PolyMet Tailings Basin Performance

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This brief report addresses the projected performance of the tailings basin for the proposed PolyMet copper nickel mine in northeast Minnesota. This note is based on the information presented in the Final Environmental Impact Statement (FEIS) for the proposed project and other supporting documentation. The comments in this note are derived from my experience in preparing and reviewing Environmental Impact Statements for controversial federal projects over 31 years of service at Oak Ridge National Laboratory. I have contributed to 16 published Environmental Impact Statements and Environmental Assessments in the areas of surface water and groundwater hydrology. I have been an expert witness in several legal proceedings regarding the conclusions presented in these documents. As these comments note, the conclusions drawn in the FEIS and the modeling performed to support these conclusions have a great deal of uncertainty. The uncertainty in the analysis is sufficient to conclude the FEIS does not provide defensible evidence of the environmental impacts to be expected from the proposed action. Given the magnitude of the PolyMet proposal, the actual impacts to water resources from the tailings basin are likely to be significant and would persist into the indefinite future.

The FEIS includes a lengthy analysis of the tailings basin, which is actually a 200 ft. tall tailings pile without a liner, for the proposed action. The FEIS concludes that 90% of the tailings leakage that remains as groundwater will be captured and contained within a containment barrier surrounding much of the tailings pile and that 100% of the surficial seepage from the tailings will be collected and contained. (FEIS 5a 179, FEIS Table 5.2.2a 37). The conclusions are based on computer models of the performance of the containment barrier and dams constructed for containing the tailings and contaminated water. The analytical support for these conclusions is based on assumptions of performance that are not justified or supported by data. Lacking any demonstration of the validity of the assumptions leaves the conclusions questionable. The resulting predictions of the effectiveness of the containment barrier in preventing the discharge of contaminants are questionable.

The tailings pile itself was originally constructed by LTV Steel Mining Company for disposing of tailings from the previous taconite mining operation. The tailings from the previous operation were placed on the ground without any liner or other form of containment. The tailings derived from taconite mining were piled to a maximum height of approximately 200 ft. at the highest point and are encircled by an earthen dam. Approximately one-half of the tailings pile has a fill depth of approximately 60 ft. from the taconite mining operations. The proposed action is to use the lower of the two filled halves of the tailings pile for the tailings from copper nickel mining. Significantly, the site of the tailings basin site included three creeks that drained to the north, east and south of the basin. While these creeks have long since been covered by a thick layer of taconite tailings, hydrologically these creeks remain functional paths for water to be discharged from the tailings basin. While the discharge of the creeks has been reduced by the thick layer of tailings placed on top of the creeks, the creeks will continue to be viable discharge locations for waters in the tailings pile in the future no matter what is done to contain the discharge.

The use of the existing tailings pile by PolyMet will increase the depth of fill within the tailings pile to 200 ft. across the entire tailings pile. Upon closure of the copper nickel mine, bentonite enriched soil will be placed on top of the tailings to allow a pond to form. This pond will cover most of the half of the tailings pile used for disposing of copper nickel tailings (FEIS Fig. 3.2-29). This pond will provide an additional 140 ft. of hydraulic head (pressure) on the base of the dam encircling the tailings pond, and will increase the leakage from the tailings pile. This phenomenon will continue for the indefinite future. Evidence of this phenomenon can be seen in the current condition of the tailings pond. FEIS Fig. 4.2.2-17 shows the existing groundwater mound associated with the tailings pile. The hydraulic gradient across the tailings pile is 150 ft. This large gradient is proportional to the flux of groundwater to the north and west of the existing tailings pile. The existing hydraulic gradient to the east suggests a limited flux, but the addition of 140 ft. of copper nickel tailings will support a notable flux of groundwater to the east as well.

FEIS Fig. 4.2.2-15 illustrates the depth to bedrock in the tailings area. The recorded depths to bedrock from drilling logs range from 3.5 – 42.5 ft. PolyMet proposes to install French drains and a slurry wall along much of the perimeter of the tailings pile (A slurry wall is a bentonite enriched soil, or bentonite and concrete enriched soil that acts to reduce the conductivity of the soil). The collected water from the French drains is to be either pumped to the Wastewater Treatment Plant or pumped back into the tailings pile. Installing a French drain and a slurry wall at a depth of over 40 ft. is a significant undertaking requiring the use of a huge shovel capable of reaching 40 ft. below the surface. More importantly, the drains are to conform to the irregular surface of the bedrock. Given the variation in the surface of the bedrock, large portions of the drainage system will require pumping to be effective as drains. The irregular surface of the bedrock and the irregular thickness of the native soils suggest a three-dimensional character of groundwater flow within the native soils. This is an important consideration, which needs to be addressed in the modeling of the site performance. This is not addressed in the analysis of the tailings pile. Failure to address the three dimensional character of the groundwater transport is certain to lead to increased leakage of contaminated groundwater from the tailings pile to the nearby surface water from the north, west, and south of the tailings pile when compared to the projected model results.

The modeling of the hydrology of the tailings facility is done using the models MODFLOW, GoldSim, and XP-SWMM. MODFLOW is used to compute groundwater movement along four different vertical cross-sections of the tailings basin. GoldSim is used to compute the transport of contaminants across several one-dimensional flow paths. XP-SWMM is used to compute surface water flow paths. Given the three-dimensional character of groundwater flow in the native soils, the reduction of the flow regime to a two-dimensional and one-dimensional domain could lead to erroneous results and questionable conclusions. There is no discussion of how the three dimensional character of the flow within the tailings pile was reduced to one or two dimensional flows. This is not an elementary exercise and could lead to results that are not representative of the site.

There is no discussion of the verification of the results from modeling, which is a standard practice in modeling. Verification of results has the purpose to demonstrate that the model(s) are indeed representative of the environment they are supposed to represent. Further guidance on this important element of modeling can be found in *Hydrology Handbook, Second Edition*, ASCE Manuals and Reports on Engineering Practice No. 28, American Society of Civil Engineers, 1996.

FEIS Table 5.2.2-12 includes the fluxes of water captured by the containment system from the tailings basin and the natural groundwater flows outside the containment system as computed by MODFLOW. Independent of concerns regarding the modeling of the tailings pile and containment system, the fluxes attributable to the containment system are significant. These results suggest the pumps for the containment system need to be sized to handle about 2517 gpm from the groundwater alone. When combined with the water management system shown in FEIS Fig. 3.2-13 and the assumption of steady state flows, the water management demands for this project are large. Given the uncertainties presented in the modeling, which is used to make these predictions, the actual performance of the water management system could be seriously mischaracterized.

FEIS Fig. 5.2.2.12 shows a flow chart for the Plant Site including the tailings pile. This figure does not include any groundwater flow from the east side of the tailings pile, which is included in the modeling of the tailings basin. This figure is not a water balance in that no quantities are included. A water balance that identifies the fluxes of water within the plant/mine sites and discharges of water from the plant/mine sites for each element of the proposed project is not presented. A comprehensive water balance accounting for water use by the proposed project would be a useful tool to verify the credibility of the modeling effort for the many aspects of the proposed project.

The leakage from the pond on the top of the tailings basin is specified to be 6.5 in/yr. The text points out "The 6.5 in/yr pond leakage rate is not computed, but is a stated engineering performance specification. The hydraulic conductivity that achieves this leakage is computed using a credible Darcy's Law calculation" (FEIS A-579). Darcy's Law is a simple formula that states the flux of water through a porous media is equal to the product of the hydraulic conductivity and the hydraulic gradient. In effect, this statement assumes a solution without providing any justification for the assumption. Freezing and thawing are certain to degrade the liner with a certain increase in leakage. The long-term performance of this pond on top of the tailings pile is assumed to be constant for the indefinite future. This assumption is not justified and would be nearly impossible to justify for the long term. Since evaporation is less than precipitation in Minnesota, increased infiltration can be anticipated, which will lead to increased discharge of contaminated water from the tailings pile to surface water for the indefinite future.

The analysis of the surficial deposits or native soils presumes the hydraulic characteristics are single-valued in the MODFLOW modeling for both the horizontal and vertical directions. The modeling does not include any accounting for groundwater flow in the unsaturated zone or accounting for variations in hydraulic conductivity in the horizontal or vertical directions.

Considering soil properties to be homogeneous over large areas and depths is a significant assumption that is not justified or addressed. Failure to address these considerations leaves the modeling open to question. Data supporting the single value hydraulic characteristics are not presented. The supporting documentation is where these data are to be found. The referenced data for the tailings pile include the hydraulic conductivity range from 3.4E-4 ft/day to 2 ft/day ("Hydrogeology of Fractured Bedrock in the vicinity of the NorthMet Project" Barr, 2014b). How a single value can be assigned to this range of data is not justified. Lacking a justification for the selection of a single value leads to predictions that are uncertain, which leads to conclusions that are indefensible.

An important feature of the tailings basin containment system is the slurry wall. The slurry wall (referred to in the FEIS as a cutoff wall) is supposed to be keyed into bedrock in some descriptions (FEIS Fig. 5.2.2-14) and not in others (FEIS Fig. 3.2-28). The FEIS suggests the slurry wall is to be nearly impermeable for the indefinite future without any justification. The descriptions of the bedrock suggest that the upper portions of bedrock have greater conductivity, while the deeper portions are less conductive. However, the MODFLOW calculations were done with the bedrock being described as a no-flow barrier. Quoting the text, "It is acknowledged that the Plant Site MODFLOW model does not include bedrock. This is because the bulk hydraulic conductivity of the upper bedrock is estimated to be about two orders of magnitude lower than the hydraulic conductivity of the surficial aquifer, and it is interpreted that deeper bedrock has substantially lower hydraulic conductivity." However, FEIS Fig. 5.2.2-14 and FEIS Fig. 5.2.2-15 illustrate groundwater flow beneath the slurry wall. The FEIS leaves unresolved how a slurry wall is to be installed in bedrock and how effective it can be. Also remaining is the question of how much groundwater is actually flowing in bedrock rather than relying on estimates or interpretations not based on data.

The role of bedrock in the groundwater flow in and around the tailings basin is not viewed with any consistency in the FEIS or the supporting documentation. The data presented in the Barr (2014b) report includes the existence of an artesian well that produces 10-12 gpm. Artesian wells are not typically associated with an unconfined surficial aquifer, especially with a discharge of 10-12 gpm, but are usually associated with a confined aquifer overlain by clay or a tight rock formation. Other than appearing in the data included in the Barr (2014b) report, no explanation is provided. The lack of consistency within the analysis yields inconsistent conclusions.

The FEIS analysis of the tailings pile is questionable for the reasons listed above and for the many inconsistencies within the analysis. The supporting data contained in PolyMet technical reports and not in the FEIS are subjected to arbitrary interpretations prior to use in modeling. The representativeness of PolyMet's modeling results with the actual performance of the tailings basin is open to argument. Absent from the analysis is the long-term performance of the tailings pile. While the conclusions of the FEIS are not supported, the conclusions confirm that the tailings pile likely will remain an environmental concern for the indefinite future. This is disconcerting for the groundwater and surface water resources of the St Louis River watershed.

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Senior Research Scientist, Energy Division (2000 – 2001), Environmental Sciences Division (2001 – 2008). Research in waste management and safety analysis, preparation of Environmental Impact Statements for energy related projects.

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Program Manager, Waste Management and Safety Analysis Program, Center for Energy and Environmental Analysis, Energy Division. Manager of Division work in radioactive, hazardous, industrial, and mixed waste management and safety analysis. Major activities include performance assessment and safety analysis reports for DOE sites.

1989 – 1997 OAK RIDGE NATIONAL LABORATORY

Research and Development Group Leader, Applied Physical Sciences Group, Environmental Analysis and Assessment Section, Energy Division. Manager of Section work in radioactive waste management and safety analysis. Focus of research was on geologic and hydrologic analysis. Preparation of performance assessments fpr DOE low-level radioactive waste disposal facilities. Conduct of site-specific analyses for waste management, Safety Analysis Reports, Environmental Restoration, and Environmental Impact Statements. Manager of a staff of 7 with a budget of $2 million.

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Research Staff, Energy Division. Preparation of technical analyses of water resource issues in radioactive waste management, in-situ uranium mining, uranium milling, synfuels technologies, and hydropower. Development of waste management strategies for Lockheed Martin facilities, performance of site characterization studies of low-level radioactive waste disposal sites. Preparation of Environmental Impact Statements and Environmental Assessments for energy related projects.

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Research Associate, Energy Division. Preparation of Environmental Impact Statements, Environmental Assessments, and environmental analyses of nuclear, coal, geothermal, and conservation technologies. Conduct research investigations in environmental monitoring, surface water hydrology, and groundwater hydrology using theoretical, numerical, and field methods.

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Research/Teaching Assistant. Performance of laboratory research in the field of tire mechanics, Instructor for rigid body dynamics, statics, strength of materials, and advanced numerical analysis.

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Teaching Assistant for Mechanical Engineering Laboratory.

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Product Design Engineer, Engine and Foundry Division, Research and Development Center.

Education

1977 Ph. D., Applied Mechanics, University of Michigan, Ann Arbor, Michigan.
1973 M. S., Engineering Science, Clarkson College of Technology, Potsdam, New York.
1969 B. S., Mechanical Engineering, Clarkson College of Technology, Potsdam, New York.

Professional/Academic Honors

Pi Tau Sigma, Mechanical Engineering Honor Fraternity, 1969
Registered Professional Engineer,
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Significant Event Award, Martin Marietta Energy Systems, 1991
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Board Certified, American Academy of Environmental Engineers, 1996 – 2007
In Appreciation, American Society of Civil Engineers, Environmental Engineering Division, 1992
In Appreciation, American Society of Civil Engineers, Environmental Engineering Division, 1999
Certificate of Appreciation, Defense Logistics Agency, Department of Defense, 2005
Who's Who in Science and Engineering, 2007
Who's Who in America, 2007
Who's Who in the World, 2007
Retirement Certificate, Oak Ridge National Laboratory, 2008

Professional Activities

Reviewer, American Society of Civil Engineers, Hydraulics Division (1982 – 1996)
Reviewer, Elsevier Publishing Co. (1987)
Reviewer, Nuclear and Chemical Waste Management (1986 – 1995)
Member, American Society of Civil Engineers
Member, American Society of Mechanical Engineers
Member, Sigma Xi
Member, DOE Waste Classification Working Group, 1987
Member, DOE Task Force on Uranium Waste Problems, 1988
Member, DOE Low-Level Radioactive Waste Technical Resource Group for 40 CFR 193, 1988
Member, DOE Low-Level Radioactive Waste Peer Review Committee for DOE Order 5820.2A, 1988 – 1997
Member, DOE Performance Assessment Technical Resource Group for DOE Order 5820.2B, 1994 – 1995
Member, DOE Federal Facilities Compliance Act Disposal Work Group, 1994 – 1996
Member, DOE Defense Nuclear Facilities Safety Board Recommendation 94-2, Site Assessment Team, 1995
Member, DOE Defense Nuclear Facilities Safety Board Recommendation 94-2, Research and Development Task Team, 1995
Member, DOE Defense Nuclear Facilities Safety Board Recommendation 94-2. Working Group Assessment Team, 1995
Member, DOE Order 435.1 Revision Team, 1996 – 2000
Adjunct Associate Professor, North Carolina State University, Department of Mechanical and Aerospace Engineering, 1987 – 2000

Ph. D. Dissertation Committee Co-Chairman, North Carolina State University, Department of Mechanical and Aerospace Engineering, 1987 – 1993

Secretary, Air and Radiation Management Committee, Environmental Engineering Division, American Society of Civil Engineers, 1989 – 1990

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Secretary, Programs Committee, Environmental Engineering Division, American Society of Civil Engineers, 1992 – 1994

Member, American Society of Civil Engineers Task Committee on Mixed Waste, 1988 – 1993

Vice-Chair, Professional Activities Committee, Environmental Engineering Division, American Society of Civil Engineers, 1994 – 1996

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Secretary, Conference and Exhibits Council, Environmental and Water Resources Institute, American Society of Civil Engineers, 2001 – 2003

Member, Conference and Exhibits Council, Environmental and Water Resources Council, American Society of Civil Engineers, 1999 – 2001, 2003 – 2005

Session Moderator, Radiation Management, National Conference on Environmental Engineering, Reno, Nevada, 1991

Session Moderator and Organizer, Management of Low-Level Radioactive Waste, 1996 ASCE Annual Convention and Exposition, Washington, D.C.

National Abstract Review Committee, 1991 National Conference on Environmental Engineering, American Society of Civil Engineers

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Session Moderator and Organizer, Low-Level Radioactive Waste, American Society of Civil Engineers National Meeting, 1996

National Abstract Review Committee, 1999 National Conference on Environmental Engineering, American Society of Civil Engineers

Technical Organizing Committee, 2000 National Conference on Environmental Engineering, American Society of Civil Engineers

Organizing Committee, International Water Congress 2001, American Society of Civil Engineers

Conference Chairman, 2002 Joint CSCE/ASCE International Conference on Environmental Engineering, Niagara Falls, Ontario

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Publications

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