0. EXECUTIVE SUMMARY

Environmental review of proposed mining operations in Duluth Complex rock requires evaluation of potential impacts of tailings on water quality. Sulfide minerals present in such mine tailings can react with oxygen and water to release acid and heavy metals. This reaction is affected by the water content of the tailings and the depth within the tailings. Laboratory dissolution tests are typically conducted by mining companies to aid in predicting the water quality resulting from tailings dissolution. The effectiveness of predictions based on such tests is dependent on their design and the extrapolation of the laboratory results to field conditions. Both of these aspects require an understanding of reactions occurring in tailings basins and the variables that affect these reactions. The present study contributes to this understanding and provides an extensive dissolution test data set for comparison with, and to inform interpretation of, test results submitted for environmental review.

In the present project laboratory dissolution tests were conducted on tailings produced by pilot-plant processing of Duluth Complex rock from the Babbitt prospect (also known as AMAX or Mesaba prospect) of the Partridge River Intrusion. Reaction of these tailings affects water quality, and the effects of 1) tailings water content and 2) bed depth on reactions were examined. Of particular interest were reactions affecting pH and release of copper, nickel, cobalt, and zinc. The present report addresses the characterization of tailings (bulk density, particle size distribution, chemistry, mineralogy, static tests) and 10 years of laboratory dissolution testing. Dissolution tests were conducted on 75-g samples in unsaturated (uncovered) and saturated (covered) reactors (both in triplicate) and in duplicate 1000-g humidity cells.

Key dissolution tests results are as follows.

1. All test produced circumneutral drainage pH, with the minimum of all values near 6.4.
2. During the first three years of testing, sulfide oxidation in saturated (non-evaporating) reactors was more rapid than that in unsaturated (evaporating) reactors, apparently due to the greater water retention.
3. The aforementioned accelerated oxidation yielded slightly lower drainage pH values in the saturated reactors.
4. The slightly lower pH values resulted in nickel concentrations in saturated reactor drainage that were roughly 25 times those in drainage from the unsaturated reactors.
5. Sulfide mineral oxidation rates (normalized for tailings mass) for the humidity cells were limited by oxygen diffusion, resulting in drainage pH values higher and trace metal concentrations lower than those for the smaller reactors.

Thus, although similar Partridge River intrusion tailings are unlikely to produce acidic drainage, nickel release will increase with pH decreasing into the sixes. Results further indicated that such decreases are more likely in areas of the basin in which tailings are saturated (but not submerged). The data generated also provide a basis for evaluating the variation of oxidation reactions with tailings depth and 10 years of drainage quality data for comparison with, and to aid interpretation of, future results.