Chapter I

Introduction

Ever since coal was first mined in the United States near Richmond, Virginia, there has been acidic mine drainage (AMD) (Skousen and Ziemkiewicz, 1995). Often referred to as "yellow boy" because of its coloration from iron oxides, this acidic, metaliferous discharge has been responsible for the destruction or impairment of over 20,000 km of streams and 72,000 hectares of surface waters in the United States (Herlithy et al., 1989; Kleinmann, 1989). Not until the passage of the Surface Mining and Control Reclamation Act in 1997 was a concerted effort exerted to control the formation and discharge of AMD by coal mining operators. Initially, AMD was treated using chemical means entirely. This method proved to be very effective in raising the pH and precipitating dissolved metals out of solution. However, the complexities of constructing and running a treatment system along with the high costs involved invited experimentation with alternative treatment methods. One of these alternatives was a group of systems called *passive treatment* systems. These systems grew out of a model for AMD treatment that was based on the capacity of natural wetlands to mitigate the impacts of AMD. The term *passive treatment* was used because rather than actively adding chemicals to treat AMD, these systems rely on natural biogeochemical processes to achieve improved water quality. These systems typically resemble natural wetlands in appearance but are modified in various ways to achieve the desired treatment results. The Successive Alkalinity-Producing System (SAPS) is one of the latest of the passive treatment system designs and the focus of this research

The SAPS system was developed in the late 1980s in response to some of the shortcomings of existing designs (Hendricks, 1991; Kepler and McCleary, 1994). It was designed to neutralize acidity and raise the pH of the AMD in order to promote the conditions necessary for the oxidation and precipitation of the dissolved metals. This was achieved by constructing an artificial wetland with a bed of limestone located beneath an organic substrate. The dissolution of the limestone generates bicarbonate alkalinity which is able to neutralize the acidity present in the water. A drainage network located below the limestone ensures that the entire volume of water passes through this layer. SAPS systems also benefit from the colonization of sulfate reducing bacteria. These bacteria thrive in the reduced zones of the organic layer and, as a byproduct of their biological activity, aid in AMD treatment by generating additional quantities of bicarbonate alkalinity.

Many of these systems have been installed throughout Appalachia and, in most cases, have proven to be an effective method of AMD treatment. Unfortunately, while the fundamental principles that governed the function of these systems were well understood, the ability to size the SAPS according to a given AMD discharge was not. This resulted in the inappropriate design and substandard performance of certain systems. This Thesis describes research designed to improve the understanding of the function of the SAPS systems and provide guidelines for the design of future systems.

The justification and background for conducting this research is presented in Chapter 2 with a review of the relevant literature. The research itself is divided into two major components. The first component involves the development of a model for predicting the alkalinity generation capacity of the SAPS systems. This model is based on several years of field observations from eight systems in Virginia and West Virginia. The results of this work are presented in Chapter 3. The second component examines the changes in water chemistry as the AMD flows through the organic and limestone layers of the SAPS. This was performed through a study of laboratory columns that replicated the design of SAPS in the field. These columns were run continuously for one year and the results are presented in Chapter 4. Chapter 5 draws from the conclusions that were made in both areas of research and suggests a new model for designing SAPS based on influent AMD characteristics. Finally, Chapter 6 summarizes the results of the research and highlights the significant conclusions.