EXECUTIVE SUMMARY

The Minnesota Department of Natural Resources (MN DNR) has been performing environmental research to assess the reactivity of sulfide bearing rock for decades. One of the longest running experiments is the Duluth Complex Leach Pile (DCLP) located at the MN DNR Hibbing field research site. The DCLP is a composite of three sulfide bearing Duluth Complex rock piles originally constructed under a 1978 cooperative research agreement between the MN DNR and Amax Environmental Services Inc. Upon termination of the cooperative research program in 1994, rock from three of the piles was moved to Hibbing to continue the experimental work. At the Hibbing field research site, the rock was placed on a double lined leachate collection system and has been monitored since 1996. The continuation of this rock weathering experiment has documented a 38 year record of a changing rock leachate composition.

The DCLP leachate composition and flow volume data was used to calculate annual sulfate release rates from 1978 to 2015. These release rates are incorporated into an empirical model that numerically describes the rate of sulfur removal from the rock pile over time. This empirical model shows that over the 38 year period of record, the rate of sulfur release has decreased by about a factor of six, and approximately 1,000 kg of sulfur has been removed from the 812 tonne rock pile.

A theoretical model was developed using a shrinking particle model that incorporated rock characterization data (e.g., sulfur concentration, particle size distribution, and sulfide surface area exposed) and an experimentally derived sulfide oxidation rate law. The sensitivity of the theoretical model to the changing mass fractions of different rock particle sizes was investigated. The sensitivity analysis found that the theoretical model is very sensitive to the mass of particles less than about 0.149 mm highlighting that a well-defined particle size distribution is paramount for accurate theoretical predictions.

The theoretical model results are within a factor of two of the empirical modeling results demonstrating theoretical prediction can be a relatively accurate approach when the chemical and physical parameters of the waste rock are well defined. The relatively close agreement between the empirical and theoretical sulfur removal models demonstrates that theoretical approaches for predicting the rate of sulfur removal from a waste rock can be of value for developing mine waste management strategies.