GROUND WATER RECOVERY PROBLEMS ASSOCIATED WITH OPEN PIT RECLAMATION IN THE WESTERN U.S.A.

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INTRODUCTION

Coal consumption and production increased in the United States in 1985. While the coal production in traditional coal-producing states in the Appalachian region (Pennsylvania, Ohio and West Virginia) is decreasing, the coal production in the western region increased in 1985 by 3.4%. The largest open pit mine coal production in the western U.S. are concentrated in Wyoming, Montana, North Dakota, Colorado and New Mexico. Wyoming produced 125 Mt of coal in 1985.

The rank of coal mined by open pits in the western U.S. ranges from lignite to high volatile A. bituminous. The heat value ranges from 7,500 to 12,000 BTU per pound, and the ash and sulfur contents are typically low. Most of the coal is mined by dragline and truck and shovel methods. Production rates reached up to 11 Mt per year in some of the Wyoming mines.

Coal mining in the western U.S. is controlled by strict environmental laws. The Surface Mining Control and Reclamation Act of 1977 established procedures for obtaining a "permit to mine" and for developing plans for reclamation after completion of mining. A federal agency, "Office of Surface Mining" was established to regulate the open pit mining in the U.S. In addition, each state has its own department responsible for regulating mining within the particular state. Federal and State regulations require an analysis of the environmental impacts of mining. Of particular concern in the semi-arid region of the western U.S. is the impact of open pit mining of surface and ground water resources. A detailed evaluation of the pre-mining hydrologic characteristics and the potential effects of mining on the hydrologic balance in the area affected by mining are important components of the studies for each proposed mine site.

HYDROGEOLOGY OF THE COAL MINING DISTRICTS

Most of the coal bearing strata in the western U.S. were deposited during either the Cretaceous Period or the Tertiary Period. Cretaceous and Tertiary coal-bearing formations
contain numerous coal seams separated from one another by strata of claystone, siltstone, shale or sandstone. The sandstone and coal strata are typically water-bearing. In many areas of the western U.S. the coal seams are significant aquifers supplying water for domestic and stock purposes. The coal strata are situated predominantly in synclinal basins and, therefore, aquifers are unconfined near the outcrops and confined in the deeper areas of the basins. Permeabilities of both sandstone and coal aquifers are relatively low. Both materials have average hydraulic conductivities of approximately $2 \times 10^{-4}$ cm/sec and storage values on the order of $5 \times 10^{-6}$. These values were obtained by detailed studies of 12 mining districts in Montana, Wyoming and North Dakota (Rehm, et. al, 1980). The sandstone and coal strata are typically recharged at outcrops by the direct infiltration of precipitation and snowmelt and by the infiltration of water from surface streams and reservoirs. Flow patterns are controlled by geologic gradients and structures. Waters from sandstone and coal aquifers in the western U.S. contain a wide range of concentrations of most constituents. The concentration of total dissolved solids typically ranges from 500 to 5,000 mg/l. In most waters sodium is the principal cation and bicarbonate is the principal anion. However, large amounts of calcium, magnesium and sulfate are found in most aquifers.

In the western U.S. where the coal sulfur content is typically low (<0.7%) the acid mine drainage problem is not as pronounced as in the Appalachian region where about 6,000 tons of sulfuric acid are being produced daily through oxidation of pyrite (Ahmad, 1974).

MINING IMPACTS AND REGULATIONS

Open pit mining of coal disturbs the pre-mining physical characteristics of the land on which it occurs. Materials removed from overburden and interburden of mined coal seams are replaced after the mining operation. The original aquifers in sandstone and coal strata are disturbed and replaced by mine spoils. Physical and chemical characteristics of the mine spoils are different from the pre-mining aquifer properties. Hydraulic parameters of mine spoils, permeability and porosity, in particular, are different from the original aquifers. Chemical equilibrium in the pre-mining hydrologic system is disturbed by disposing new chemical constituents available for dissolution in the mine spoils.

Prediction of post-mining surface and ground water conditions is a part of planning for any surface mining operation in the U.S. The determination of the probable hydrologic consequences of proposed open pit mining and reclamation operations is required by law and is part of the application for a permit to mine. The components of the mine