6

Evaluation and Control of Ground-Water Quality in the Rocky Mountain Area

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INTRODUCTION

In these days of increasing environmental and regulatory control, the evaluation of natural and affected ground-water quality and the control of the generation, movement, and discharge of pollutants is assuming ever-increasing importance in the development and operation of mineral resource recovery projects. Such evaluation and control is especially critical in areas of diverse geology and mineralization such as the Rocky Mountain mining districts. In the following discussion, specific techniques of ground-water quality evaluation are described, with examples of results of previous evaluations, and a broad outline of ground-water quality control measures is presented.

GROUND WATER QUALITY EVALUATION

The purposes of ground-water quality evaluations are as varied as the geologic conditions. Unfortunately, some evaluations are conducted merely to comply with regulatory requirements, and are not designed to meet actual operational needs. It is true that many regulatory requirements are imposed by existing regulations such as the New Mexico Environmental Improvement Division ground water protection regulations. Additional stringent requirements will be imposed by the Environmental Protection Agency's regulations, including those recently proposed under the authority of the Resource Conservation and Recovery Act for solid waste disposal sites (Federal Register, February 6, 1978) and for hazardous waste disposal sites (Federal Register, December 18, 1978), and under the Underground Injection Control Program of the Safe Drinking Water Act (Federal Register, April 20, 1979) which defines sand backfill operations as underground injection of waste.

There is a need to recognize and document naturally-occurring ground water pollution in areas of mineralization, to forestall imposition of requirements for remedial measures to improve on nature. Such evaluations to document natural conditions should be conducted under custody procedures to assure the admittance of the data into possible future hearings or litigation.

Finally, there is a growing recognition that proper ground-water quality evaluations can be a valuable operational tool, especially in mining techniques such as in-situ and heap leaching.

Since there is a clear, demonstrable, and expanding need for ground-water quality evaluation programs, it is important to factor the program into overall project development plans. Many times, significant time and cost savings could be realized by combining environmental drilling requirements with ongoing exploration drilling requirements. All too often, exploration drilling is completed, followed by separate drilling for environmental assessment. The solution is to involve the environmental personnel early in the exploration program. Much valuable environmental data can be collected at little additional cost during the deposit delineation phase, and exploratory holes converted to use as monitoring facilities.

Additional costs savings can be achieved by most efficient spatial layout of the monitoring network. The Scientific Method should be applied to the extent of the development of a hypothesis of effects to be monitored, followed by the development of a monitoring program designed to most efficiently monitor such effects. For example, a waste storage pond would be expected to impose a mound of contaminated ground water on the regional ground-water body, with waste movement radially out from the pond and most rapid movement in the down-gradient direction. Three or four radial lines of monitor wells would provide much more information on the effect of the source on the ground-water resource than the normal system of a single concentric ring of wells. In an evaluation of waste movement from an Idaho tailings pond, the radial movement concept was merged with a need to document the effect of discrete subsurface gravel channels, by varying the distance from the pond to the observation wells in a "picket fence" of wells around the pond. The density of monitor wells was varied in accord with observed ground-water discharge (Rouse, March 1977).

There is an increasing appreciation of the three-dimensional nature of ground-water flow. Study of a ground-water flow net will demonstrate that significant differences in head can occur, even in isotrophic media, in the recharge and discharge portions of a ground-water flow regime. Often, mines serve as ground-water discharge points, while tailings ponds, often located in discharge points, serve as local sources of ground-water recharge. Therefore a ground-water monitoring program should provide data on the three-dimensional ground-water pressure and quality gradients. This can be achieved by multiple completion wells such as described by Pickens, et.al. (September-October 1978) or by nested ground-water monitoring wells. An evaluation of local conditions will be required to establish the most cost-effective method. Drilling techniques should be selected to minimize contamination and provide the most representative data.

Once the ground-water evaluation network is designed and installed, care must be exercised to assure that the samples are collected, preserved, and analyzed to provide data representative of the formation fluid and documenting the parameters of concern. Analytical costs for ground-water monitoring can be rather substantial, frequently in the range of $200 to $500 per sample. It is not economically justifiable to cut corners in the collection of the sample. This is especially true in view of the fines and possible jail sentences which can be imposed for the presentation of false data to the regulatory agencies.

All too often, ground-water samples are collected by lowering a bailer into the standing water in an observation well. When considered in view of variables such as sulfate reduction, sulfide oxidation, denitrification, surface inflow, bacterial contamination, casing reaction, and the velocity of ground-water movement, it is obvious that a bailer sample represents little but the bottle of water sent to the analytical laboratory.

The next refinement is to pump or bail some finite quantity of water before collection of the sample. The normal rule of thumb is to pump a ground-water monitor well to produce a volume of water equivalent to two or three times the bore volume; however, like all rules of thumb, this is only a first approximation. Work by Envirologics in southeastern Utah and work by Gallagher in the South Texas in-situ leach operations indicates that a much better way is to pump the monitor well until a constant value of pH and conductivity is attained. A sample of the water at this time should represent formation fluid. One well in southeast Utah that required pumpage of approximately 17,000 gallons of water before yielding a constant value of pH and conductivity.

Equipment required for adequate ground-water sample collection varies with site conditions. At the northern Idaho site previously described, ground-water was within potential suction lift of the surface, so samples were withdrawn by use of a gasoline powered centrifugal pump, by inserting a plastic intake line in the wells. Portable equipment developed for blast hole dewatering can be used for pumping of samples out of monitoring wells. The EPA research laboratory in Ada, Oklahoma has developed a design for a truck or trailer-mounted rig that includes a generator, a powered hose reel, and a submersible pump on the lower end of the hose reel, Envirologics has recently purchased such a unit for sample collection and the conduct of pump tests, and are pleased with the design concept.

Once the sample is withdrawn from the well, the problems are only beginning. As stated, the analytical support can be quite expensive. Poor sample collection and preservation renders the results even less than useless because it can give a false sense of security or a false sense of a problem that isn't there. The sampling is for trace quantities of material; for example in uranium mining, one of the parameters of greatest concern is radium-226 which is recorded in pCi/l, a unit representing 1×10^{-12} grams per liter of radium, or almost down to individual atoms of radium. Therefore sample contamination can be critical.

Most monitor wells are not developed as water wells, with the result that the produced water contains suspended sediment. Acidification of such a sample for heavy metals preservation will leach metals and radionuclides out of the solids giving an erroneous reading. Immediate field filtration prior to acidification is required for valid samples. Experience has shown that addition of the unpreserved filtered water to the sample bottle will result in an ion exchange taking place within the bottle wall, resulting in loss of much of the material. It is recommended that the preservative be added to the bottle first, followed by the filtered sample, thereby avoiding some of the ion exchange problem.

Unfortunately development of many resource recovery projects will involve various hearings and, all too often, litigation. For this reason, it is recommended all the sampling be done under custody procedures so that the data will be hearing and/or court admissible. This requires development of a record of the collection, transportation, and analysis of the sample. Envirologics has adopted an EPA custody procedure, so that they would have a hard time objecting to the custody procedure used.

GROUND-WATER QUALITY CONTROL

After a properly designed and operated ground-water evaluation program is active, thought can be applied to use of ground-water quality control measures to prevent quality degradation or to restore the quality of waters.

Ground-water quality control measures can be classified under the broad headings of recharge control, discharge control, and treatment; the latter of which should be avoided whenever possible.

The idea behind recharge control is to prevent the leaching and movement of contaminants by segregation of contaminants and transportation water. This can take the form of construction of an impervious channel for streams crossing subsidence areas or fracture zones, to prevent infiltration leaching soluble minerals from old workings. It can take the form of surface grading and sealing of the upper surface of inactive tailings ponds or waste dumps, to prevent infiltration of precipitation into the dump and subsequent transport of sulfide oxidation products. It frequently takes the form of vegetative transpiration, where growth of vegetation on tailings ponds or waste dumps is used for erosion prevention and also enchances the evapotranspiration of infiltrated water.

During a study of pollution problems in the Grants Mineral Belt of New Mexico (EPA Region VI, September 1975) it was observed that mine water entering the mines through long holes was at concentrations of less than 10 pCi/l, but that, after flowing along the haulage drifts and contacting oxidized ore, the water in the mine sumps was at concentrations of up to 250 pCi/l before discharge. Since it is much easier to treat from 10 pCi/l to 3 pCi/l than from 250 pCi/l to 3 pCi/l, the concept of recharge prevention could be applied by the installation of pipe transport systems to eliminate leaching, or at least by "housekeeping" measures to minimize contact between mine water and ore solids.

Discharge control measures are designed to prevent the movement of contaminated waters into surface or ground water. Such measures can take the form of pond and pit liners. In the case of mine drainage, it can take the form of plugs in mine portals or drifts. This has been widely used in eastern coal mines, but must be used with caution in western hard-rock mines, where excessive water heads could result in danger of seal failures. Discharge control in western mines frequently takes the form of grouting of water-filled fractures. The suggestion has been made that opportunities exist for freezing of inactive workings in certain Rocky Mountain mining districts.

In the case of tailings ponds, discharge control measures may take the form of the provision of an absorption media such as peat or clay, to absorb and hold pollutants contained in seepage through the pond bottom. For example, natural peat deposits left at the bottom of a tailings pond have a substantial capacity to sorb metals and radionuclides from seepage. Similarly, the addition of a clay liner at the bottom of a tailings pond will not only reduce water loss through seepage, but will also improve the quality of the water which does seep, as a result of ion exchange between the clay and the seepage.

In general, treatment systems should be avoided wherever possible, since dependence on treatment can result in a perpetual cost, with significant water quality impacts upon cessation. The only recommended use of treatment is cases such as mill discharge where the water quality problem will cease once the project is completed. In the case of acid mine drainage in the San

Juan Mountains, Ross (September 1973) examined the possibility of producing a salable smelter feed by sequential treatment of acid mine drainage by neutralization and sulfide precipitation.

As shown, ground-water evaluation and control measures need not be expensive. In these days of increasingly stringent environmental controls, the success of a mineral recovery project may well depend on the innovative application of ground-water evaluation and control measures. Failure to apply such innovative approaches may result in the forced application of expensive, inflexible approaches by regulatory agencies.

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