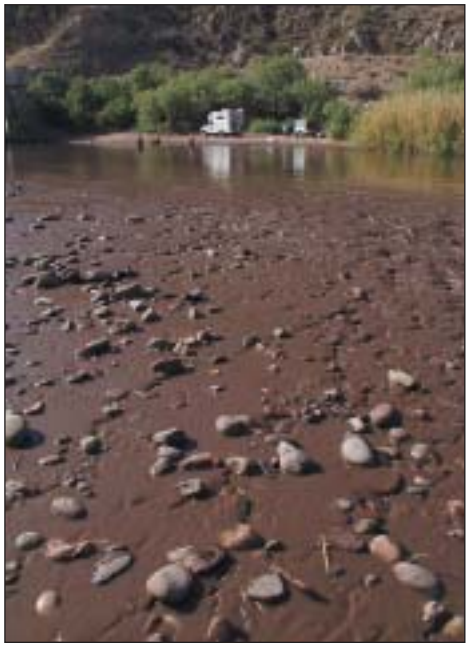
USGS Measures the Response of the Rodeo/Chediski Burn

U.S. Geological Survey

In mid-July, U.S. Geological Survey (USGS) scientists began sampling sediment and organic-rich streamflow coming from the Rodeo/Chediski fire burn area of Arizona's White Mountains to discern possible ecological and water-quality effects of this discharge. In addition, three new USGS streamflow gages are allowing advance warning of possible flooding to affected Arizona communities.

Monsoon thunderstorms that began in early July in the Rodeo/Chediski fire burn area have produced large peak streamflows in response to relatively small amounts of rainfall. The sediment-laden water running off the burn area contains organic debris, dissolved nutrients, and other chemical compounds released by the fire's combustion, said Mark Anderson, chief of hydrologic investigations and research for the U.S. Geological Survey in Tucson.



The Salt River above Roosevelt Lake is laden with sediment and debris after the first monsoon rains from the Rodeo/Chediski burn area. USGS staff (in background) collected samples of the river for chemical analysis to better understand the effects of fire on the water quality of the river. Photograph by N. Duet, USGS, July 19, 2002.

USGS hydrologic technicians install the gage house that will hold equipment for monitoring the streamflow of Carrizo Creek in the Rodeo/Chediski burn area. Photograph by C. Smith, USGS, June 30, 2002.

This sediment and organic-rich water from the burn area significantly increased the flow of the Salt River, the major tributary of Roosevelt Lake. USGS scientists began collecting water samples of these first inputs to the lake, a primary water supply for the Phoenix metropolitan area, on July 17. The water samples collected by USGS scientists from the Salt River upstream from Roosevelt Lake will be analyzed to determine the types and amounts of dissolved nutrients, salts, metals, and organic carbon as well as suspended sediment flowing into the lake.

"Results from these samples will aid land and water managers in determining the amounts of nutrients and organic matter flowing into Roosevelt Lake that could affect drinking-water quality, aquatic habitat, and the ecology of the lake," Anderson said. "If amounts are too high, low oxygen levels, fish kills, and drinking-water taste and odor problems may develop later this summer."

Three new streamflow gages installed by the USGS in the burn area immediately after the fire provided the advance warning that these monsoon flows were on the way. The gages, which were installed in cooperation with the White Mountain Apache Tribe, also provide flood warning for the communities of Carrizo and Cibecue where precautionary evacuations occurred during these storms based in part on the USGS data transmitted in real time from these gages. The USGS in Arizona

operates a network of 220 streamflow-gaging stations that are part of a nationwide network of more than 7,000 gages. This network of gaging stations safeguards lives and property and ensures adequate information is available for managing water resources. Key to that information network is a core of federally funded stations that are a part of a National Streamflow Information Program. Additional streamflow and water-quality monitoring by the USGS in Arizona will provide valuable data for understanding the hydrologic impacts of wildfires in Southwestern watersheds.

"Thanks to these new, real-time gages, we were able to predict the arrival time of this first fire runoff into Roosevelt Lake and have scientists on the scene ready to measure and collect samples of this scientifically important first flush of water after the fires," Anderson said.

Field measurements taken by the USGS after the flood wave passed the sampling site on the Salt River above Roosevelt Lake revealed that dissolved oxygen concentrations had dropped dramatically from a typical six milligrams per liter to as little as one milligram per liter. "For comparison," said Anderson, "three to five milligrams per liter of oxygen is required to sustain fish over a long period." "But," he noted, "USGS data show that it's not all bad news for the Salt River – concentrations of dissolved salts in the river decreased as the added storm runoff diluted the normally salty summer streamflow." (See related article on page 7.)

Visit the Arizona District home page at http://az.water.usgs.gov

Melting the Way to Environmental Remediation

The U.S. Department of Energy's Los Alamos National Laboratory has begun the next phase of testing on its Non-Traditional In Situ Vitrification (NTISV) technology. The technology uses electrical energy to convert contaminated soil buried at the site into an inert, environmentally benign glass-like block. This next step of the NTISV project is the hot test-coring phase, which involves sampling a section of an inactive absorption bed that was heated and vitrified in April, 2000. The vitrified mass has now cooled to approximately 100 degrees F. The low-level radionuclides present in the test area are now expected to be immobilized to a non-leachable state within the vitrified mass. The scope of the current field effort is to core and collect samples of the vitrified mass and then analyze their mineralogical and chemical constituents. The samples will be submitted to an off-site contract laboratory for analysis and the data will be used to verify the effectiveness of the NTSIV technology. This demonstration is being conducted in accordance with the Laboratory's Resource Conservation and Recovery Act (RCRA) corrective action program that is regulated by New Mexico Environment Department (NMED) requirements. The Environmental Remediation project prepared and submitted an interim measures plan to the NMED in February 2000; the plan was approved in in April 2000.

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EPA Announces New Method for Analyzing Perchlorate Concentrations in the Field

Under the Measurement and Monitoring Technologies for the 21st Century (21M2) initiative, the U.S. Environmental Agency's (EPA) Technology Innovation Office (TIO) helped fund a project to develop a procedure for analyzing perchlorate in the field. The project, which was implemented by Region 9, has resulted in a field method to measure perchlorate concentrations in groundwater. The method, which uses an ion selective electrode, has a method reporting limit of 15 micrograms per liter (µg/L) and a detection limit of 3 µg/L. The method is subject to some interference from bromide, chloride, and nitrate. Currently, the EPA has not established a maximum contaminant level for perchlorate in drinking water.

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NM Tech Researchers Studying Biodegradation of Contaminants in Aquifers

Excerpted from the Divining Rod, newsletter of the New Mexico Water Resources Research Institute, April 2002

New Mexico Tech biologist Dr. Rebecca Reiss and environmental engineer Peter Guerra are trying to understand how, and to what extent, naturally occurring microbes can remove contaminants from New Mexico groundwater. The contaminants under investigation include ethane, dibromoethane (EDB), and dichloroethane (EDC), which are used in the petroleum industry and are often found in soil and groundwater impacted by leakage from underground storage tanks. The initial objective of the researchers was to characterize the biodegradation of EDB and EDC by monitoring a specific gene associated with the microorganisms that degrade those compounds. However, preliminary results suggested that the process used to detect that gene in DNA extracted from groundwater was unreliable. An alternative approach was developed that involved the production of protein extracts from groundwater samples. The activity of certain proteins was related to chlorine production and in turn to biodegradation rates.

The researchers were able to establish the following principal findings: 1) The protein analysis has the greatest potential for monitoring bioremediation of dihaloethanes. 2) The protein extraction process is relatively fast and easy. 3) The assay for chlorine production can be used to estimate biodegradation rates in groundwater, which can then be incorporated directly into contaminant attenuation models that include non-biotic factors such as evaporation and photochemical oxidation. 4) Microbial culturing is not required.

The direct enzyme assay approach precludes the need for information about the variety of microbes in an aquifer. However, if species diversity information is obtained, a better understanding of the bacterial species responsible for biodegradation will result. The researchers plan to develop standard operating procedures for environmental engineers to monitor biodegradation potential within contaminated aquifers. As they learn more about how the biodegradation takes place, they will be able to develop more efficient bioremediation techniques.

The WRRI report, "Genetic Techniques for the Verification and Monitoring of Dihaloethane Biodegradation in New Mexico Aquifers" will be available online at wrri.nmsu.edu when it is completed.

Evaluating the Vulnerability of the Nation's Water Infrastructure

Roberta Bowen – *Weston Solutions*

As early as 1996, the President's Commission on Critical Infrastructure Protection (PCCIP) identified the vulnerability of the Nation's water infrastructure to potential attacks as a matter of concern. Following the events of September 11, protection of critical infrastructure, including water distribution systems, has become a national priority. As a result, a series of risk assessment methodologies are being used to evaluate threats to key components of the nation's infrastructure. Large, publicly owned water providers (serving populations greater than 100,000 people) are currently performing water vulnerability assessments (WVAs) as well as developing emergency response/operating plans (EOP) and implementing security enhancements to protect the water infrastructure from potential attacks.

In general, a WVA consists of a threat assessment, facility characterization, security effectiveness evaluation, and risk management. The intent of the WVA process is to assess the vulnerability of a community water system to internal and external threats intent on disrupting the ability of the provider to supply potable water. This could include disruption to the supply of drinking water as well as to the supply of water for fire protection or for critical industries or users. Once the threat scenarios are identified, recommendations are made to mitigate each threat. The United States Environmental Protection Agency (EPA) has endorsed the Risk Assessment Methodology for Water (RAM-W^{SM}) developed by Sandia National Laboratories as the preferred method for conducting WVAs. Consultants providing WVAs for water providers must be trained and certified in the use of the RAM-W or in a similar assessment method. Completion dates for the majority of the large provider assessments is December 31, 2002 or six months after receipt of the grant from EPA.

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used. However, pit-lake chemistry was only modeled as a fully mixed concentration based on inflowing groundwater quality. The same transport model was however applied at another mine to model density-coupled transport of liquor solution from stockpiles – another application for groundwater transport models.

New Mexico Copper Mine: For a proposed copper mine in New Mexico, the groundwater flow patterns were complicated by the presence of an adjacent dewatered mine. The existing mine did however permit a useful evaluation of likely hydraulic characteristics of the bedrock to be made, and those characteristics were used in evaluating the proposed mine. Alternate plans for surface water diversions were evaluated for their effects on flow patterns through stockpiles, along drainages, and on pit lake levels over time. Predicted groundwater drawdowns due to evaporation from the pit lake surface were used to assess potential impacts to other water users, and flow rates and travel times from stockpiles adjacent to the lakes were used in geochemical calculations of the evolution of the lake water quality.

Arizona Copper Mine: For a large copper mine in Arizona, the current mine pits are large enough that, when filled with groundwater, evaporation from the lake surfaces will naturally create a groundwater capture zone that will contain all the mine workings and most of the stockpiles. In fact, the predicted evaporation rates from the mine pits are approximately the same as the current mine dewatering rates, so that predicted groundwater flow directions and water levels should, at steady state, be similar to current conditions. Since this mine lies along a natural drainage, the effects of several 50-year and 100-year storm runoffs as well as daily runoffs were crucial to the lake mass balance calculations. Due to the complex geometry of the mine pits, and the fact that during filling, lakes coalesce and overflow forming larger lakes, it was necessary to develop a method to sidestep the constraints of a pit-lake geometry defined by model calculation cells. It was found that the simplest way to do this was to derive equations defining the pit water levels and surface areas as a function of water volume contained. These equations were then used in combination with predicted inflow and evaporation rates, to arrive at a new predicted lake level for subsequent groundwater / surface water calculations. The detail with which the pit geometry was specified was found to significantly affect the predicted lake levels.

Summary

In general, despite the complexities inherent in characterizing groundwater flow adjacent to mines, it was found that the modeling analyses helped to clarify the cause and effect of different water management decisions, and to illustrate the range of predicted flow rate and lake levels, as well as surrounding groundwater levels at different stages in a mine's development. Model audits will demonstrate the reliability of conclusions over time. Uncertainties in the hydraulic characteristics of the fractured rocks continue to pose the main uncertainty in the predicted pit-lake results.

References

Baker, F.G., L.E. Parslow, T.M. Hoefner, and H.F. Pavlik, 1988. Modeling dewatering and rewatering of mine pit lakes using the PITLAKE module for MODFLOW. MODFLOW'98 International Conference, Golden, Colorado, October 1998.

Cheng, X., and M.P. Anderson, 1993. Numerical simulation of groundwater interaction with lakes allowing for fluctuating lake levels. Groundwater, 31, 6, 929-933.

Chung, K-P., and M.P. Anderson, 1998. Simulation of Lake Levels: Comparison Between MODFLOW's Lake Package and the Use of High Conductivity Zones. MODFLOW'98 International Conference, Golden, Colorado, October 1998.

Council, G.W., 1997. Simulating lake-groundwater interaction with MODFLOW. Proceedings of the 1997 Georgia Water Resources Conference, the University of Georgia.

Doherty, J., and S. Bengston, 1988. Use of MODFLOW in simulating the mining of mineral sands from a moving artificial pond. MODFLOW'98 International Conference, Golden, Colorado, October 1998.

Fontaine, R.C., and D.B. Stone, 1998. Simulating pit lake filling using the LAK2 package for MODFLOW. MODFLOW'98 International Conference, Golden, Colorado, October 1998.

Merritt, M.L. and L.F. Konikow, 2000. Documentation of a program to simulate lake-aquifer interaction using the MODFLOW ground-water flow model and the MOC3D solute-transport model. U.S. Geological Survey Water-Resources Investigation Report 00-4167, 146 p.

Moreno, J., P. Sinton, R.D. Bartlett, and A.L. Williamson, 2002. A method for simulating pit lake development and passive containment resulting from complex geometry pit lakes. EPA Hardrock Mining 2002 conference, Westminster, CO, May 2002.

Nair, S.K., and M.M. Wilsnack, 1998. A comparison of two approaches to simulating lake-groundwater interactions with MODFLOW. MODFLOW'98 International Conference, Golden, Colorado, October 1998.

Rembe, M., and D. Wenske, 1998. The lake package - an additional boundary condition for the modular three-dimensional finite-difference ground-water flow model MODFLOW. MODFLOW'98 International Conference, Golden, Colorado, October 1998.