GEOLOGY, HYDROGEOLOGY, AND GROUND-WATER CHEMISTRY OF THE PLANT YATES GYPSUM STACKING AREA, COWETA COUNTY, GEORGIA

J. C. Redwine, R. J. Tinsley, D. V. Patel, and D. Bloomberg

AUTHORS: J. C. Redwine, R. J. Tinsley, and D. V. Patel, Southern Company Services, Inc., P. O. Box 2625, Birmingham AL 35202; D. Bloomberg, Ardaman and Associates, 8008 S. Orange Avenue, P. O. Box 593003, Orlando FL 32859-3003.
REFERENCE: *Proceedings of the 1991 Georgia Water Resources Conference,* held at The University of Georgia, March 19-21, 1991. Kathryn J. Hatcher, Editor, Institute of Natural Resources, The University of Georgia, Athens, GA.

INTRODUCTION

Southern Company Services, Inc., plans to demonstrate an innovative flue gas desulfurization (FGD) or scrubber process at Georgia Power Company's Plant Yates on the Chattahoochee River between Carrollton and Newnan, Georgia, in northern Coweta County. The project is funded by the U.S. Department of Energy (DOE), the Electric Power Research Institute (EPRI), and The Southern Company as part of the DOE Clean Coal Technology projects. This particular FGD process will produce a solid byproduct in the form of gypsum ($CaSO_4 \cdot 2H_2O$) and a gypsum/fly-ash mixture. The byproducts will be stored on site in two gypsum stacks.

Gypsum stack leachates typically contain sulfate, sulfite, and sulfide concentrations at the parts per million level. Other elements commonly found include B, Ba, Ca, Cd, Cr, Cu, Fe, Ni, Pb, Se, Sr, V, and Zn (Rai and others, 1989). These elements, if released, could adversely affect ground-water quality. In order to implement a meaningful ground-water monitoring program, baseline geochemistry of both soil and ground water should be established prior to gypsum stacking.

The objectives of the hydrogeology and related work at the site were to: 1) Permit the gypsum stacking facility according to the requirements in Chapter 319-3-4, Solid Waste Management, Environmental Protection Division, Georgia Department of Natural Resources; 2) Meet the environmental requirements of the funding agencies, including The Southern Company; 3) Design a technically-sound ground-water monitoring program for the site, including optimum locations, depths, and construction details for monitoring wells; 4) Establish baseline geochemistry of soil, rock, and water prior to construction of the gypsum stacks; and 5) Develop a cost-effective methodology for performing hydrogeological and related investigations at Piedmont sites.

The methods and results described in this paper can be used to assess sites and design systems to protect ground-water resources in Georgia, particularly in the Piedmont region. Though surface water has been the water source of choice for residents of the Piedmont to date, ground water represents an underutilized resource and will likely play a larger role in meeting the future needs of Georgia's growing population and industry.

METHODS

A variety of investigations were performed at the Plant Yates site, some of which are still in progress. These included photogeology and lineament studies; review of regional geology and site-specific geologic mapping; drilling and soils testing, both physical and geochemical; shallow seismic refraction; hydraulic conductivity (slug) testing; monitoring well installation; and water sampling and chemical analysis, including analysis for radon. Brief descriptions of these investigations follow. A specially adapted ground-water sampling technique was used for radon analysis.

Photogeology and Lineament Studies

Lineaments, mappable linear features on aerial photography and remotely-sensed imagery, often represent geologic features that enhance permeability (hydraulic conductivity). Such features include stratigraphic contacts, faults, zones of fracture concentration (Lattman and Parizek, 1964), or other features.

Geologists studied side-look airborne radar (SLAR) imagery of the Yates site and black-and-white aerial photographs taken in 1955, 1958, 1965, 1971, 1978 and 1989.

In the immediate gypsum stacking area, two lineaments were mapped from photographs. These were traced on transparent overlays and transferred onto the topographic maps of the area. Since these may indicate zones of increased ground-water movement, one ground-water monitoring well was located along one lineament.

Review of Regional Geology and Site-Specific Geologic Mapping

Plant Yates is located in the Inner Piedmont region of Georgia, immediately southeast of the Brevard Fault Zone, an inactive fault which forms the northern boundary of the Inner Piedmont and Dadeville Complex lithologies (McConnell and Abrams, 1984; Seal and Kish, 1990). The area is underlain by various igneous and metamorphic rocks. A literature survey was performed to determine what regional rock units extended into the area. This work was followed by very detailed (1 inch = 20 feet) geologic mapping of the gypsum stacking area. Large-scale mapping is required because rock types (which affect ground-water chemistry and permeability) and structural features (which affect permeability distributions and flow) vary significantly over short distances in the Piedmont.

Drilling and Soils Testing

Geologists took advantage of planned engineering drilling and testing to collect hydrogeologic data. Drilling augmented site-specific geologic mapping, and two borings were extended into rock. Engineering blow counts were recorded for soil and saprolite. Grain-size (seive) analysis and Atterberg limits tests were performed on select samples. Investigators classified the residual soil and saprolite based on material properties, as well as parent rock type for geochemical purposes.

Shallow Seismic Refraction

Borings provide data from discrete points. Investigators performed shallow seismic refraction profiling to yield continuous coverage and constructed seismic profiles of the site. Seismic profiles were then correlated with hydrogeologic sections and location of the water table.

Hydraulic Conductivity (Slug) Testing

Ardaman and Associates performed in situ rising head and falling head permeability (slug) tests in the gypsum stacking area in five locations using temporary piezometers. Rising head permeability tests involve bailing a piezometer or well of a determined volume and clocking the time taken for the water level to return to equilibrium. Falling head tests involve adding a determined volume of water and clocking the time taken to return to equilibrium. Results from each type of test agreed closely.

Monitoring Well Installation

Monitoring wells were drilled and installed based on the investigations described previously. Wells were located and designed based on the following criteria: 1) outline of the gypsum stacking area; 2) anticipated directions of ground-water flow; and 3) stratigraphy (Figure 1). Wells were screened to intercept zones of anticipated higher flow, e.g., stratigraphic contacts between geologic units, lineaments, and higher permeability zones determined from slug testing. After collection of water-table data, investigators determined direction of ground-water flow and computed flow rate based on the method described in Driscoll (1986).

Water Sampling

Ground-water samples were then collected and analyzed for select metals. Temperature, pH, and specific conductance were measured in the field. Dedicated ground-water sampling bladder pumps were used to collect samples while minimizing the possibility of well contamination. The technique has also proved to be of time-saving value for sample collection efforts. A special sampling technique was developed for radon gas.

CONCLUSIONS

Geologic and related investigations revealed that the Plant Yates gypsum stacking area is underlain by three very different geologic units: Waresville Schist (amphibolite interlayered with chlorite schist); Franklin Gneiss (intrusive granitic gneiss); and sheared Franklin Gneiss. The Waresville Schist and overlying saprolite could yield trace metals to ground water in the area (Table 1). Iron and manganese anomalies occur in one water-supply well at the plant.

TABLE 1. Geochemistry of the Waresville Schist.

Chemical Composition	(Percent)	Trace Metals	(ppm)
SiO_2	48.54	Ba	–
Al_2O_3	14.56	Co	37
TiO_2	1.48	Cr	248
FeO	12.03	Cu	49
MgO	7.02	Li	8.0
CaO	11.11	Ni	77
Na_2O	2.91	Sr	271
K_2O	0.36	V	288
MnO	0.223	Zn	83

(After Stow, Neilson, and Neathery, 1984)

Four hydrogeologic units occur at the Yates site: Soil, saprolite, weathered rock, and intact rock. Definition of the hydrogelogic units and hydrogeologic conceptual model for the site is based on quantitative data such as hydraulic conductivity, grain size analysis, Atterberg limits, blow counts, and seismic velocities (Table 2 and Figure 2).

The subsurface hydrology of the site is typical for that of the Piedmont; in fact, the models described by LeGrand (1967, 1979, and 1987) apply very well. Hydraulic conductivity values, based on both rising head and falling head slug tests, tend to decrease slightly with depth. For example, the weathered rock shows values approximately one order of magnitude lower than the saprolite. The water table occurs approximately 15 to 35 feet beneath the surface in the gypsum stacking area, depending on topography. Ground water flows from topographically high to low areas, as expected. Geologic discontinuities do not appear to perturb flow significantly, though monitoring wells were located on identified stratigraphic contacts and lineaments. Bedrock topography maps correlate with water-table contour maps and are therefore reliable indicators of flow direction. Computed ground-water flow velocity is on the order of 10^{-6} to 10^{-5} cm/sec or approximately 10 to 100 ft/year, based on slug test data and a calculation described by Driscoll (1986).

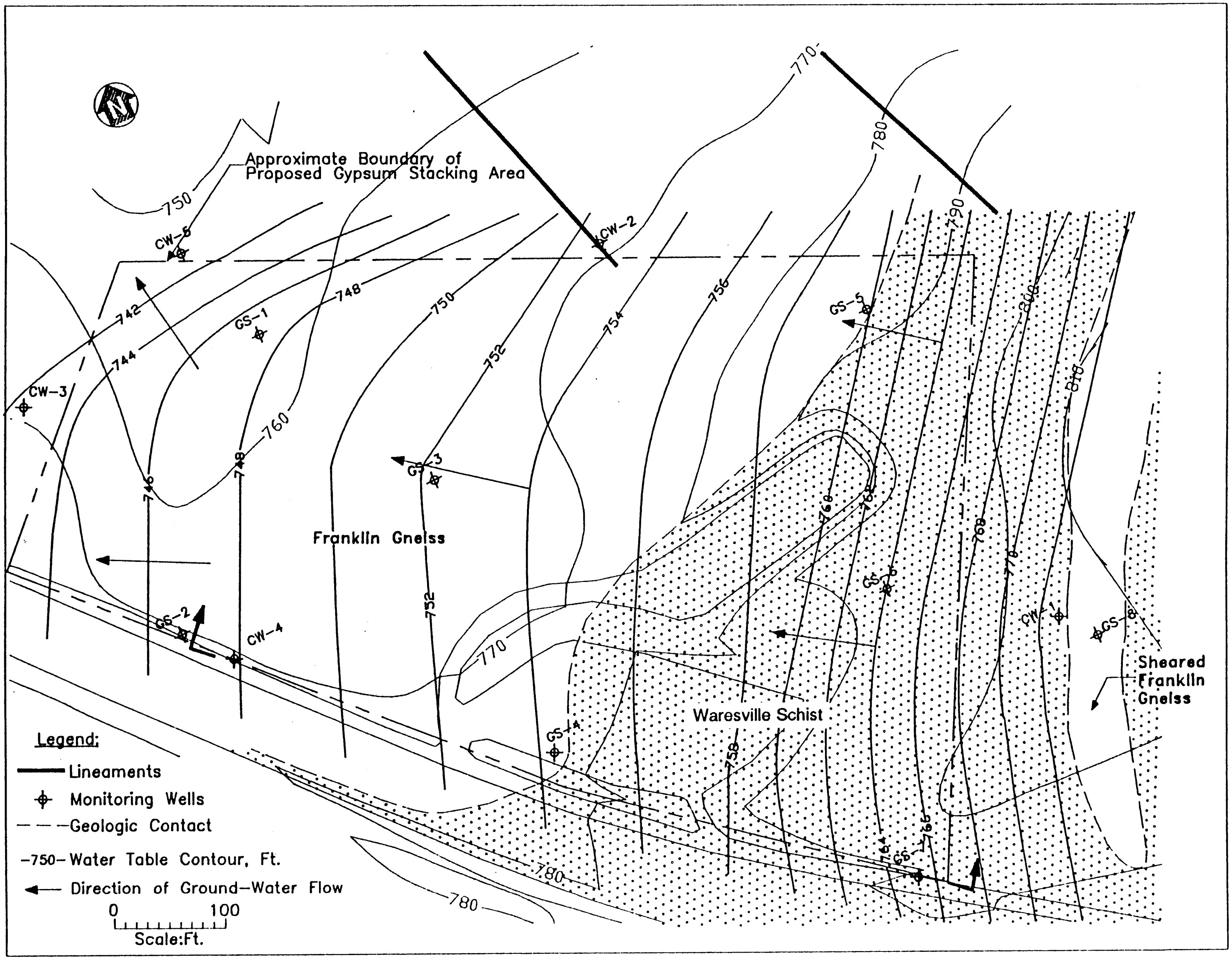

Figure 1. Monitoring Wells with Respect to Site Hydrogeology — Plant Yates Gypsum Stacking Area.

TABLE 2. Correlation of Hydrogeologic Data for the Plant Yates Gypsum Stacking Area.

Hydrogeologic Unit	Approximate Depth, ft	Unified Soils Classification	Blow Counts	Seismic Velocity, ft/sec	Approximate Hydraulic Conductivity, cm/sec
Soil	0 to 4	CL, ML, MH	n = 6 to 38	<2000	Not tested, unsaturated zone
Saprolite	4 to 35	SM, SC, ML	n = 11 to 50	2000 to 5000	1.5×10^{-4} to 8.7×10^{-4}
Weathered Rock	15 to >50	Not Applicable	n > 50	5000 to 8000	3.9×10^{-5} to 8.8×10^{-5}
Intact Rock	>35	Not Applicable	RQD > 50%	>8000	Not tested

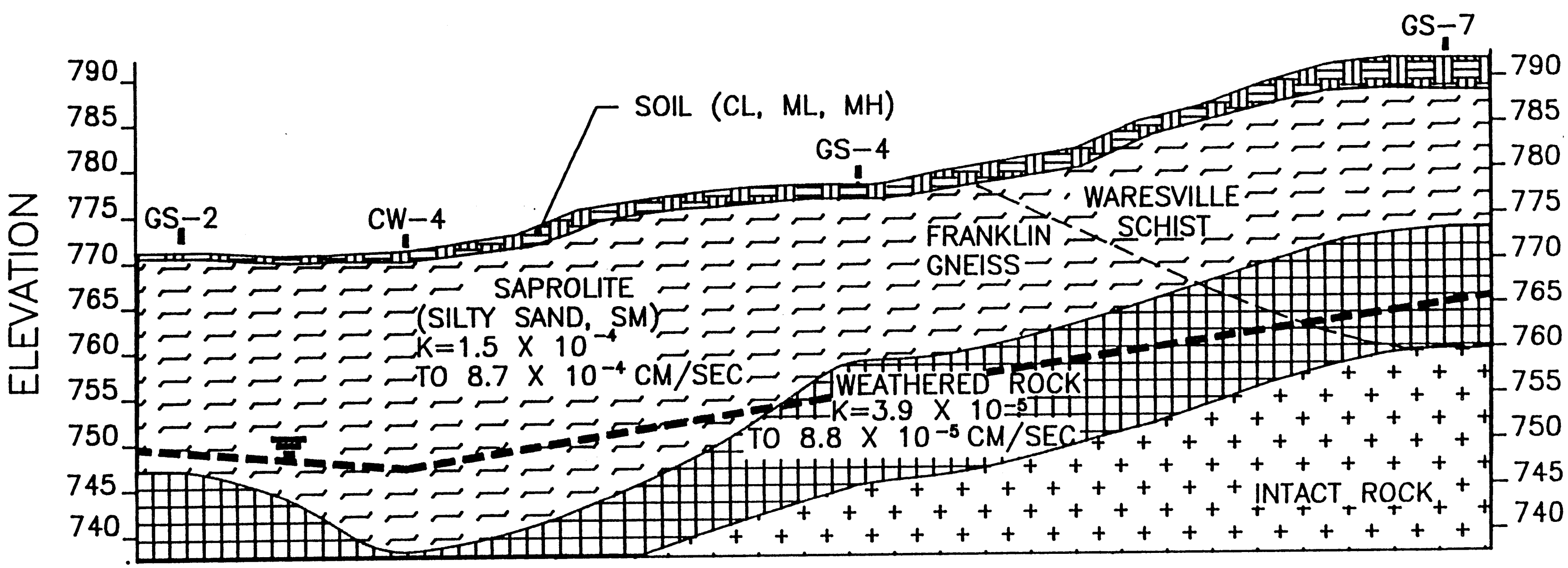

Figure 2. Conceptual Hydrogeologic Model — Plant Yates Gypsum Stacking Area, Section View.

Preliminary water-quality results indicate that ground water in the surficial aquifer at Plant Yates is low in dissolved solids and is appropriate for many applications. This finding implies that minerals now present in the shallow soils and saprolite are relatively insoluble and that much of the soluble material has been removed by weathering.

Radon anomalies, probably associated with the granitic rocks, occur in samples from some of the monitoring wells. Results from the radon-222 analysis in water indicate that the sampling method developed for the Plant Yates project is effective.

LITERATURE CITED

Driscoll, F.G., 1986, Groundwater and Wells, second edition, Johnson Division, St. Paul, Minnesota, pp. 1089.

Lattman, L.G., and Parizek, R.R., 1964, Relationship between fracture traces and the occurrence of ground water in carbonate rocks, Journal of Hydrology, vol. 2, pp. 73-91.

LeGrand, H. E., 1967, Ground water of the Piedmont and Blue Ridge Provinces in the southeastern states, U. S. Geological Circular 538, pp. 11.

LeGrand, H. E., 1979, Evaluation techniques of fractured-rock hydrology. In W. Back and D. A. Stephenson (guest editors), Contemporary Hydrogeology - The Georgie Burke Maxey Memorial Volume, Journal of Hydrology, vol. 43, p. 333-346.

LeGrand, H.E., 1987, Radon and radium emanations from fractured crystalline rocks — a conceptual hydrogeological model, vol. 25, no. 1, Ground Water, pp. 59-69.

McConnell, K.I., and Abrams, C. E., 1984, Geology of the greater Atlanta region, Georgia Geological Survey Bulletin 96.

Rai, D., Zachara, J.M., Moore, D.A., McFadden, K.M., and Resch, C.T., 1989, Field investigation of a flue gas desulfurization (FGD) sludge disposal site, Electric Power Research Institute, Palo Alto, California, EA-5923, Research Project 2485-8.

Richter, K. E., 1990, Implications from remotely-sensed imagery for post-Cretaceous basement movement in Central Alabama. Geological Society of America, Southeastern Section, Tuscaloosa, Alabama, April 4-6, 1990.

Seal, Thomas, and Kish, Stephen, 1990, The Geology of the Dadeville complex of the western Georgia and eastern Alabama inner Piedmont: initial petrographic, geochemical, and geochronological results, Geological Survey of Alabama Guidebook VII, pp. 65-77.

Stow, S.H., Neilson, M.J., and Neathery, T.L., 1984, Petrography, geochemistry, and tectonic significance of the amphiboles of the Alabama Piedmont, American Journal of Science, vol. 284, pp. 416-436.