U.S. Department of the Interior
U.S. Geological Survey

Ground-Water Flow Study in the Vicinity of the Savannah River Site, South Carolina and Georgia

Many regions of the United States are planning for increased water-supply demands as a result of population and industrial growth. Ground water often is the most practical source of new water supply because of its general good quality and availability near the source of need. However, ground water is vulnerable to contamination and, once contaminated, presents near insoluble remediation problems. Thus, many communities are justifiably concerned about maintaining the good quality of their ground-water reservoirs. One area of such concern is along the South Carolina-Georgia state line in the vicinity of the U.S. Department of Energy, Savannah River Site (SRS).

INTRODUCTION

The U.S. Department of Energy (DOE), Savannah River Site (SRS) (fig. 1) has manufactured nuclear materials for the National defense since the early 1950's. A variety of hazardous materials, including radionuclides, volatile organic compounds, and trace metals, are either disposed of or stored at several locations at the SRS.

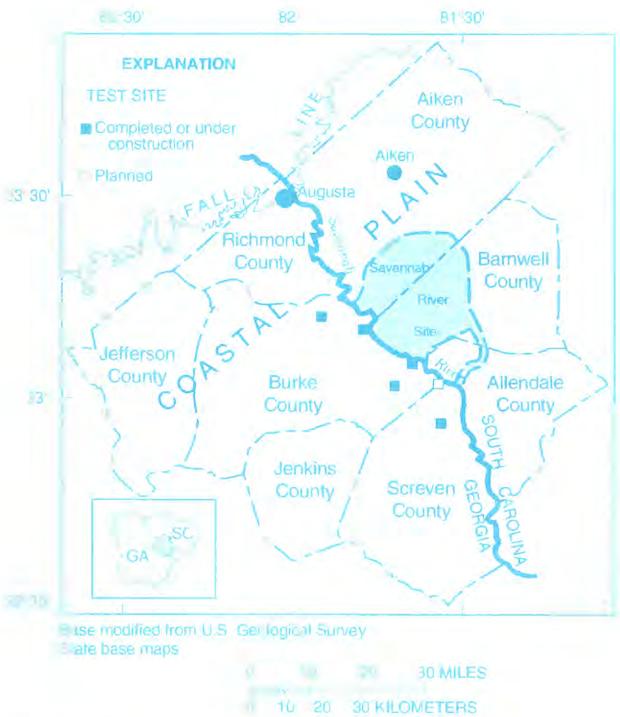


Figure 1. Location of study area and test sites.

Ground water originating in the vicinity of the SRS is thought to flow westward and discharge to the Savannah River. However, ground-water flowpaths in the vicinity of the Savannah River are poorly understood and need to be defined to determine the potential for contaminated ground water to migrate from the SRS, beneath the Savannah River, into Georgia. Contamination of ground water has been detected at several locations within the site (fig. 2).

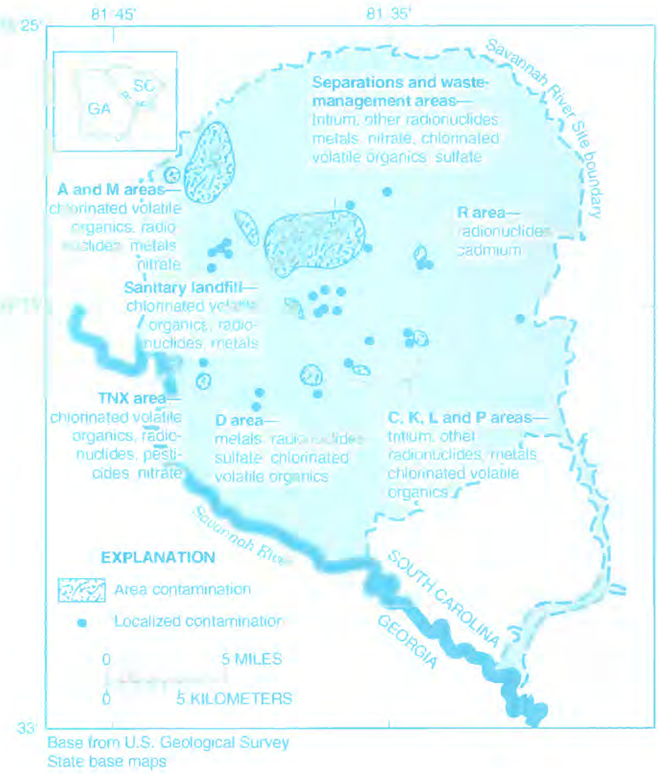


Figure 2. Areal and local ground-water contamination sites at the Savannah River Site. Modified from Westinghouse Savannah River Company, 1994.

Two issues raised concerning the possible migration of contaminated ground water offsite from the SRS are:

- Is ground water flowing from the SRS through aquifers in South Carolina and beneath the Savannah River into Georgia (herein called trans-river flow)?
- Under what pumping scenarios could such ground-water movement occur?

Description of Study Area

The study area covers 4,592 square miles (mi^2) in the northern part of the Coastal Plain of Georgia and South Carolina (fig. 1). The SRS covers about 300 mi^2, or 7 percent of the study area (fig. 2). The northern limit of the study area and boundary between the Coastal Plain and Piedmont is marked by the Fall Line. Coastal Plain sedimentary rocks consist of alternating layers of sand, clay, and lesser amounts of limestone that progressively thicken from the Fall Line to the southeast, reaching an estimated thickness of 2,700 ft in the southern part of the study area. These rocks comprise highly permeable water-bearing units through which ground water readily flows (aquifers), and low perme-ability confining units that restrict the flow of ground water.

Silvaculture and agriculture are the predominant land uses in the study area where pine timber, cotton, and soybeans are major crops. Kaolin is mined in parts of the study area. The largest cities in the study area are Augusta, Ga.—population 44, 639, and Aiken, S.C.—population 19,872 in 1990 (U.S. Department of Census, 1991).

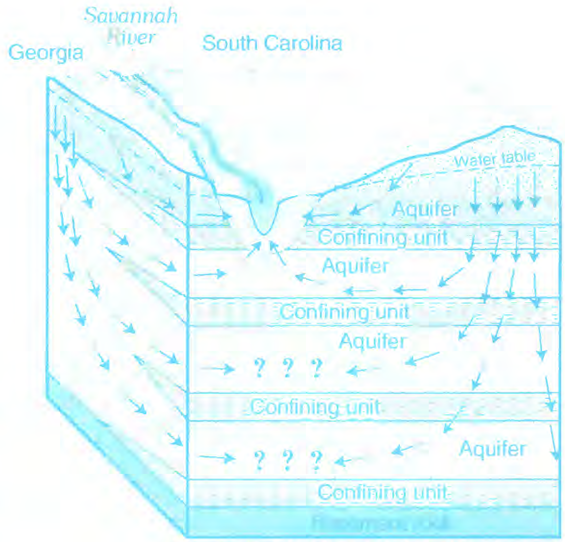
Trans-River Flow

Trans-river flow is a term that describes a condition whereby ground water originating on one side of a river migrates beneath the river floodplain to discharge points located on the other side of the river. Natural factors controlling the potential for trans-river flow include (1) water-bearing properties of aquifers and confining units; (2) thickness and areal extent of confining units; and (3) hydraulic gradient.

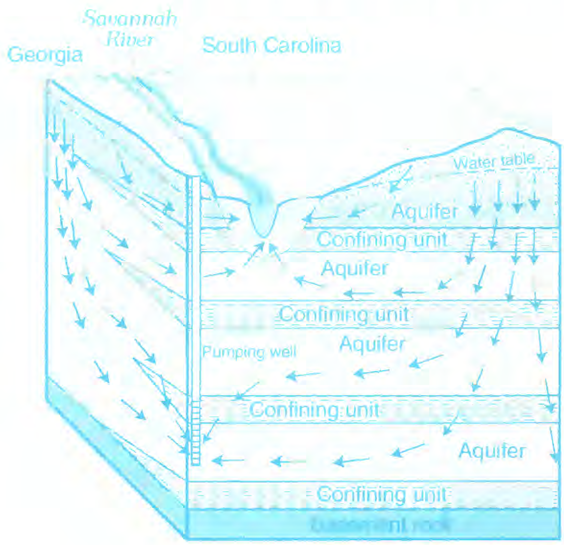
The Savannah River acts as a hydrologic "sink" into which ground water from surrounding and underlying aquifers discharge (fig. 3). This sink is thought to have formed as the river eroded through the uppermost confining units and was subsequently filled with permeable alluvium. It is possible, however, that some ground water can flow beneath the river to the opposite side of the river from its point of origin in response to natural or human-induced hydraulic gradients.

SRS GROUND-WATER STUDY

Because of the highly complex nature of ground-water flow in the SRS region, the DOE in 1991 requested that the U.S. Geological Survey (USGS) conduct a study to define ground-water flow and stream-aquifer relations in the Savannah River basin in the vicinity of SRS. Other participants in the 6-year study include the Georgia Department of Natural Resources, Clemson University, and the University of Georgia. A committee consisting of representatives from SRS and Georgia and South Carolina State agencies provides technical oversite. The major objective of the study is to quantitatively describe ground-water flow in the vicinity of the SRS and the Savannah River, including evaluation of stream-aquifer relations, to determine whether trans-river flow is occurring. Effects of selected hypothetical pumping scenarios on the potential for trans-river flow also are being evaluated. The study is being implemented in two phases.



Ground-water flow system (unstressed)



Hypothetical effects of pumpage on ground-water flow system

EXPLANATION

→ Direction of ground-water flow

Figure 3. Possible ground-water flow conditions beneath Savannah River.

Phase I

Phase I of the study, completed in 1994, defined the geologic, hydrologic, and water-quality conditions in the SRS area through field investigations, test drilling, data analysis, and ground-water flow modeling (Clarke 1992). Elements of phase I included

- drilling 18 test wells at five cluster sites on the Georgia side of the Savannah River to define geology, hydrologic, and water-quality conditions;
- analyzing geologic data from 5 test and 110 existing well sites to determine the depth, thickness, and areal extent of seven aquifers and six confining units beneath the SRS and the Savannah River;

- analyzing geologic data from 18 shallow borings drilled in the flood plain to determine how deeply the ancient Savannah River has cut into underlying aquifers;

- conducting aquifer tests in 14 test and 14 existing wells to determine water-bearing properties of aquifers;

- sampling water from 14 test and 2 existing wells to determine chemical quality of ground water;

- installing continuous water-level monitors in 16 test and 2 existing wells to monitor ground-water levels;

- constructing maps showing ground-water levels and flow directions in major aquifers for prepumping (pre-1953) and modern-day (1992) conditions;

- developing a geographic information system (GIS) data base for more than 4,000 wells and linking the GIS to a ground-water flow model; and

- developing a ground-water flow model to simulate prepumping conditions in seven aquifers.

Water Quality

Analysis of water sampled from 14 test wells and 2 existing municipal wells indicate that the water is within the U.S. Environmental Protection Agency (USEPA) primary drinking-water standards (1993) having no detectable concentrations of contaminants in the deeply buried aquifers. Concentrations of tritium below the USEPA maximum contaminant level of 20,000 parts per liter (U.S. Environmental Protection Agency, 1993) were detected in one 100-foot deep well in northern Burke County, Ga. (Clarke and others, 1994). The source and extent of tritium concentrations in shallow ground water in Georgia were reported by Summerour and others (1994).

Phase II

During phase II, a more focused site-specific data collection program will be implemented near the Savannah River using geologic and water-quality data and information from phase I. Based on data and flow-model simulations conducted during phase I, the area having the greatest potential for trans-river flow is near the Burke-Screven County, Ga., line south of the SRS. To provide better definition of ground-water flow conditions in this area, several wells are planned at a cluster site during phase II. Calibration of the ground-water flow model from prepumping to modern-day (1992) conditions is to be completed. Model simulation of hypothetical pumping scenarios that might induce trans-river flow are planned. Upon completion of phase II, a long-term network is planned to monitor ground-water levels and water-quality data near the Savannah River.

PROJECT BIBLIOGRAPHY

For information on SRS project findings, reports and abstracts prepared by project staff are listed below.

Baum, J.S., 1993, Three-dimensional modeling of ground-water flow in the vicinity of the Savannah River site, South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 25, no 4, p. 2.

Baum, J.S., and Falls, W.F., 1995, Delineation of depositional environments and observed effects on ground-water flow properties near the Savannah River Site in South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 27, no. 2, p. 36.

Baum, J.S., Falls, W.F., and Edwards, L.E., 1994, Sedimentological techniques applied to the hydrology of the Atlantic Coastal Plain in South Carolina and Georgia near the Savannah River Site *in* proceedings, Society of Sedimentary Geology Symposium, June 12-15, 1994: Denver, Co., American Association of Petroleum Geologists.

Baum, J.S., McFadden, K.W., Flexner, N.M., Harrelson, L.G., and West, C.T., 1994, Management of geohydrologic data using a geographic information system for a three-dimensional ground-water-flow model of the Savannah River Site area, South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 26, no. 4, p. 3.

Benson, S.M., Moore, Jerry, Daggett, John, and Snipes, D.S., 1993, The influence of barometric pressure fluctuations, earth tides, and rainfall loading on fluid pressures in Coastal Plain aquifers, Burke County, Georgia *in* proceedings wtih abstracts, Southeastern Section: Boulder, Co., The Geological Society of America, v. 25, no. 4, p. 3.

Clarke, J.S., 1992, Evaluation of ground-water flow and quality in the vicinity of the Savannah River Site, Georgia and South Carolina *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 24, no. 4, p. 47.

___1993, Conceptual models of possible stream-aquifer relations in the vicinity of the Savannah River Site, Georgia and South Carolina *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 25, no. 4, p. 8.

Clarke, J.S., Falls, W.F., Edwards, L.E., Fredricksen, N.O., Bybell, L.M., Gibson, T.G., and Litwin, R.J., 1994, Geologic, hydrologic, and water-quality data for a multi-aquifer system in Coastal Plain sediments near Millers Pond, Burke County, Georgia: Georgia Geologic Survey Information Circular 96, 34 p.

Clarke, J.S., and West, C.T., 1994, Development of water-table and potentiometric-surface maps for Coastal Plain aquifers in the vicinity of the Savannah River Site, South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., Geological Society of America, v. 26, no. 4, p. 8.

___1995, Use of a geographic information system to develop hydrogeologic unit outcrop and subcrop maps in the vicinity of the Savannah River Site, South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 27, no. 2, p. 44.

Delaimi, R.M., 1993, Development of a cross-sectional ground-water flow model for the Coastal Plain aquifers near the Savannah River Site, Georgia and South Carolina *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 25, no. 4, p. 10.

Edwards, L.E., and Clarke, J.S., 1992, Biostratigraphic investigations help evaluation of the ground-water-flow system near the Savannah River Site, Georgia and South Carolina *in* proceedings, Fifth North American Paleontological Convention, Chicago, Ill., June 28-July 1, 1992: Chicago, Ill., Field Museum of Natural History, Paleontological Society, Special Publication.

Edwards, L.E., and Frederiksen, N.O., 1992, Paleogene palynomorph correlations in eastern Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 24, no. 2, p. 46.

Falls, W.F., and Baum, J.S., 1995, Recognition of the Millers Pond aquifer in the vicinity of Burke County, Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 27, no. 2, p. 52.

Falls, W.F., Baum, J.S., and Edwards, L.E., 1994, Sedimentological techniques applied to the hydrology of the Atlantic Coastal Plain in South Carolina and Georgia near the Savannah River Site *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 26, no. 4, p. 13

Falls, W.F., Prowell, D.C., Edwards, L.E., Frederiksen, N.O., Gibson, T.G., Bybell, L.M., and Gohn, G.S., 1993, Preliminary correlation of geologic units in three coreholes along the Savannah River in Burke and Screven Counties, Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 25, no. 4, p. 14.

Hetrick, J.H., 1992, Geologic atlas of the Wrens-Augusta area: Georgia Geologic Survey Geologic Atlas 8, scale 1:100,000.

Hodges, R.A., Snipes, D.S., Benson, S.M., Daggett, J.S., Price, Van, Temples, Thomas, and Harrelson, Larry, 1994, Hydraulic properties of the Midville aquifer at the Savannah River Site, South Carolina *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 26, no. 4, p. 20.

___ 1995, Hydraulic conductivities of Late Cretaceous Coastal Plain aquifers at Miller's Pond, east-central Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 27, no. 2, p. 66.

Leeth, D.C., and Nagle, D.D., 1994, Geomorphology and geologic characteristics of the Savannah River floodplain in the vicinity of the Savannah River Site, South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 26, no. 4, p. 24.

Moore, Jerry, Benson S.M., Snipes, D.S., Daggett, John, James, April, Kroening, David, Price, Sarah, Price, Van, Jr., and Temples, Thomas, 1993, Characterization of aquifer properties in Coastal Plain sediments in Burke County, Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 25, no. 4, p. 58.

Patterson, G.G., 1992, Localized ground-water discharge to the Savannah River near the Savannah River site, South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 24, no. 2, p. 45.

West, C.T., 1995, Using a geographic information system to calibrate a ground-water flow model of the Savannah River Site, South Carolina and Georgia *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 27, no. 2, p. 96.

REFERENCES

Clarke, J.S., 1992, Evaluation of ground-water flow and quality in the vicinity of the Savannah River Site, Georgia and South Carolina *in* Abstracts with Programs, Southeastern Section: Boulder, Co., The Geological Society of America, v. 24, no. 4, p. 47.

Clarke, J.S., Falls, W.F., Edwards, L.E., Fredricksen, N.O., Bybell, L.M., Gibson, T.G., and Litwin, R.J., 1994, Geologic, hydrologic, and water-quality data for a multi-aquifer system in Coastal Plain sediments near Millers Pond, Burke County, Georgia: Georgia Geologic Survey Information Circular 96, 34 p.

Summerour, J.H., Shapiro, E.A., Lineback, J.A., Huddlestun, P.F., and Hughes, A.C., 1994, An investigation of tritium in the Gordon and other aquifers in Burke County, Georgia—Final Report, Georgia Geologic Survey Information Circular 95, 93 p.

U.S. Bureau of the Census, 1991, Census data—Georgia and South Carolina *in* Census of Population and Housing, 1990 [*machine readable data files*]: Washington, D.C., U.S. Department of the Census, Public Law (P.L.) 94-171

U.S. Environmental Protection Agency, 1993, Maximum contaminant levels (subpart B of part 141, National primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, parts 100 to 149, *revised* July 1, 1993, p. 600.

Westinghouse Savannah River Company, 1994, Savannah River Site environmental report for 1993: Westinghouse Savannah River Company, Aiken, S.C., WSRC-TR-94-075, *prepared for* U.S. Department of Energy, contract no. DE-AC09-89SR18035, variously paged.

For more information, please contact

District Chief
U.S. Geological Survey
3039 Amwiler Road, Suite 130
Atlanta, GA 30360
(770) 903 - 9100

Additional earth science information can be found by accessing the USGS "Home Page" on the World Wide Web at "http://www.usgs.gov" or the USGS, Georgia Water Resources "Home Page" at "http://wwwga.usgs.gov"; or by calling 1-800-426-9000.

Ground-water flow study in the vicinity of the Savannah River Site, South Carolina and Georgia by John S. Clarke

U.S. Department of the Interior
U.S. Geological Survey