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Comment on the NorthMet Supplemental Draft Environmental Impact Statement

I recently read much of the November 2013 Supplemental Draft Environmental Impact Statement (SDEIS) entitled "NorthMet Mining Project and Land Exchange", as well as several of the reports referenced in the document. The purpose of this commentary is to offer some suggestions that can be considered for improving the conceptual model of hydrogeologic conditions at the proposed Mine Site and Plant Site/Tailings Basin area. Improving the quality of the conceptual model will lead to improved prediction of potential impacts to groundwater, engineering of containment systems, and design of monitoring systems.

Broadly summarized, my comments focus on improving the understanding of flow through fractured bedrock. The current conceptual models in the SDEIS characterize the Duluth Complex and Giants Range Batholith bedrock as bulk masses of rock with low, uniform permeability. Although this type of characterization is sometimes deemed sufficient for some purposes, such as numerical modeling of water budgets (flux) at relatively large scales, it has well known deficiencies when applied to numerical modelling of smaller-scale sites, especially for predicting solute transport. Instead, the development of conceptual models that employ techniques whereby discrete fractures or fracture zones are more fully considered, results in improved prediction of solute transport, including better estimates of travel times, and recognition of variation in flow directions and discrete pathways in three dimensions.

Investigations aimed at characterizing the hydrogeologic conditions of fractured bedrock for the purposes of predicting solute transport in crystalline bedrock elsewhere on the Canadian Shield routinely use a number of well-known techniques that were not applied in the hydrogeologic studies at the NorthMet Mine Site and Plant Site/Tailings Basin area. A key component of those investigations is the acquisition of hydraulic and water chemistry data at relatively discrete intervals of bedrock, with the focus on fracture characterization. In part this is accomplished through testing and water sampling of boreholes constructed with relatively short open hole intervals at variable depths (e.g. "nested" wells) and/or discrete interval packer testing and water sampling of long open holes. When these techniques have been used in generally similar hydrogeologic settings elsewhere on the Canadian Shield, the results support hydrogeologic conceptual models that differ substantially from those proposed for the Duluth Complex and Giants Range Batholith described in the SDEIS. Of particular significance for solute transport, the conceptual models commonly include key fractures or fracture zones of relatively high hydraulic conductivity, and multiple flow systems within the bedrock at individual sites. These flow systems are variably connected to the surface water system, have variable residence times, can have upward and downward vertical gradients within a local area, and horizontal flow directions that differ from one another.

The data collected thus far from the proposed NorthMet Mine Site and Plant Site/Tailings Basin area are not sufficient to recognize the kinds of hydrogeologic features known to be characteristic of other crystalline bedrock settings on the Canadian Shield, described above. Nor are the data sufficient to adequately support the simpler conceptual model currently depicted in the SDEIS. The comments below specifically address where improvements could be made to the conceptual models for the Mine Site and Plant Site/Tailings basin area.

Mine site

The SDEIS indicates that hydrogeologic characterization of the mine site is based largely on single well, short-term recovery tests of 10 deep (349'-1438') exploratory boreholes open entirely or mostly to the Duluth Complex, and multi-well, longer term aquifer tests that include 10 pumping and observation wells. The more rigorous, multi-well aquifer tests are focused on characterization of the Virginia Formation, and specifically on the potential impact of mine dewatering on nearby wetlands. Flow direction within the bedrock is based on a potentiometric map using head levels measured from bedrock holes ranging from about 50 to several hundred feet in depth. Casing is set at shallow depths in all boreholes, and therefore open-hole intervals are several tens (rare) to hundreds (common) of feet in length. Characterization of fractures at the Mine Site is based largely on inferences drawn from geologic context. For example, the SDEIS suggests that high permeability conduits for groundwater over long distances through bedrock are unlikely to apply to the Duluth Complex because its emplacement age postdates tectonic activity sufficient to generate hydrogeologically significant, extensive faults and fractures. It is also suggested that densely fractured uppermost bedrock known to be common in crystalline bedrock elsewhere in the world has been removed by glacial scouring at the Mine Site. Ultimately the conceptual model for the Duluth Complex proposed in the SDEIS is that of a “highly competent” bulk rock mass with a uniformly very low hydraulic conductivity. Numerical models based on this characterization lead to solute transport travel times exceeding one thousand years (e.g. summaries on pages 4-45 and 5-33 of SDEIS).

The SDEIS conceptual model for the Mine Site could be much better supported. First, inferences about the likelihood of extensive fractures of hydraulic significance in the Duluth complex are based on the incorrect premise of insufficient post-emplacement tectonic activity to generate such features in the region. Faults of potential hydraulic significance are common in the Duluth Complex, including near the Mine Site ((Minnesota Geological Survey (MGS) S-21 and/or MGS M-119)), and the tectonic history, as well as glacial and erosional history of the region, includes activity capable of generating extensive fracture systems that post-date emplacement of the complex. Second, the manner in which data were collected at the Mine Site, especially the use of long open hole intervals for hydraulic testing and water sampling, is insufficient to test the hypothesis that extensive high transmissivity fractures or fractured zones are absent. Discrete fractures and fractured zones commonly go unrecognized when hydrogeologic measures such as water chemistry, hydraulic conductivity, and heads are averaged across several tens to hundreds(most boreholes at the site) of feet of bedrock. Scale effect is also a factor. Boreholes are less likely to intercept hydraulically active fractures than the proposed pit walls. This also should be discussed as part of the SDEIS.

Information from outside of the Mine Site area appears to be inconsistent with the SDEIS suggestion that densely fractured uppermost bedrock has been removed by glacial scouring in the area. A site-specific example is a well-known contamination site in a younger Midcontinent Rift intrusive complex near Finland Minnesota where abundant fractures in the uppermost 100 feet of bedrock serve as fast-flow groundwater conduits (e.g. Harza Engineering Company, 1999). Furthermore, specific capacity data from Duluth Complex water wells ((County Well Index (CWI)) in northeastern Minnesota also are suggestive of enhanced fracturing in uppermost bedrock. Specific capacity tests of 366 wells in the Duluth Complex indicate hydraulic conductivities for wells open only to the upper 100 feet of bedrock are about two orders of magnitude greater than for wells open to greater depths beneath the bedrock surface. The shallower wells have average and median hydraulic conductivity values calculated from specific capacity data that are 3-4 orders of magnitude greater than the bulk conductivity value used in the modelling of the Duluth Complex at the Mine Site as described in the SDEIS.

Improved understanding of the hydrogeologic system in the Duluth Complex at the Mine site could be achieved by the acquisition of hydraulic and water chemistry data at much more discrete intervals. This would include testing and sampling of boreholes with shorter open hole intervals at variable depths (e.g. “nested” wells) and/or discrete interval packer testing and water sampling of long open holes. These techniques, along with information that can be acquired from a number of borehole geophysical tools, have been routinely applied in similar crystalline rock settings to characterize the hydrogeology of fracture systems. The hydraulic and water chemistry information from these discrete intervals in a number of boreholes would ultimately lead to an improved conceptual model for the prediction of solute transport.

Plant Site and Tailings Basin area

No subsurface hydrogeologic information was collected from the Giants Range Batholith, which underlies the Plant Site/Tailings Basin area. Instead, the hydrogeologic characterization of the Giants Range Batholith relies on a number of general observations and inferences based on geologic context. For example, the SDEIS draws on an analogy with the Mine Site, suggesting that the Giants Range Batholith is mechanically similar to the Duluth Complex, and assuming that the two units have similar stress, weathering and erosional histories, they are therefore likely to have similar hydrogeologic characteristics (SDEIS page 4-95). The conceptual model for the Giants Range Batholith is that of a single rock mass with uniformly low permeability. It is treated as a no-flow boundary.

The SDEIS would be considerably improved by providing stronger support for the conceptual model of the Giants Range Batholith described above. The use of the Duluth Complex as a hydrogeologic analogue is difficult to support. The Giants Range Batholith is Archean in age, more than 1.5 billion years older than the Duluth Complex, and therefore the assumption that the two units have similar stress, weathering, and erosional histories is not valid. As stated on page 4-45 of the SDEIS, shear zones and other hydraulically significant discontinuities are known to be common in Archean rocks of the Canadian Shield. In Minnesota, faults are known to be common across much of mapped extent of the Giants Range Batholith, including in the Plant Site/Tailings Basin area (MGS S-21 and/or MGS M-119). Hydraulically significant fractures in the Giants Range Batholith are documented to have transported contaminants at the Northwoods Closed Landfill (MPCA reports) several miles north of the Plant Site/Tailings Basin area. Furthermore, specific capacity tests of 103 water wells (CWI) in the Giants Range Batholith are indicative of the presence of enhanced fracturing in uppermost bedrock: The hydraulic conductivities calculated from specific capacity data of wells open only to the upper 100 feet of bedrock are about three orders of magnitude greater (average and median values) than for wells open to greater depths beneath the bedrock surface. The values for the shallower wells have average and median hydraulic conductivity values 3-4 orders of magnitude greater than the bulk conductivity value used for modelling of the Giants Range Batholith at the Plant Site/Tailings Basin area as described in the SDEIS.

As with the Mine Site, improved understanding of the hydrogeologic system in the Giants Range Batholith at the Plant Site/Tailings Basin area could be achieved by the acquisition of hydraulic and water chemistry data at much more discrete intervals. Hydraulic and water chemistry data from discrete intervals in shallow (<50 feet) bedrock conditions would be particularly useful to test the inference of a no-flow boundary. Bedrock groundwater chemistry could be particularly useful at this site, because constituents derived from past activities at the existing Tailings Basin may serve as a tracer to better understand solute transport through the bedrock. Such constituents have already been recognized in groundwater sampled from unconsolidated sediment in the area (SDEIS page 4-114).

SUMMARY

The SDEIS would be considerably improved with the development of conceptual models based on data derived from a number of well-established techniques that provide greater insight into fractured bedrock conditions. Improved conceptual models will lead to better prediction of solute transport, including estimates of travel times, and recognition of variable flow directions and discrete pathways in three dimensions.

Sincerely,

X

Anthony C. Runkel
Chief Geologist
Signed by: Anthony C. Runkel