, it has provided no analysis to support its contention that this will be adequate to protect groundwater.

In fact, the permit application and other materials contain virtually no details of this aspect of the closure plan. The discussion in the permit application reads in its entirety:

> As a contingency plan, KEMC will leave the WWTP and associated infrastructure in place for five years after reflooding is complete. If monitoring indicates there is the potential for upward migration of mining related constituents associated with the underground openings, KEMC will pump water out of the upper bedrock workings, treat it at the WWTP and recirculate the treated water back into the upper bedrock workings. This process of flushing the upper bedrock workings with clean water will continue for a period of several years until water quality conditions in the upper workings are protective of groundwater in the regional aquifer. Note this is not a perpetual care contingency.[51]

In addition to the lack of support for Kennecott's five-year time frame, no scientific or engineering analysis has been offered to support the assumption that pumping and treating will *ever* result in continued, long term compliance with groundwater standards. (In other words, standards may be met at the point when pumping and treating are discontinued, but no analysis has been done that indicates that conditions in the mine will not lead to future violations.) No limits have been proposed or required for the levels of various constituents in mine water in the bedrock after mine closure. The mine plan and the state permit are completely silent on the question of what the quality of water in the mine will (or must) be when pumping and treating are discontinued. With so little information on the closure plan, EPA cannot assume that permanent achievement of drinking water standards will be attained.

III. The bedrock within which the mine workings will be located may itself be an Underground Source of Drinking Water.

As we have pointed out in previous correspondence, Kennecott has not done enough testing to determine whether water in the bedrock at the proposed mine site is itself an Underground Source of Drinking Water (USDW). This water (measured at 60 to 375 feet below surface in Kennecott

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50 *Id.* Tr 9: 1890-93; Maest Exhibit pp. 10, 11.

51 Mining Permit Application p. 77.

studies) has a total dissolved solids (TDS) concentration ranging from 168 to 287 mg/L,[52] and thus would be considered a USDW if it contains a sufficient quantity of water. See 40 C.F.R. § 144.3.

Kennecott discounts the upper bedrock as having too low a permeability to qualify as a USDW. As explained above, however, Kennecott has not collected sufficient data to support this conclusion. Only one pump test and four packer tests were performed in the entire bedrock aquifer. The testing was not targeted to intersect fractures. Other information indicates that the bedrock is likely to contain very significant fractures, and that the fractures may produce a significant amount of water. Kennecott's data is simply inadequate to support its conclusions.

The above discussion regarding contaminant levels in the mine water applies directly to water in the upper bedrock. If the bedrock does meet the definition of a USDW, construction of the mine will lead directly to the contamination of a USDW, and that contamination is likely to be high enough that it will violate primary drinking water standards for some constituents. Although Kennecott plans a pump-and-treat system at the close of mining, *that system is intended to clean the water only to a level that will protect the alluvial aquifer.* It is entirely possible that Kennecott and MDEQ will decide that the alluvial aquifer will be protected even when water in the upper levels of the bedrock remain high in some contaminants. To reiterate, the mine plan and the state permit do not contain parameters that water in the mine must meet before the pump and treat system is discontinued.

IV. The interaction of water between the alluvial aquifer and the bedrock is unknown.

The lack of data on bedrock groundwater also seriously compromises Kennecott's conclusions regarding protection of the alluvial aquifer. The data is so scant that the potential for movement between bedrock groundwater and water in the alluvial aquifer is simply unknown. Furthermore, in the state contested case hearing, Dr. Prucha testified that in addition to insufficient data on the bedrock aquifer, the number and spatial orientation of testing wells of the *alluvial* aquifer are also inadequate. As shown in Figure 23 to Appendix B-1 of the EIA, relatively few wells were located near the key area of interest, the ore body and proposed mine workings. More wells are needed in that area, given the very complex unconsolidated system with several layers of varying permeability that pinch out in places, including several places where bedrock is exposed at the ground surface.[53]

When Dr. Coleman attempted to predict impacts on the alluvial aquifer from contaminated water left in the mine, he was unable to create a valid model because of the lack of data.[54] However, he has produced a memo (previously submitted to EPA) that explains his concern that hydraulic heads may push water out of the mine and into the alluvial aquifer.

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52 Mining Permit Application Appendix B-3, Table 9.2.

53 Enclosed CD, Tr 8: 1600-01, 1614-15 (Prucha).

54 Enclosed CD, Tr 13: 2758-59 (Coleman).

V. Subsidence is likely, and would result in water flowing out of the mine workings.

One of the greatest unallayed concerns about the proposed mine is that the crown pillar will fail. The crown pillar is the bedrock roof above the mine cavity in an underground mine. At the Eagle Mine as planned, crown pillar failure would most likely occur through what is known as a "plug failure," where the entire crown pillar collapses as a single chunk of rock. However, it could also occur through a slower unraveling process called subsidence. At least four of the highest caliber mining experts have expressed the opinion that when a void develops below the crown pillar, the pillar will not be strong enough to withstand gravity, and will collapse into the opening.

The evidence throughout the state contested case hearing indicated that such a void is in fact certain to develop at some point. This is because the mining plan calls for removal of the entire ore body, leaving no intact rock for structural support. Although the mine cavity will be backfilled, the backfill material will settle and disintegrate over time, leaving a significant void underneath the crown pillar.

The crown pillar is very unlikely to prove strong enough to resist the force of gravity once the backfill settles. Kennecott's geotechnical consultant Golder & Associates prepared several iterative assessments of the likely stability of the crown pillar. The first two are Appendices C-2 and C-3 to the mining permit application; the third is designated as "Attachment 7," which was included in a response to an MDEQ request for more information. These assessments were based on several systems used by the industry which are designed to yield an approximate "factor of safety" and "probability of failure" based on factors such as the quality of the rock, in situ stresses, hydrology, etc.

The initial factor of safety and probability of failure analyses contained in Appendices C-2 and C-3 indicated that the mine had an unacceptable probability of failure. Two changes were made to the mining plan in an attempt to address this problem. First, the width of the stopes was narrowed, ostensibly narrowing the span across which the crown pillar will need to remain stable. Second, the crown pillar was thickened, ostensibly leaving more intact rock above the mine opening.

Unfortuantely, neither of these changes alleviates the potential for a crown pillar collapse. While narrower stopes may reduce the chances of a roof collapse during mining, eventually the entire ore body will be mined out, leaving only backfill to support the crown pillar. *All* of the evidence and testimony in the state proceedings indicates that the backfill can be expected to break down and settle, leaving a significant void the size of the entire mine cavity directly below the crown pillar. Neither Kennecott nor MDEQ were able to produce a single expert willing to testify that a void would not develop under the crown pillar. With a void the size of the entire mine cavity, Kennecott's own analyses indicate that the crown pillar has a significant chance of failure.

The added thickness of the crown pillar is insufficient to ensure the safety of the mine for two reasons. First, where plug failures are concerned, the thickness of the crown pillar is irrelevant. The crown pillar as currently planned is 190 feet thick; the crown pillar that failed at the Athens Mine, only twenty miles away, was 1800 feet thick. Second, it appears that Kennecott has significantly overestimated the quality of the rock in the crown pillar. Kennecott's factor of safety and probability of failure analyses are rampant with errors; when these errors are corrected, the analyses show that the probability of failure is still unacceptable, even with the thicker crown pillar. In other words, thickening the crown pillar does not leave more intact rock if the rock in the crown pillar is not intact in the first place.

A. *The backfill will break down and settle, leaving a significant void below the crown pillar.*

The mine plan calls for the excavation of ore in long corridors called "stopes." The entire volume of the mine will be divided into stopes, with all stopes slated for eventual removal. At each level, the rock in alternating stopes referred to as the primary stopes would be removed first. These stopes would then be backfilled with cemented rock. Next, the rock that was left in place while the primary stopes were mined would be removed; these stopes are called the secondary stopes. Once the native rock is removed from the secondary stopes, they will be backfilled with loose, uncemented rock or sand. The mining operation would then move up to the next level and begin the process again. At the end of mining, the backfill in the stopes would stand 100 meters from the bottom to the roof of the mine.

There is no indication from any witness or document presented in the state permitting proceeding that the backfill will hold up over time in this situation. The result of the inevitable settling and breakdown of the backfill will be a void immediately below the crown pillar, extending across the entire width and length of the mine

NWF and its partners retained Dr. Stan Vitton to review the mining permit application. Dr. Vitton earned a Bachelor's degree in geological engineering from Michigan Technological University, a Master's degree in mining engineering in the area of rock mechanics and a Ph.D. in civil engineering and geotechnical engineering from the University of Michigan. Dr. Vitton is an associate professor of civil engineering and geotechnical engineering at Michigan Technological University and is the Director of MTU's Institute for Aggregate Research. Dr. Vitton formerly worked as a mining engineer and environmental permitting manager for Shell Oil Company, where he developed mining plans, oversaw the design of mines and conducted research on the effects of blasting on the stability of underground mines. Dr. Vitton routinely assesses roof stability of mines for projects including several for the Michigan Department of Transportation, and one of the stability of an underground hard rock mine approximately 20 miles south of the proposed Eagle Mine.[55]

Dr. Vitton does not believe that Kennecott's backfill plan will provide the necessary support to prevent subsidence. First, backfill through the entire mining area, primary and secondary stopes, will settle. In one example of a mine using similar backfill material, the mine had a 34% void in the cemented aggregate; leaving roughly 34% of the backfilled space for the backfill to settle into. Settlement occurs over 20 to 50 years, and continues even after the backfill is compacted. Studies show that in 100 days, mine rock settles about 7 1/2%. Settlement over 50 years is of course much greater.[56]

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55 Enclosed CD, Tr 4: 572-81 (Vitton); Tr 5: 738-39 (Vitton).

56 Enclosed CD, Tr 4: 681 (Vitton); Tr 38: 7933-46 (Vitton).

This settlement will be exacerbated by the breakdown of the concrete in the primary stopes from acidic water and sulfate. Salts and brine are also known to deteriorate cemented rock fill. Dr. Vitton testified that a condition known as Thaumasite attack is particularly prevalent in buried concrete, and it completely destroys the cementatious binding ability of the concrete, transforming it into mush. This occurs particularly in the presence of acidic groundwater. All of the conditions for Thaumasite would exist at the Eagle project, and Dr. Vitton believes that it is a very serious concern for the cemented aggregate backfill.[57]

Blasting is also likely to contribute to the breakdown of the backfill. The planned backfill strength of 218 psi for the primary stopes is very low for cemented rock fill that will be subjected to blast vibrations. In contrast, the strength of the intact rock is 10,000 to 20,000 psi. In other words, blasting will be calibrated to break up rock of 10,000 to 20,000 psi, while adjacent cement walls of 218 psi are expected to remain intact. Furthermore, if there is not a good bond between the cemented rock fill and the host rock, rebounding will occur, increasing fracturing in the cemented backfill. Dr. Vitton found this very problematic, and testified that it is not consistent with practices in other mines.[58]

Finally, the strength of the cemented rock is likely to be negatively influenced by the backfill methods. Under the mine plan, the cemented rock fill would be end dumped 400 feet, causing segregation of the materials, leading to a strong bottom and a very weak top. Liquefaction resulting from dumping the material down open stopes is another problem that is well described in many industry papers.[59] Kanowna Belle Mine is a currently operating mine that attempted to use similar backfill. Segregation was an extreme problem with variations in strength throughout the backfill, causing that company to switch to cemented paste backfill.[60]

All of these issues of deterioration and settlement will result in a void below the crown pillar across the entire span of the mine. As explained below, the crown pillar will not be stable if such a void develops, and yet this void is virtually certain to occur.

Mr. Stone, who was the only witness testifying for Kennecott regarding the backfill plan in the state contested case, admitted that the backfill was designed for safety during mining, and not for long term environmental protection. The backfill strength is designed only to support itself to a height of 30 meters, yet the stopes are planned to be 100 m high. Mr. Stone was unaware of any analysis regarding the ability of the backfill to support its own weight at the end of mining. Kennecott has also provided no evidence that the backfill will hold up to blasting; Mr Stone testified that he did not know that anyone has yet considered a blasting plan or thought about the safety of blasting against the backfill in a disciplined way.[61] Furthermore, Mr. Stone admitted that

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57 Enclosed CD, Tr 38: 7942-43 (Vitton); Tr 5: 744-45 (Vitton).

58 Enclosed CD Tr 4:674-75 (Vitton).

59 *Id.* at 677.

60 Enclosed CD Tr 38: 7916 (Vitton).

61 Enclosed CD Tr 22: 4566-72, 4610 (Stone).

acid mine conditions are a problem for cemented rock fill.[62] In sum, Kennecott has presented no evidence that the backfill will be sufficient to prevent a crown pillar collapse.

B. A thicker crown pillar will not prevent a plug failure.

As explained above in the discussion of bedrock hydrology, very, very little work was done to characterize the faults, dikes, and fracturing at this site. Cores were drilled to locate and characterize the ore body, *not* to identify features that might contribute to subsidence. Methods such as extended pump tests that could provide information on the extent of fracturing of the bedrock were not done. Existing information such as water loss during the drilling of cores that could also shed light on the degree of fracturing was not used. Drilling logs should contain this information, but they are not part of the applications, and Kennecott has consistently refused to produce them for review. Kennecott seems to have taken the approach that the less known about fractures in the bedrock, the better the chances of getting permitted.

As described above, what little evidence there is indicates that significant faults and fracturing very likely exist. This is relevant in assessing rock stability as well as water movement, because faults, fracturing, and dikes are all features that contribute to instability as well as the movement of water. As Dr. Bjornerud, a structural geologist at Lawrence University, testified, the known dikes and faults in the area of the proposed mine constitute discontinuities in the rock that should be investigated because they can be zones of weakness.[63]

Dr. Bjornerud also pointed out that the bedrock outcropping known as Eagle Rock provides good evidence of the quality of the bedrock, and should be considered as evidence of the condition of the rest of the bedrock that is not available to see and touch.[64] One of the most dramatic features of Eagle Rock is fracturing or "joints" breaking the rock into columns that are quite uniform in thickness. This is an example of "columnar jointing," which forms when a hot magma body cools quickly. When the magma cools it contracts and the rock is completely broken into rodlike cylinders. "When you see something like this, usually it continues right across the entire thickness of the magma body and it means that *the rock is completely broken into these rod-like cylinders.*" Dr. Bjornerud also identified "brecciated (broken-up, sheared) contacts between dike and country rock at the outcrop; this demonstrates that there has been a lot of deformation of the rock at the time the dike was in place."[65]

Dr. Bjornerud also discussed information culled from the eight drill core photos that she was able to inspect. These photos were all of drill cores taken from the crown pillar area. The drill cores show a zone of sheared and almost rubblized rock that has mineralization along it, including a mineral called serpentine, which is extremely slippery and known for very low friction. Appendix C1 of the Mining Permit Application noted that much of the peridotite has been changed to

62 Enclosed CD Tr 15: 3248 (Stone).

63 Enclosed CD, Tr 3:476-477 (Bjornerud). Mining Permit Application Appendix C1, page 13.

64 Dr. Bjornerud's work is more fully explained and illustrated in Appendix 8 to NWF's Comments on the Mining Permit Application, previously submitted to EPA.

65 Enclosed CD, Tr 3:472-83 (Bjornerud).

serpentine. Serpentine is notorious for having a lower core friction than other silicate minerals, and therefore needs more confining pressure, or lateral stress, to keep it from slipping.[66] Dr. Bjornerud spent approximately 30 hours reviewing core photos, and arrived at the conclusion that "much of the core was very poor quality rock."[67]

The presence of faults, dikes, and other discontinuities has led the experts to conclude that plug failure is a very real possibility at this mine. Dr. Sainsbury, Dr. Vitton, and Mr. Jack Parker, another eminent mine engineer, were all of the opinion that based on the little that is known about the geology at this site, a catastrophic plug failure of the type that occurred at the Athens Mine, just 20 miles away, is entirely possible. Dr. Vitton testified that the proposed Kennecott mine site is similar to the Athens mine site because both deposits are vertically oriented, and both have dike structures on both sides that form planes of weakness.[68] Dr. Sainsbury expressed exactly the same concern.[69] The crown pillar at the Athens mine was 1800 feet thick, leading to the conclusion that the thickness of the crown pillar is irrelevant in the event of a plug failure.

Dr. Vitton also referenced a similar collapse at Rio Tinto's Palabora Mine in South Africa.[70] Dr. Vitton testified that there are many similarities in the work done to characterize the sites at Palabora and Eagle. At Palabora as at the Eagle Mine, hydrology and the fracturing of the crown pillar were poorly analyzed. As it turned out at Palabora, the hydraulic conductivity of the crown pillar was several orders of magnitude greater than was originally estimated. The ore at Palabora is vertically dipping, just like at Eagle, and the compressive rock strengths at Palabora are roughly the same as Eagle. Modeling performed at Palabora by external consultants indicated that the walls would be stable; history has shown that this wasn't true. Now Kennecott (the American arm of Rio Tinto) appears to be repeating the same pattern in Michigan.

Neither Kennecott nor MDEQ has offered any explanation why the permitted 87.5 m thick crown pillar will be any safer than Kennecott's original proposal, which Dr. Sainsbury and others agreed would be unstable. Neither has ever conducted or reviewed any calculation that would justify the 87.5 meter final thickness of the crown pillar. The proposed crown pillar dimension remains scientifically unsupported in the state permit proceedings.

The fact is that the crown pillar was thickened in the late stages of the state permit proceedings like a bone thrown to the many experts who had weighed in on this issue, but without any supporting analysis. The attitude was "let's just thicken the pillar and call it good," without any real assessment of whether thickening the pillar would actually address the identified problem.

66 *Id.* at 481-483.

67 Enclosed CD, Tr 4:508 (Bjornerud); core_photo_05EA099_20; kennecott_rock_cores_101.

68 Enclosed CD, Tr 4:604 (Vitton).

69 Enclosed CD, Sainsbury May 5 2006 Report p. 11-12.

70 Enclosed CD, Tr 4:600-03 (Vitton); Tr 38:7989-92 (Vitton).

C. Kennecott has significantly overestimated the strength of the rock in the crown pillar.

Kennecott used a formulaic approach to assessing the stability of host rock at the Eagle mine site, using numbers representing the various factors that have a bearing on rock stability to arrive at another number by which to judge the quality of the rock and ultimately the stability of the mine. To the extent that it has been revealed, Kennecott's work was riddled with errors, inconsistencies, and failures to follow industry standards. Added to that is Kennecott's refusal to allow access to most of the underlying physical evidence, documentation and even raw data.

The analysis begins by calculating a Rock Mass Rating (RMR). RMRs should be based on an examination of rock obtained from drill cores and on-site observed conditions. In this case, however, it has never been made clear who performed the RMR calculations, when they were done, or what methods were used. MDEQ's rock mechanics expert William Blake testified that he tried to find out "who really did the RMR calculations for Kennecott and how it was done." He went on to say, "I don't think the issue was really resolved. It certainly wasn't resolved to my satisfaction."[71]

The RMR analysis includes five parameters and one adjustment factor that attempts to provide a sense of how the rock will perform under various types of stresses.[72] RMR76 (the version used by Kennecott) consists of six parameters:

A1 = rock strength
A2 = Rock Quality Designation (RQD)
A3 = spacing [of joints]
A4 = condition of joints
A5 = level of groundwater present, and
AB = adjustment for joint orientation.

In its review of the mining permit application, which is supposed to be a public review process, NWF's experts attempted to review the work that was done to arrive at RMRs for this site. Kennecott refused to allow access to the actual drill cores, and MDEQ has repeatedly stated that it has never reviewed the drill cores itself. NWF was finally able to obtain photos of eight drill cores from the Michigan DNR, and reviewed Kennecott's RMR determinations on the basis of those photos. Based on that evidence (the only evidence made available to the public or the state agencies), Kennecott has significantly overestimated the strength of crown pillar.

The first error discovered by NWF's experts was that Kennecott did not include "discrete features" such as fractures found in the drill cores in its calculation of the A2 RQD values.[73] The permit application text states: "*the structural features identified during the logging have not been incorporated into the GoCAD model.*" The application reveals:

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71 Enclosed CD, Tr 5: 807-08 (Blake).

72 Enclosed CD Tr 4: 641-42 (Vitton).

73 *Id.* at 645.

> Based on the information in the two Microsoft access to databases, there have been other discrete structural features identified in the Eagle project. These discrete features have been stored in a separate table of the database instead of being included in the main database. [74]

Kennecott's application identifies at least 143 discrete features in the crown pillar.[75]

> Additional discrete structure may be present in the crown pillar, which could have a significant effect on the behavior of the crown. Current contours of RQD and RMR show low value zones (one such zone extends approximately east/west across the northern contact of the intrusion) that may indicate the location of discrete structure.[76]

Clearly, these features are very significant and relevant to the analysis of crown pillar stability, and it is completely unacceptable to ignore them when assessing crown pillar strength.[77]

In a similar vein, Table 4 of Appendix C3 makes reference to 40 individual "major structural zones" -- anything that had shown evidence of intense shearing or breaking of the rock that was longer than a meter in core length. Most of the zones shown on Table 4 have RMR values of 40 or less. These are the zones where failures would be likely to occur.[78]

Dr. Bjornerud supplemented Golder's table of major structural discontinuities by looking at areas that Golder itself had already identified as major structural discontinuities and noting areas of comparably sheared and broken rock. At the end of the process, Dr. Bjornerud had added a total of 157 meters of major structural discontinuities from the same cores where Golder had found only 80 meters.[79]

The second problem identified by NWF's experts was that Kennecott used the outdated 1976 RMR (RMR76) system, rather than the updated 1989 version (RMR89), which is more commonly used today. According to Dr. Vitton, the RMR 89 system is clearly superior to the RMR 76. The RMR 89 system uses an increased database of civil engineering projects *and mining case histories*, and increases the weighting of factors for the spacing of fractures and the influence of water.[80]

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74 Mining Permit Application Appendix C2, page 13.

75 Enclosed CD, Tr 4: 657 (Vitton). Mining Permit Application Appendix C3, Fig. 20.

76 Mining Permit Application Appendix C3, page 9.

77 Enclosed CD, Tr 4: 642, 706-07 (Vitton).

78 Enclosed CD, Tr 4: 520-23 (Bjornerud).

79 *Id.*

80 Enclosed CD, Tr 4:627 (Vitton); Tr 38:7953-54 (Vitton); Tr 3:491 (Bjornerud).

Third, Kennecott omitted data and used flawed data in its analysis. Based on Kennecott's RQD and RMR tables and core photographs, not all sections of core were assigned RMR values; values for some core sections are simply missing.[81] For the eight cores of which NWF had photos, the following table shows the percentage of cores without RMRs.[82]

Hole ID	**55**	**60**	**62**	**64**	**67**	**69**	**99**	**101**
Total run (meters)	**137**	**85**	**300**	**280**	**280**	**271**	**142**	**121**
Not reported (meters)	**12**	**11**	**59**	**51**	**15**	**33**	**49**	**26**
Not reported (percentage)	**9**	**13**	**20**	**18**	**5**	**12**	**34**	**21**

Dr. Bjornerud testified that predictions of crown pillar stability when these kinds of percentages from core runs are missing simply cannot be accepted. Since the point is to assess the overall quality of the rock, leaving some rock out of the equation brings the whole exercise into question. MDEQ's rock mechanics expert Dr. Blake agreed with Dr. Bjornerud that the missing data had to be interpreted as "bad rock" in that it suggests a significant fault, a broken rock zone, and that it is not an acceptable practice to eliminate these zones from the analysis.[83] But that is exactly what Kennecott did, and MDEQ has thus far looked the other way.

The fourth error identified by NWF experts is that Rock Quality Designations (RQDs) (parameter A2) were improperly assigned. Kennecott's own description of how the A2 parameter was developed is: "Rock quality was recorded as the link of all solid core greater than 10 cm long." The additional missing step in the proper method is to divide that total by the length of the entire run of core. Without that final step, the worst quality rock has once again been eliminated from the assessment, which is what happened here. Kennecott's method results in incorrect RQDs for the A2 parameter.[84]

Fifth, Kennecott erroneously assigned an A5 factor that represents completely dry rock. This conflicts with Mark Logsdon's testimony on Kennecott's behalf that the crown pillar would be saturated.[85] The application itself states, "The water depth that was used in the analysis assumes the crown pillar was completely saturated with water."[86] The assumption of dry conditions for the A5 factor is a concern that was raised by Dr. Sainsbury as well as by Dr. Vitton. This erroneous assumption significantly inflated Kennecott's RMR values.

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81 Enclosed CD, Tr 4: 659 (Vitton); Kennecott_rock_cores_101.

82 Enclosed CD, Tr 4:516 (Bjornerud).

83 Enclosed CD, Tr 5: 894-895 (Blake).

84 Enclosed CD, Tr 4: 636-38 (Vitton).

85 Enclosed CD, Tr 20: 4255-56 (Logsden).

86 Mining Permit Application Appendix C3, page 14.

Sixth, Kennecott improperly imported the A5 value from RMR 89 into the analysis, using the RMR 89 maximum value of 15 for dryness instead of the RMR 76 value of 10. This meant that Kennecott's possible score added up to 105, when the entire system is based on a total score of 100. This means that all of the RMR values probably started out too high.[87]

Seventh, Kennecott did not perform necessary adjustments for the orientation of discontinuities in the rock, the AB parameter. In fact, this parameter was not mentioned at all in the report. The permit allows tunnels, or vertically oriented rock with a void underneath, which is a very unfavorable condition in terms of the AB factor. With this orientation, Kennecott should have subtracted 12 (-12) from its RMR ratings. Kennecott made no adjustment at all for the AB parameter.[88]

To the extent permitted by the limited information Kennecott made available to them, Drs. Vitton and Bjornerud performed their own calculations of RMR values to assess whether Kennecott's work was reasonable and realistic. They used Kennecott values for the A1 and A2 parameters. Dr. Bjornerud calculated the A3 and A4 parameters. She also made an assessment for the A5 parameter. Dr. Vitton assigned an AB parameter value of (-2) instead of the maximum of (-12) to give Kennecott the benefit of the doubt. Dr. Vitton arrived at an average RMR for the crown pillar based on the eight cores for which he and Dr. Bjornerud received and reviewed photographs. Dr. Vitton's average RMR for the crown pillar was 45, compared to Kennecott's values that ranged from 75 to 90.[89]

To add to our concerns, MDEQ has accepted Kennecott's assessment of the rock mass with virtually no review or oversight. No one from or representing the state agency has looked at the drill cores themselves; the most that has been done is to look at photos of three cores. No one at MDEQ has reviewed Kennecott's calculations or the numbers that went into them. MDEQ has simply taken Kennecott at its word that the crown pillar will be stable, despite discrepancies in methodology and despite the very grave concerns expressed by MDEQ's own contractor.

In summary, *the evidence indicates that Kennecott eliminated the worst portions of the samples (which consisted of rubble) from its RMR analysis.* As a result the number designated to represent the rock quality of these cores was significantly higher (indicating better quality rock) than was actually the case. In addition, Kennecott used a method of averaging rock quality designations over the length of a core sample that also significantly skewed the analysis to indicate a higher rock quality than actually exists. Kennecott assumed dry conditions when in fact the rock is saturated, and eliminated the adjustment for the orientation of discontinuities. When NWF's experts performed the same analyses correcting these problems, the RMR ratings were much lower than those obtained by Kennecott.

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87 Enclosed CD, Tr 3:497 (Bjornerud).

88 Enclosed CD, Tr 3: 497-98 (Bjornerud); Tr 4: 617, 627 (Vitton).

89 Enclosed CD, Tr 4: 659-63 (Vitton).

D. When Kennecott's errors are corrected, the probability of failure is unacceptable even with a thicker crown pillar.

Once RMR calculations were made, Kennecott utilized those calculations in the "scale span" and "CPillar" methods to assess crown pillar stability. The scale span method considers actual data from mines around the world, scales them to a certain value, compares the rock quality in the mines and plots them to determine which indicate stable conditions and which indicate unstable conditions. Mines with a factor of safety of below 1.0 have failed, while those above 1.0 have not.[90]

It is important to understand that comparing potential mines to existing mines is not an exact science, and that factors of safety above 1.0 do not necessarily indicate that a mine will not fail. Rather, 1.0 represents the level at which a mine is expected to fail, while numbers going up from 1.0 represent a decreasing risk that they will fail. Kennecott's target factor of safety was 2 or greater.[91] Even at that level, however, a mine presents a significant risk of failure over time. Kennecott's expert Kevin Beauchamp testified that with a crown pillar thickness of 87.5 meters as permitted, *the crown pillar presents a 10% chance of failure.*[92] In the context of UIC regulation, this translates to a 10% chance that groundwater will become contaminated at this site. And in reality, considering the errors in Kennecott's work, that chance is much greater.

Dr. Vitton used several scenarios in the scale span method to assess crown pillar stability. He looked at the permitted 87.5 m thick crown pillar, with an opening of the full crown pillar span, 68 x 50 m. As explained above, this is likely to be the dimension of the void that will eventually develop below the crown pillar. In that scenario and with an RMR of 70, the scale span method gives a factor of safety of 1.12. With an *RMR of 45 (representing Dr. Vitton's best judgment of the actual quality of the rock), the factor of safety is 0.17.*[93] Even if Kennecott managed to limit the void opening to one stope, an RMR of 50 gives a factor of safety of only 1.49.[94] Thus in the final analysis, Kennecott's prediction that the mine will be stable depends both on an unfounded theory that only one stope would ever be open at a time *and* on abysmally flawed RMR values.

Kennecott also used the CPillar method to analyze the likelihood of plug failure at the Eagle mine. CPillar is a very simple method in which the weight of gravity pushing down and the strength of the surrounding rock are analyzed. The inputs to this program are RMR values, uniaxial

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90 Enclosed CD, Tr 5: 624-31 (Vitton).

91 *Id.* at 748.

92 Enclosed CD, Tr 16: 3435 (Beauchamp).

93 Enclosed CD, Tr 5: 751-56 (Vitton).

94 *Id.* at 768

compressive strength values and horizontal stress values.[95] Kennecott's CPillar analysis used RMR values of 75 and 85, which once again significantly overestimate the strength of the rock.[96]

In addition to RMR values, horizontal stress is a key component of the CPillar method. But Kennecott has made no attempt to identify an accurate horizontal stress value for this site. To our knowledge, no horizontal stress measurements have been taken at the site. Instead, Kennecott used average stress measurements for the entire Canadian Shield.[97] According to Dr. Vitton, the original stress field is very important to the integrity of the mine. One of the most important lessons learned from the Athens Mine relates to ground stresses in the area immediately above the stope.[98]

It is entirely possible to take local stress measurements from the surface by hydrofracturing or computing borehole deformation.[99] In a situation such as this one, where preventing crown pillar collapse is so critical and the quality of the rock is so questionable, it is unconscionable not to use these methods to make sure that the crown pillar will hold up before the mine cavity is created.

Dr. Sainsbury's reports echo Dr.Vitton's and Jack Parker's concern about horizontal stresses. Dr. Sainsbury utilized Mr. Parker's seminal work on lateral stress fields in the White Pine Mine, which is also in the U.P. Mr. Parker's paper shows that horizontal stresses can go from very high compression to no stresses to tension in very close proximity. Dr. Sainsbury stated that Mr. Parker's paper should have been reviewed in considering this project, given that the application does not include any measurement of in situ horizontal stress at the proposed mine site.[100]

Without better data, Kennecott's conclusion that the CPillar analysis indicates that the crown pillar will be stable is completely unwarranted. The analysis actually did no better than make up numbers for at least 2 of the 3 variables in the equation. The exercise simply provides no basis for any conclusions whatsoever about stability of the crown pillar.

To reiterate, the thickening of the crown pillar does not alleviate many of the concerns raised by Dr. Sainsbury (along with Dr. Vitton, Dr. Bjornerud, and Mr. Parker). Although Dr. Sainsbury appears to have "signed off" on the mine plan with the increased crown pillar, he did so in a carefully-worded one-page memo that does not retreat from his earlier concerns.[101] There is no evidence that Dr. Sainsbury actually ever reconsidered the issues he raised, especially the stability of the crown pillar after settling of the backfill, and the potential for a plug failure like the one that

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95 Enclosed CD, Tr 4: 605 (Vitton). Mining Permit Application Appendix C2, Fig. 29.

96 Enclosed CD, Tr 4: 613 (Vitton).

97 *Id.* at 607.

98 Enclosed CD, Tr 38:7957 (Vitton).

99 Enclosed CD, Tr 3:490 (Bjornerud); Tr 4:621 (Vitton).

100 Enclosed CD, Tr 4:682-85 (Vitton); Sainsbury May 5 2006 Report p. 6.

101 Enclosed CD, Sainsbury Nov 9 2006 memo.

occurred at the Athens mine. In fact, on the *same day* that Dr. Sainsbury wrote his one-page memo, he sent an e-mail message to Andre van As of Rio Tinto, stating:

> In my, and the states [sic] opinion, the rock mechanics issues at Eagle are going to be a potential stumbling block for the project. The rock mechanics work conducted thus far, which forms the basis of the mine permit application, is not defensible. Some of the analyses conducted actually indicate that crown pillar stability should be a serious concern. The main difficulty with the review process thus far has been the lack of Kennecott/Rio Tinto [] associated with the project that have an understanding of the rock mechanics issues. I would like to keep Rio Tinto in the loop on the rock mechanics review process. Can you advise if there is anyone from Kennecott/Rio Tinto with rock mechanics input on this project?[102]

It thus appears that Dr. Sainsbury's concerns were not allayed by thickening of the crown pillar.

E. Failure of the crown pillar is likely to result in violations of drinking water standards.

Kennecott's prediction that the crown pillar will be stable is based on a long list of faulty assumptions, missing information, and unanswered questions. The evidence shows a very real possibility that the backfill inside the mine will deteriorate and settle, opening a void under the crown pillar. Whether through catastrophic collapse or through slow unraveling, the roof of the mine will sink. To this day, nothing has been done to assess the potential impacts of subsidence on groundwater and other resources in the area. However, common sense indicates that if the crown pillar collapses, water in the reflooded mine is likely to be displaced by rock, and thus the water will move out of the mine cavity. As explained above, virtually nothing is known about the bedrock hydrology or about connections between the bedrock and alluvial aquifers. The only prudent course is to proceed with the assumption that drinking water standards may be violated unless sufficient evidence is produced indicating otherwise.

VI. The EPA should use its UIC authority to ensure that the Lake Superior Binational Program and LaMP objectives are met

As explained by the 2008 Lake Superior Lakewide Management Plan:

> In 1990, the fifth biennial report of the International Joint Commission (IJC) to the U.S. and Canadian governments recommended that Lake Superior be designated as a demonstration area where "no point source discharge of any persistent toxic substance will be permitted." In response, on September 30, 1991, the federal governments of Canada and the U.S., the Province of Ontario, and the States of Michigan, Minnesota, and Wisconsin announced a Binational Program to Restore and Protect Lake Superior.[103]

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102 Enclosed CD, Sainsbury Nov 9 2006 email.

103 Enclosed CD, 2008 LaMP p. 1-2.

In addition to establishing the goal and target dates for zero discharge of nine persistent, bioaccumulative toxic substances, including mercury, the Binational Program established the goal of protecting and restoring the native ecosystems and species of the Lake Superior basin. The impetus for this program was both to prevent the degradation of an area that is still relatively pristine, and to actively demonstrate on an international level that zero discharge and the preservation of native ecosystems is possible even in an inhabited area.

The promises of the Binational Program are implemented through the Lakewide Management Plan ("LaMP") process. In the recent 2008 LaMP, the governmental partners (including EPA) reaffirmed their commitment to using and following the LaMP documents.[104] But several goals and objectives of the Lake Superior Binational Program and the 2008 LaMP have thus far been ignored in the process of permitting the proposed Eagle Mine.

One such goal is zero discharge of mercury.[105] At the end of mining, mercury will be present in the mine water at a much higher level than would be allowed for discharge into surface water.[106] The high risk of subsidence at this site indicates a corresponding risk that mercury will be discharged to surface water at a concentration that violates water quality standards. In light of the increased scrutiny that the governments have promised to give to discharges of mercury within the Lake Superior basin, and the complete lack of concern that MDEQ has shown on this issue, it is incumbent on EPA to use its available authorities to ensure that this discharge does not happen.

The 2008 LaMP also reaffirms the Binational Program habitat goal:

> To protect, maintain, and restore high-quality habitat sites in the Lake Superior basin and the ecosystem processes that sustain them. Land and water uses should be designed and located compatible with the protective and productive ecosystem functions provided by these natural landscape features.[107]

Given that the Salmon Trout River is home to the last native coaster brook trout run in the United States outside of Isle Royale, it seems beyond dispute that this is one such "high-quality habitat site."

The 2008 LaMP places an emphasis on the use of watershed management plans to help meet the habitat goal, acknowledging the management plan for the Salmon Trout River and noting that such plans provide "guidance for implementation of actions that will reduce existing water quality impacts and provide a basis for protection from future impacts."[108] However, the EPA and MDEQ-approved watershed management plan has been completely ignored in mine permitting

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104 *Id.* at 1-1.

105 The mine will also discharge mercury to groundwater through the TWIS at above background levels, which NWF also objects to. However, this letter is limited to issues concerning the mine workings as a UIC well.

106 *See* Coleman GLIFWC_10-10-2007[1] p. 6.

107 Enclosed CD, 2008 LaMP p. 1-6.

108 *Id.* at 6-3.

proceedings. In essence, the management plan found that locating a sulfide mine within the headwaters of the Salmon Trout was not "compatible with protective and productive ecosystem functions," and therefore advises against locating a mine here.[109] Despite the commitment to habitat protection and to watershed management plans exhibited by the LaMP, and despite the governments' avowed commitment to the LaMP as a governing document for ecosystem management, the Salmon Trout River Watershed Management Plan might as well not exist.

As the EPA knows from its Superfund program, the mining of sulfide ores is one of the largest sources of water contamination and aquatic habitat degradation in the United States today. What has been so disheartening in the state permitting proceeding is the realization that despite the Lake Superior Binational Program and LaMP documents, and despite all that is known about the difficulty of accurately predicting impacts from sulfide mining and the need for very careful site characterization and planning, nothing has changed. We cannot rely on the State of Michigan to protect water or aquatic habitat from the impacts of mining sulfide ores.

Thank you for your attention to this issue. I can be reached for discussion at 906/361-0520 or by email at michelle.halley@sbcglobal.net.

Sincerely,

F. Michelle Halley/JER

Michelle Halley

109 Enclosed CD, Salmon Trout River Watershed Management Plan p. 41.