RESULTS OF ANNUAL TRITIUM PROJECT BASE FLOW STUDIES, BURKE COUNTY, GEORGIA 1991-1995

Joseph H. Summerour

GEORGIA DEPARTMENT OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA GEOLOGIC SURVEY

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GEORGIA DEPARTMENT OF NATURAL RESOURCES
Lonice Barrett, Commissioner
ENVIRONMENTAL PROTECTION DIVISION
Harold Reheis, Director
GEORGIA GEOLOGIC SURVEY
William H. McLemore, State Geologist

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ABSTRACT

A base flow study consists of the collection of surface water samples from springs, small first-order streams, and small second-order streams in a localized area, during a period of time when ground-water discharge (from the unconfined aquifer) is the primary contribution to stream flow. This normally occurs in the Fall of the year when evapotranspiration is high but precipitation and runoff are low. The purpose is to make an assessment of unconfined aquifer geochemistry without the diluting effects of runoff. Base-flow studies represent a unique opportunity to gather geochemical information on shallow unconfined aquifers in a very cost-effective manner.

As a part of EPD's Tritium Project, base flow studies were conducted in eastern Burke County, Georgia, during the Fall of 1991, 1992, 1993, 1994, and 1995. During each base flow study, surface water sampling took place over a period of two to nine days, following a period of at least two weeks without significant rainfall. After each base flow study, tritium values of each sample site were used to construct contour (isopleth) maps to illustrate distribution of tritium in the unconfined aquifer. After five years of base flow studies, tritium-value isopleth maps consistently show areas of higher concentrations north and northwest of Hancock Landing (on the Savannah River). The highest tritium values measured in this area are 2200 picoCuries per liter (11% of EPA Maximum Contaminant Level). The primary source of tritium in the unconfined aquifer is interpreted to be the Savannah River Site, in South Carolina, reaching Georgia via meteorological pathways, though other possible pathways have not been ruled out.

The contour maps are useful for comparison with tritium values of local shallow water supply wells and EPD monitoring wells.

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INTRODUCTION

Statement of Problem

Tritium, a radioactive isotope of hydrogen with a half-life of 12.35 years (Fritz and Fontes, 1980), has been released from the U. S. Department of Energy (DOE) Savannah River Site (SRS) from the initiation of SRS operations in 1954 (Murphy, et al, 1991). These releases occurred as water vapor and/or as a gas from routine operations and process errors (mechanical and human). Since 1954, approximately 25.4 million Curies of tritium (Table 1, Figure 1) have been released to the atmosphere and surface waters during normal operations (Arnett, et al, 1992, 1993, 1995; Murphy, et al, 1993). In addition, more than one million Curies (Ci) have been released due to mechanical or human process errors (Murphy, et al, 1991). Routine SRS operations placed another seven million Ci into seepage basins and burial grounds. Due to radioactive decay, 9.9 million Ci of tritium remain in the environment and approximately 3.2 million Ci remain in seepage basins and burial grounds (Murphy, et al, 1991).

Because of concern over tritium releases from SRS in South Carolina, the Environmental Radiation Program of the Georgia Environmental Protection Division (EPD) has periodically conducted analyses for tritium in rainfall, well water, soil, vegetation, and milk (from dairies). The regular collection of rainfall samples began in mid-1981.

Following the 1991 discovery of above-background levels of tritium in several residential water wells and one public water supply well in eastern Burke County, Georgia, the EPD Tritium Project began at the request of Governor Zell Miller, with funding provided by DOE (Summerour, et al, 1994). The purpose of the study was assessment of geographic extent, hydrologic extent and amount of tritium pollution in ground and surface waters in Burke County. The base flow studies described in this report are part of this project.

During the Tritium Project (including base flow studies), the Environmental Radiation Laboratory, at the Georgia Institute of Technology, conducted low resolution tritium analyses of all water samples. The detection limits for tritium for this laboratory are 100 picoCuries per liter (+/- 100), 0.5 percent of the Environmental Protection Agency (EPA) Maximum Contaminant Level (MCL) for tritium of 20,000 picoCuries per liter.

Because the true depths of most wells in eastern Burke County are uncertain and the number of springs and streams far exceeds the number of wells, a base flow study is the best available method to evaluate areal distribution of tritium in the water table (unconfined) aquifer. The 1991 through 1995 base flow studies provide a five year set of results for comparisons with future tritium analyses.

Location of Study Area

Burke County is on the eastern margin of Georgia, south of Augusta (Figure 2) and is bordered on the north by Richmond County, on the west by Jefferson County, on the south by Emanuel and Jenkins Counties, on the southeast by Screven County, and on the east by the Savannah River. The base flow study area is primarily in eastern Burke and southern Richmond Counties, extending from the Waynesboro area in the west to the Savannah River on the east and from central Richmond County in the north to the Burke-Screven County line in the south. The U.S. Department of Energy (DOE) Savannah River Site (SRS) is located directly across the Savannah River from Burke County.

Table 1. Yearly totals of SRS atmospheric tritium releases (1954-1994) with decay corrected to 1996 values.

Year	Released Tritium-Ci (Curies)	Year	Released Tritium-Ci (Curies)	Year	Released Tritium-Ci (Curies)
1954	216[1]/20	1968	762,000[1]/158,344	1982	434,000[1]/197,839
1955	36,100[1]/3,617	1969	496,000[1]/109,018	1983	618,000[1]/297,976
1956	469,000[1]/49,703	1970	513,000[1]/119,263	1984	786,000[1]/400,853
1957	1,200,000[1]/134,512	1971	621,000[1]/152,703	1985	667,000[2]/359,797
1958	2,340,000[1]/277,438	1972	822,000[1]/213,795	1986	425,000[3]/242,488
1959	1,050,000[1]/131,677	1973	601,000[1]/165,337	1987	590,000[3]/356,060
1960	951,000[1]/126,145	1974	937,000[1]/272,650	1988	462,000[3]/294,905
1961	886,000[1]/120,097	1975	518,000[1]/159,428	1989	310,000[3]/209,301
1962	1,110,000[1]/164,722	1976	304,000[1]/98,964	1990	250,000[3]/178,534
1963	1,130,000[1]/177,369	1977	381,000[1]/131,190	1991	200,000[3]/151,071
1964	1,520,000[1]/252,355	1978	360,000[1]/131,112	1992	156,000[3]/121,636
1965	744,000[1]/130,651	1979	333,000[1]/128,279	1993	191,000[4]/161,408
1966	675,000[1]/125,375	1980	317,000[1]/129,164	1994	160,000[4]/143,015
1967	689,000[1]/135,362	1981	395,000[1]/170,235		

(1.) Murphy and others, 1993 (2.) Arnett and others, 1992 (3.) Arnett and others, 1993 (4.) Arnett and others, 1995

Physiographic Setting

Burke County is located in the Louisville Plateau District of the Atlantic Coastal Plain physiographic province (Paul Huddlestun, personal communication, 1997). The Louisville Plateau District has a geomorphic relief of 100 to 150 ft. (30 to 50 m.) and is moderately dissected by a well-developed dendritic stream pattern (Atkins, et al, 1996). Local stream valleys are generally narrow except for larger creeks and major rivers, which have wide flood plains occupied by wetlands.

Sources of Tritium

Naturally occurring stable isotopes of hydrogen are Protium (H) (^1_1H) and Deuterium (D) (^2_1H) (Murphy, et al, 1993). Tritium (T) (^3_1H) is a radioactive isotope with a half-life of 12.35 years (Fritz and Fontes, 1980; Murphy, et al, 1993). The mode of decay for tritium is by emission of a weak beta particle with an average energy emission of 5.7 KeV and a maximum energy emission of 18.6 KeV (Murphy, et al, 1993). With emission of the beta particle, tritium converts to helium. For this report and other Tritium Project reports (Summerour, et al, 1994; Summerour, et al, *in preparation*), tritium is measured in picoCuries (pCi) (1 trillionth of one Curie) per liter (of water). One picoCurie represents 0.037 electron releases (decays) per minute (Faure, 1986).

Tritium is produced naturally, in small quantities, in upper atmospheric interaction of cosmic rays with atmospheric nitrogen, resulting in concentrations of 13 to 80 picoCuries per liter (Gat, 1980). Atmospheric tritium typically oxidizes rapidly to tritiated water (HTO) and then enters the hydrological cycle (Michel, 1989), where it has a short residence time (less than one year). Tritium is removed from the atmosphere through precipitation and/or molecular exchange with surface waters (Michel, 1989). Because tritium is part of the water molecule, it follows

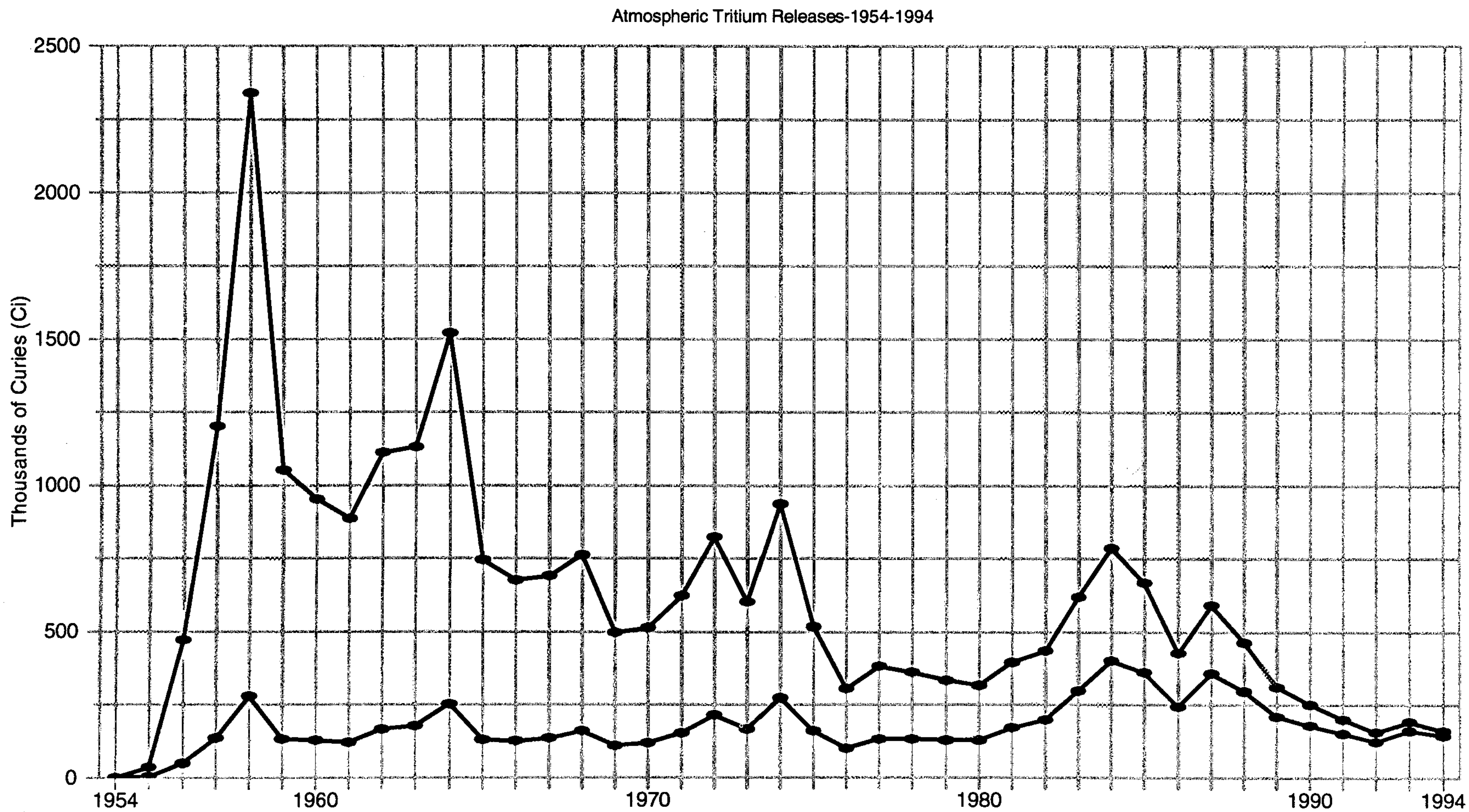

Figure 1. SRS Atmospheric tritium releases 1954-1994. Lower data curve represent values corrected for radioactive decay to 1996. Data references are listed in Table 1.

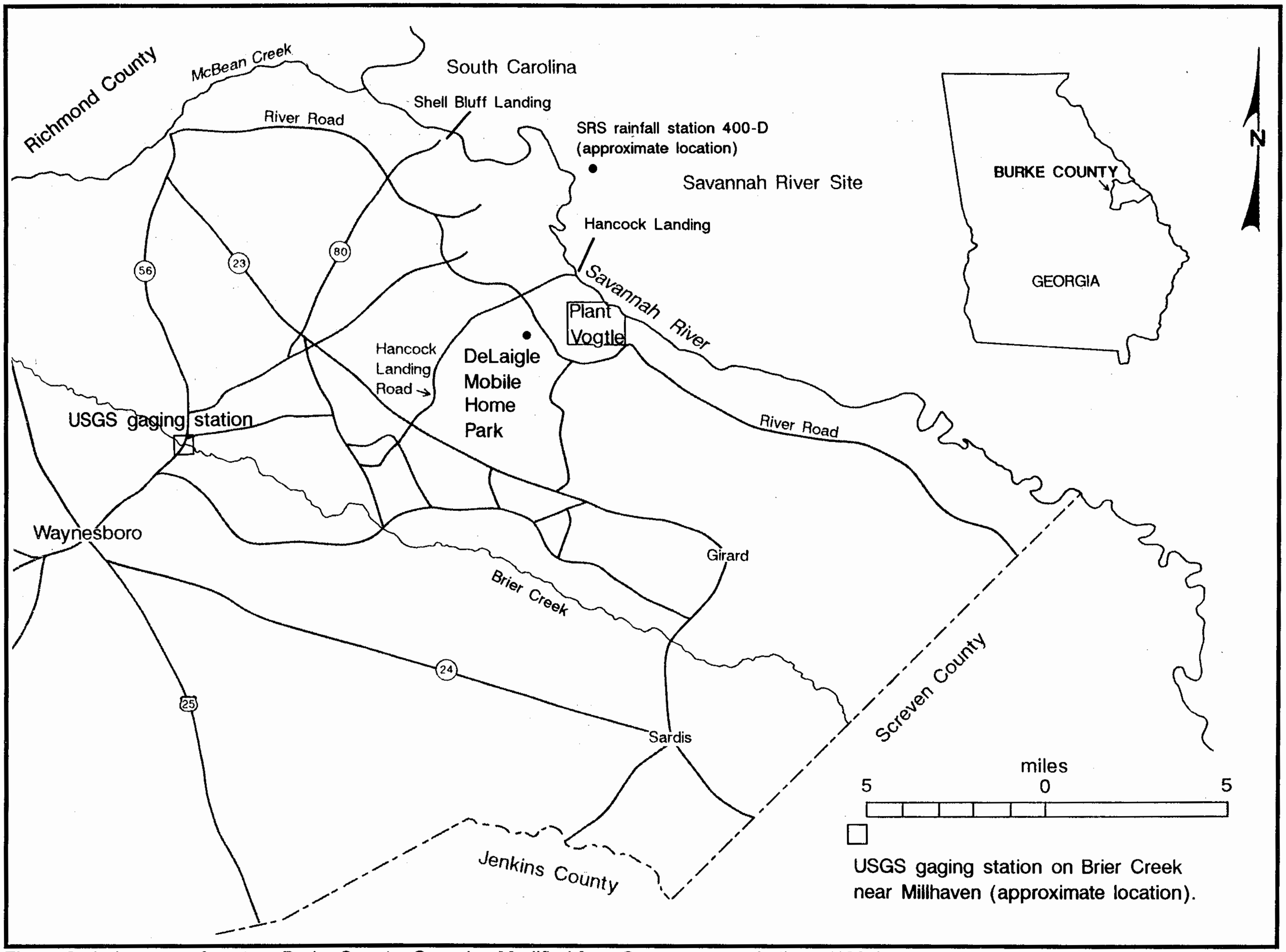

Figure 2. Index map of eastern Burke County, Georgia. Modified from Summerour and others (1994).

water through its flow and mixing processes. During normal contact between surface waters and the overlying atmosphere, atmospheric water molecules enter the liquid phase at the water surface and surface water molecules enter the vapor phase in an equilibrium (balance) exchange (Michel, 1989). Because most surface waters, especially oceans, have tritium concentrations lower than the overlying atmosphere, a net flux of tritium to surface water occurs because of this molecular exchange, i.e., a net depletion of atmospheric tritium occurs (Michel, 1989). Fractionation between hydrogen and tritium occurs, especially during phase changes, but it is minor enough to be ignored in most natural processes (Michel, 1989).

As there is less surface water on continents available for molecular exchange, atmospheric tritium values are higher above continental land masses (Michel, 1989). Other variations in tritium values are latitudinal (because of greater concentration of landmass in the northern hemisphere) and seasonal (due to seasonal changes in weather patterns) (Gat, 1980; Fontes, 1980; Michel, 1989).

Amospheric nuclear testing following World War II resulted in the introduction of technogenic ("bomb") tritium that overwhelmed natural levels of tritium by two to three orders of magnitude, in the early 1950's (Michel, 1989). After the cessation of most atmospheric nuclear testing in 1963, atmospheric levels of technogenic tritium have declined to approximately 16 picoCuries over background (natural) tritium, as of 1978 (Fontes, 1980). Current rainfall tritium values near Atlanta, Georgia measure approximately 39 picoCuries per liter (Rose, 1992, 1993).

During routine SRS reactor operations, recoveries of tritium, recovery of transuranic elements, heavy water rework, and laboratory research, tritium is released to the atmosphere as tritium oxide (or tritiated water vapor) - HTO (hydrogen tritium oxide), DTO (deuterium tritium oxide), and/or T_2O (tritium oxide) and as an elemental gas (HT, DT, and/or T_2) (Arnett, et al, 1993).

Contributions to atmospheric tritium releases are estimated at 69% from tritium separation areas, 28% from reactor facilities, and <3% from other sources (Murphy, et al, 1993).

Weather

The climate of Burke County is warm, with humid summers and mild winters. Data collected at the National Weather Service office at Bush Airport (south of Augusta) indicate that monthly high temperatures range from 91^0F in July to 58^0F in December and January, while monthly low temperatures range from 39^0F in December to 72^0F in July (Baker, 1979).

Mean annual precipitation at Bush Airport is approximately 44.6 inches per year (Baker, 1979). The highest monthly precipitation rates usually occur in July and August, a period of peak thunderstorm activity. The lowest precipitation usually occurs in October and November (Figure 3) (Baker, 1979). Information supplied by Georgia Power Plant Vogtle indicates yearly rainfall totals similar to those measured at Bush Airport. The wind rose plot shown in Figure 4 is based on a composite of hourly averaged wind data measured 200 feet above land surface (Arnett, et al, 1993) in the central portion of SRS. The data were collected from the SRS meteorological tower network from 1987 through 1991. Primary wind directions that influence tritium distribution from SRS into Georgia are from NE to SW (9% occurrence frequency) and ENE to WSW (7.5% occurrence frequency) (Figure 4) (Arnett, et al, 1993). The wind rose data collected 1987 through 1991 are similar to data collected 1982 through 1986 (Arnett, et al, 1993).

During 1987 through 1991, varying weather produced a range of dispersion conditions, from unstable (considerable turbulence with rapid dispersion) to very stable (very little turbulence with a narrow, undispersed plume) (Arnett, et al, 1993). The 1987 through 1991 data indicate that SRS experiences stable conditions approximately 21 percent of the time (Arnett, et al, 1993).

Tritium in Rainfall

Deposition of tritium in rainfall is the result of two process-rainout and washout. Rainout is the incorporation of tritium in precipitation, following condensation of tritiated water vapor (HTO, DTO, and/or T_2O) during cloud formation above the earth's surface (Murphy, et al, 1993). Washout occurs when falling rain passes through air containing tritium gas (HT, DT, and/or T_2). In the vicinity of SRS, washout is the more important process, with primary sources for tritium being facility stacks or seepage basin evaporation (Murphy, et al, 1993).

Rainfall tritium concentrations have been measured by the Georgia EPD Environmental Radiation Program since 1981 at five sites in eastern Burke County (Figure 5) and other nearby sites in Augusta, Waynesboro, and northern Screven County (Summerour, et al, 1994). Average tritium values for two EPD stations (11-Hancock Landing Road, north of Plant Vogtle) and (35-the Plant Vogtle Simulator, south of Plant Vogtle) were listed in Figures 8 and 9 in Summerour and others (1994). Higher tritium values (above 5,000 picoCuries per liter) from these and other EPD stations were listed in Appendix 3 of Summerour and others (1994).

Murphy and others (1991) produced a map (Figure 6) showing the distribution of average rainfall tritium values in the Burke County-SRS area from 1982 through 1986. The data was collected from 33 stations within a 25-mile radius of SRS. This data and EPD data verify the presence of tritium in Burke County rainfall since at least 1981.

Tritium in precipitation, from atmospheric nuclear testing, has been monitored by a worldwide network of rainfall collection stations since the late 1950's and early 1960's (Michel, 1989). Contoured tritium input values for North America show a rough north-south gradient with lower West Coast values (due to oceanic origins for most West Coast storms) and lower values in the Southwest interior, due to lower rainfall, i.e., less tritium deposited due to washout (Michel, 1989). Higher tritium input values in North and Northeastern United States are attributed to the effects of storm systems that form over the North American continent (Michel, 1989). The national tritium input contour map shows no apparent effect of SRS atmospheric tritium releases, perhaps due to the distance from SRS to the two closest rainfall monitoring stations-Ocala, Fla. (300 mi. S) and Cape Hatteras, N.C. (400 mi. ENE).

Tritium in Ground Water

Potential sources of tritium in ground water include downward infiltration (recharge) from tritiated rainfall; downward recharge from creeks, rivers, and/or lakes; vertical leakage from other aquifers; and downward leakage through the annular space of improperly grouted and/or damaged wells (Summerour, et al, 1994). In the Tritium Project study area, the local ground-water system (unconfined Upper Three Runs aquifer) is characterized by upland interfluve recharge and local downgradient discharge into small tributaries of Brier Creek and the Savannah River (Atkins, et al, 1996; Clarke, 1997).

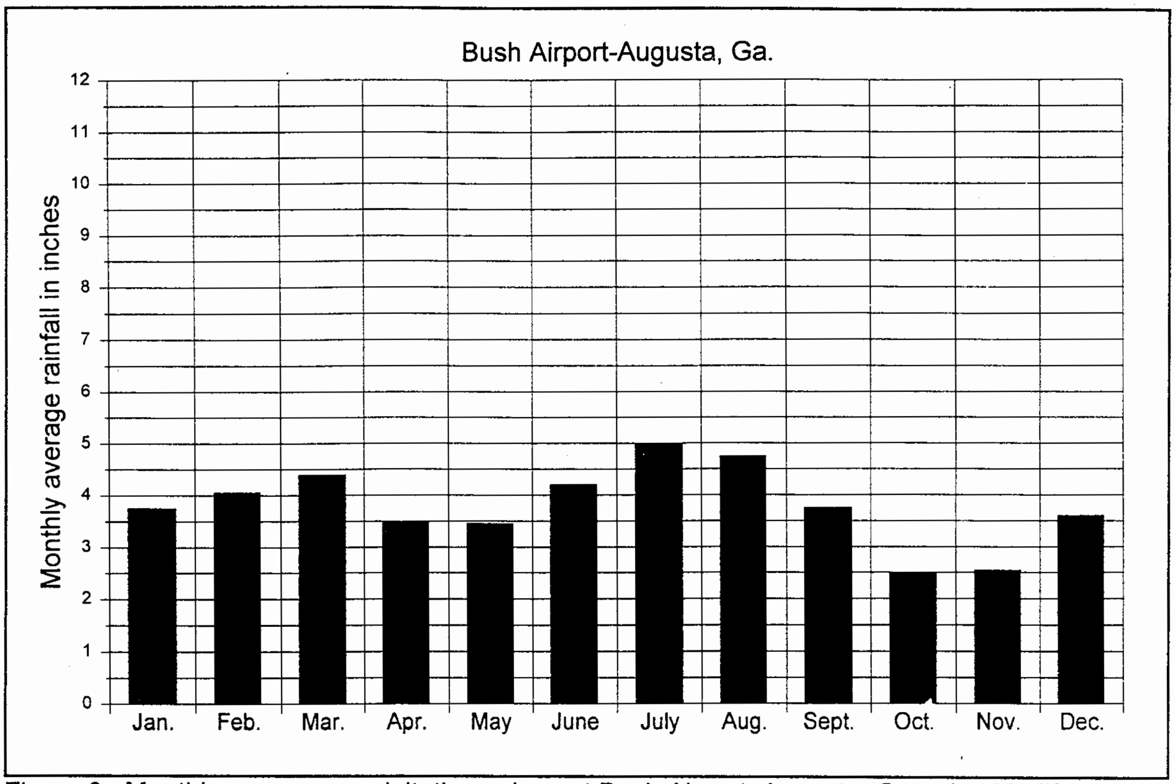

Figure 3. Monthly average precipitation values at Bush Airport, Augusta, Georgia. Modified from Gorday (1985).

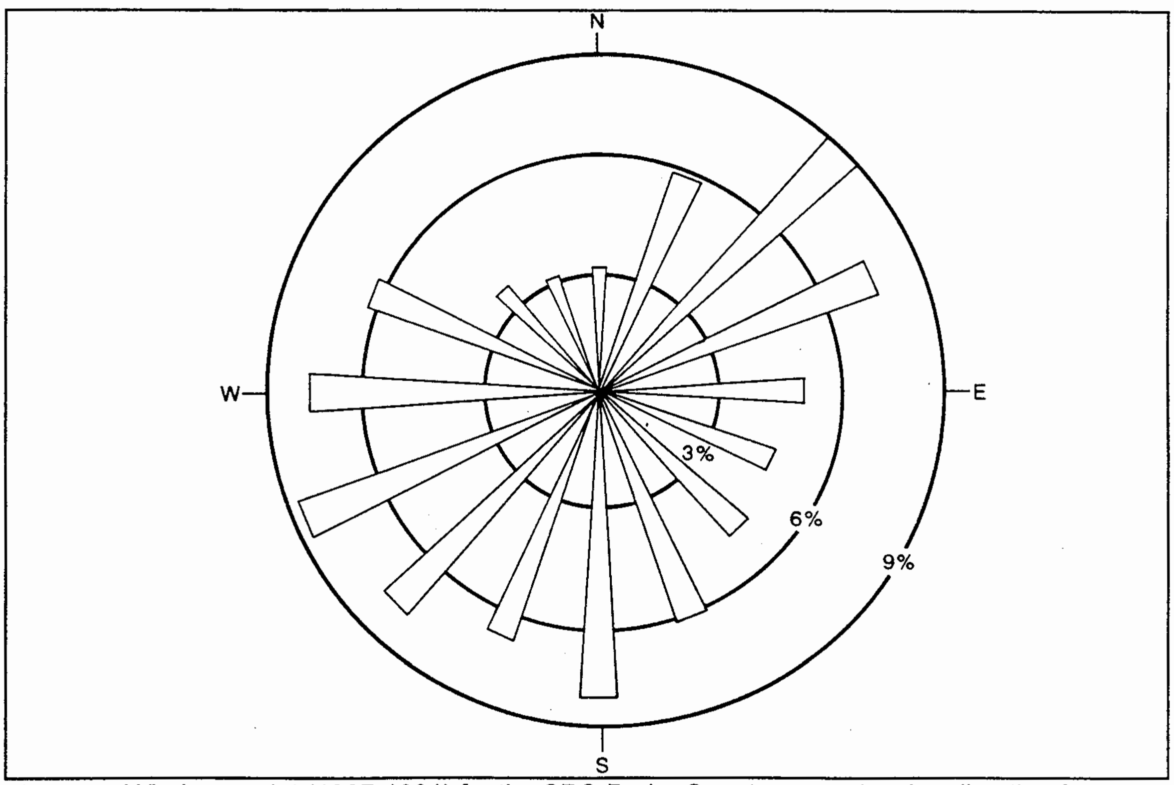

Figure 4. Wind rose plot (1987-1991) for the SRS-Burke County area, showing direction from which the wind blows and frequency of occurrence. Modified from Aadland and others (1993).

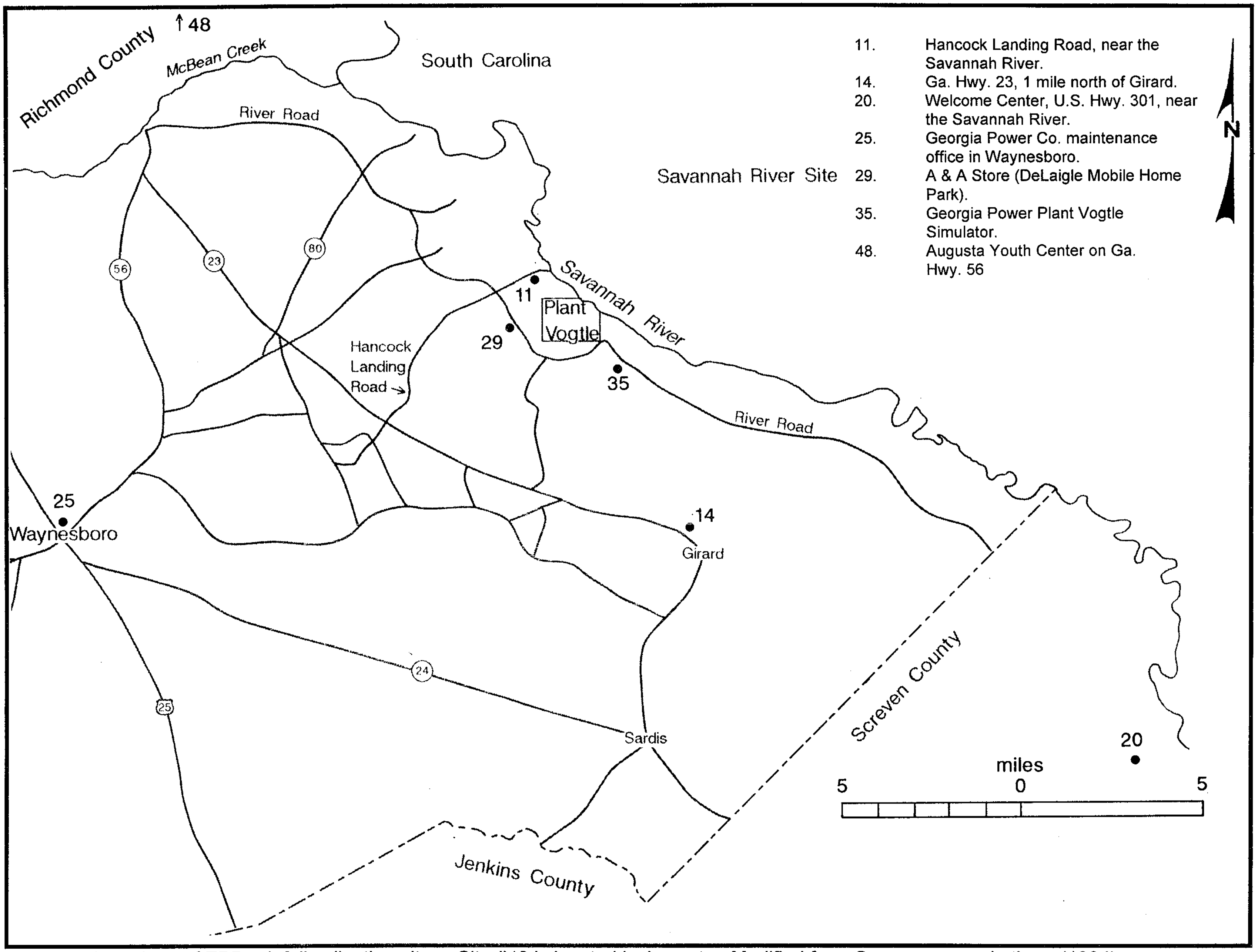

Figure 5. Locations of EPD rainfall collection sites. Site #48 is located in Augusta. Modified from Summerour and others (1994).

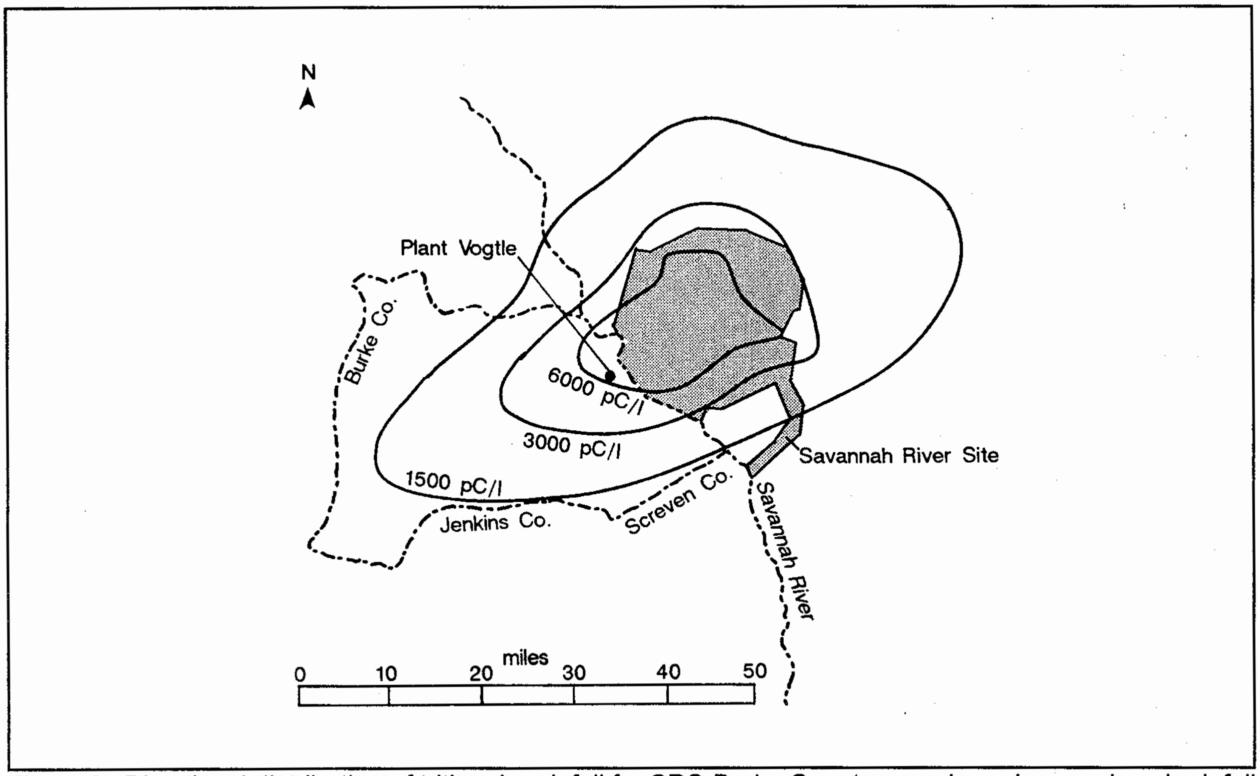

Figure 6. Directional distribution of tritium in rainfall for SRS-Burke County area, based on analyzed rainfall samples (1982-1986). Values are stated in picoCuries per liter. Modified from Murphy and others (1991).

Tritium Project Phase I sampling of shallow monitoring wells, residential wells, and base flow studies verified the presence of low-level tritium pollution in the Upper Three Runs aquifer in eastern Burke County, Georgia (Summerour, et al, 1994). These Phase I investigations and the current Phase II investigations of vadose zone tritium and vertical tritium distribution within the Upper Three Runs aquifer offer evidence that rainfall infiltration is the likely primary pathway for tritium to enter the Upper Three Runs aquifer, though other pathways have not been ruled out (Summerour, et al, *in preparation*).

A separate, regional USGS investigation of shallow ground water tritium was conducted as part of a broad overview of water quality in the Coastal Plain and Coastal Flatwoods geographic provinces of southern Georgia and northern Florida (Crandall and Berndt, 1996). Based on analyses from 27 Georgia wells (10.5 to 65 feet in depth), higher tritium values in the northern part of the study area (330 picoCuries per liter-northern Jenkins County-adjacent to the Tritium Project study area) were attributed to SRS activities. Lower tritium values in southern Georgia and adjacent Florida (17 picoCuries per liter-southern Camden County) were attributed to technogenic tritium (Crandall and Berndt, 1996; Crandall, personal communication, 1997). Tritium contours based on this data show a southwest-trending long axis (Crandall and Berndt, 1996; Crandall, personal communication, 1997; Summerour, et al, *in preparation*), similar to the long axis shown on the SRS rainfall tritium contour map (Figure 6).

Geology and Hydrogeology

Sediments underlying the Tritium Project study area consist of southeast dipping Upper Cretaceous, Paleogene, and Neogene siliciclastic and carbonate rocks unconformably overlying Paleozoic gneisses and schists and Triassic clastic rocks (Piedmont basement) (Chowns and Williams, 1983; Snipes, et al, 1993). Late Eocene Barnwell Group sediments and Middle Eocene Claiborne Group sediments are of primary interest in base flow studies (Figure 7).

Cretaceous and Tertiary sedimentary rocks underlying Burke County consist of several alternating layers of permeable sands and limestones separated by less permeable layers of calcareous, smectitic, or kaolinitic clay. Ground water flows more easily through permeable sands and limestones, termed "aquifers", if these layers yield significant quantities of water to wells and springs (Summerour et al, 1994). Less permeable "aquitards" (or confining beds) form barriers to subsurface upward or downward movement of ground water and yield little water to wells. Aquitards may protect high quality ground water in one aquifer from natural contamination or human-induced pollution that may exist in an overlying or underlying aquifer (Summerour, et al, 1994). An aquifer with an upper boundary formed by the water table is an "unconfined", "surficial", or "water table" aquifer. An aquifer that lies between two aquitards (one above and one below) is a "confined" aquifer (Freeze and Cherry, 1979).

In the Tritium Project study area, the unconfined aquifer was previously referred to as the "Jacksonian" aquifer (Vincent, 1982; Brooks, et al, 1985), on the basis of its Jacksonian (Late Eocene) age. The SRS equivalent of the "Jacksonian" aquifer is the "Upper Three Runs" aquifer (Aadland, et al, 1992). The Upper Three Runs unit designation is more consistent with hydrostratigraphic principles than the chronostratigraphic term "Jacksonian" (Summerour, et al, 1994).

In eastern Burke County, the unconfined Upper Three Runs aquifer is an anisotropic multi-layered unconfined aquifer (Summerour, et al, 1994), composed of the Late Eocene Barnwell Group, which includes the Tobacco Road Sand, Dry Branch Formation, and the Clinchfield Formation (Figures 7 and 8) (Hetrick, 1992; Huddlestun and Hetrick, 1978, 1979, 1986).

Most of the Upper Three Runs aquifer consists of the Tobacco Road Sand and the Irwinton Sand Member of the Dry Branch Formation (Figures 7 and 8). The Tobacco Road Sand is a coastal marine, massive to crudely-bedded, moderately poorly sorted, medium to coarse-grained, pebbly sand, with minor occurrences of clay, limestone, mica, and glauconite (Huddlestun and Hetrick, 1978, 1979, 1986). The Irwinton Sand Member Formation consists of shallow marine, fine- to medium-grained, well-sorted, clean sand with a variety of bedding styles (Huddlestun and Hetrick, 1986; Huddlestun and Summerour, 1996). Vertical and downgradient migration of groundwater and the elevation and location of springs may be affected by beds, lenses and laminae of marine smectitic Twiggs Clay lithology within the Irwinton Sand Member (Huddlestun and Hetrick, 1986; Huddlestun and Summerour, 1996). Underlying and locally interbedded with the Irwinton Sand Member is the calcareous Griffins Landing Member of the Dry Branch Formation. The Griffins Landing Member consists of a shallow, inner continental shelf, fairly well-sorted, massive to vaguely-bedded, calcareous sand. Updip occurrences of calcareous clay and limestone beds (along with Twiggs Clay beds) serve as partial or local confining beds for the lower part of the Upper Three Runs aquifer

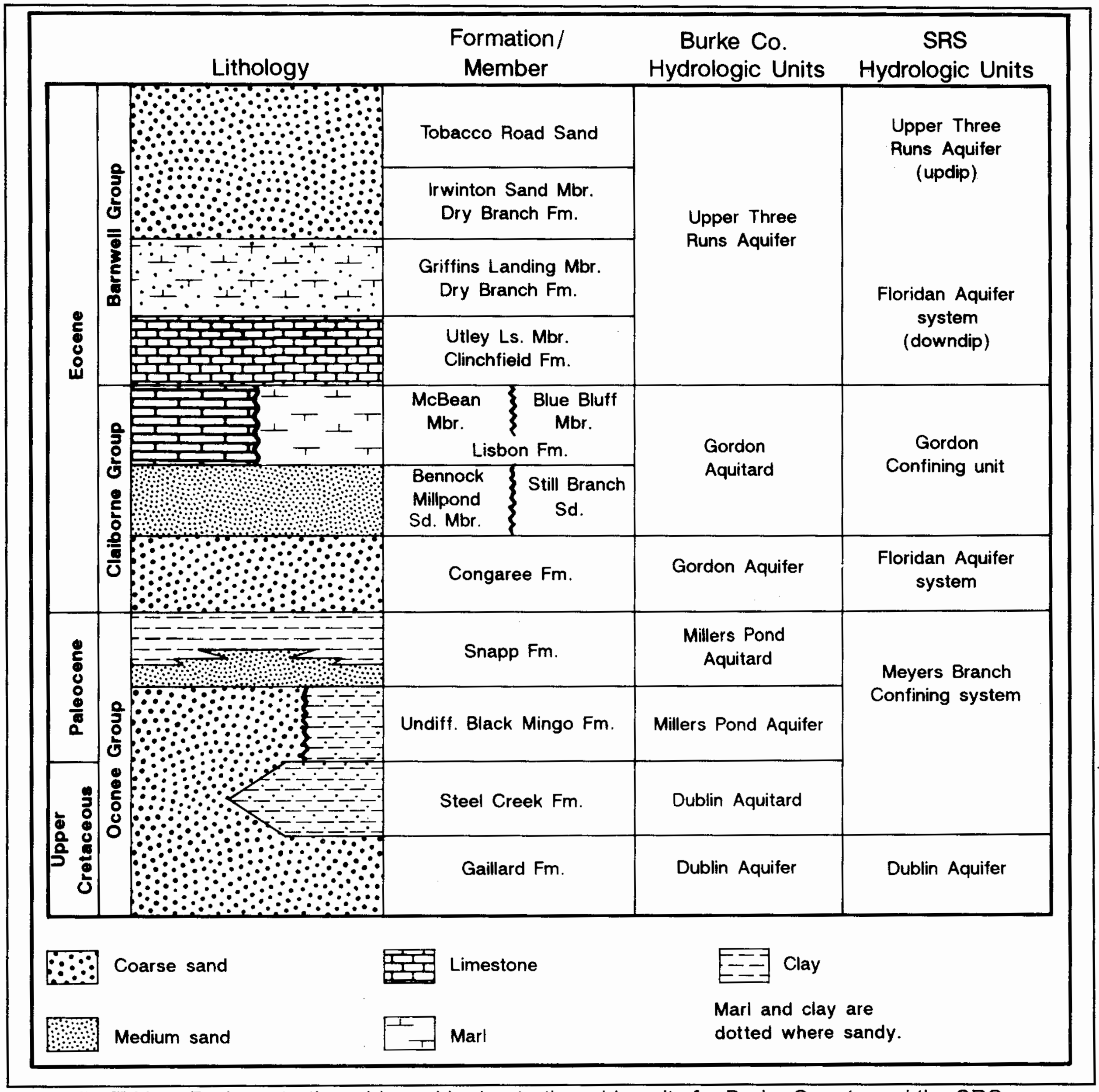

Figure 7. Tritium Project stratigraphic and hydrostratigraphic units for Burke County and the SRS area. Terminology from Aadland and others (1992), Falls and Baum (1995), Huddlestun and Summerour (1996), Falls and others (1997). Modified from Huddlestun and Summerour (1996).

(Summerour, et al, 1994; Huddlestun and Summerour, 1996; Summerour, et al, *in preparation*). Elsewhere in Burke County, the Griffins Landing Member consists of permeable calcareous sands and oyster shell bioherms and beds, which may allow further downward migration of groundwater (Summerour, et al, 1994). Locally underlying the Dry Branch Formation (especially near Plant Vogtle) is the Late Eocene Utley Limestone Member of the Clinchfield Formation. The Utley Limestone Member is a moldic, fossiliferous, variably glauconitic, variably sandy limestone, with occasional beds of calcareous sand or sandstone (Huddlestun and Summerour, 1996). In the locations where the Utley Limestone contains secondary (karstic) permeability (interconnected voids or fractures enlarged by dissolution), the presence of measurable amounts of tritium in Tritium Project wells TR92-5A and TR92-1M indicate a hydrologic connection between sandy upper parts of the Upper Three Runs aquifer and the Utley Limestone (Summerour, et al, 1994; Summerour, et al, *in preparation*). For this reason, the Utley Limestone is included in the lower portion of the Upper Three Runs aquifer in the study area.

In the study area, the Middle Eocene Lisbon Formation (Claiborne Group) underlies the Upper Three Runs aquifer. From the McBean Creek basin (Figure 8) in southern Richmond County downdip to the Shell Bluff Landing area, the McBean Limestone Member of the Lisbon Formation is a calcareous sand to sandy limestone (Huddlestun and Summerour, 1996). Downdip from Shell Bluff Landing to Hancock Landing (Figure 2), in eastern Burke County, an undifferentiated Lisbon sand is present. This sand is massive to crudely-bedded, fine-grained, argillaceous, calcareous and well-sorted (Huddlestun and Summerour, 1996). From Hancock Landing downdip, the Blue Bluff Member of the Lisbon Formation, a dense, calcareous clay, serves as the aquitard underlying the Upper Three Runs aquifer (Huddlestun and Summerour, 1996). In updip core samples, both the McBean Member and the undifferentiated Lisbon sand appear to be more permeable than the Blue Bluff Member and may allow for some downward migration of water from the Upper Three Runs aquifer into the underlying Gordon aquifer.

In the study area, the confined Gordon aquifer consists of the Middle Eocene Congaree Formation (Figure 7) and the overlying Bennock Millpond Sand Member (where permeable) of the Still Branch Sand (Summerour, et al, *in preparation*). South of the McBean Creek basin, the Gordon aquifer is not exposed and is not considered to be a major contributor to baseflow in this area. Updip of the McBean Creek basin, in southern Richmond County, where the overlying Lisbon Formation is missing, Gordon aquifer sediments crop out beneath Barnwell Group sediments in deeper creek valleys (Hetrick, 1992). In this area, kaolinitic sands of the upper portion of the Middle Eocene fluvial and deltaic Huber Formation (updip equivalent of the Congaree) compose the unconfined portion of the Gordon aquifer (Brooks, et al, 1985; Hetrick, 1992; Fallaw and Price, 1992).

Aquifer-Stream Relations

Water moving through a stream channel is from three sources: overland flow, interflow, and base flow (Freeze and Cherry, 1979; Domenico and Schwartz, 1990). Overland flow consists of rain water that moves over the land surface into stream channels. Interflow is derived from soils and sediments above the water table following rainfall events. Base flow consists of water derived from the water table aquifer.

In general, water table surface relief in a homogenous and isotropic aquifer system is a subdued replica of the local surface topography (Atkins, et al, 1996). A close correlation between water table and land surface elevation has been demonstrated for eastern Burke County in Summerour and others (1994) and Clarke (1997). An approximate water table surface map of the Upper Three Runs aquifer (Figure 9) in eastern Burke County has been constructed using the elevation of the springheads (point of origin) of perennial streams (as interpreted from USGS 7.5 minute quadrangles) supplemented by water level information from monitoring wells (Summerour, et al, 1994).

As previously mentioned, Upper Three Runs aquifer recharge is by rainfall infiltration primarily in upland areas with downward migration to the water table (Atkins, et al, 1996). In the Upper Three Runs aquifer,

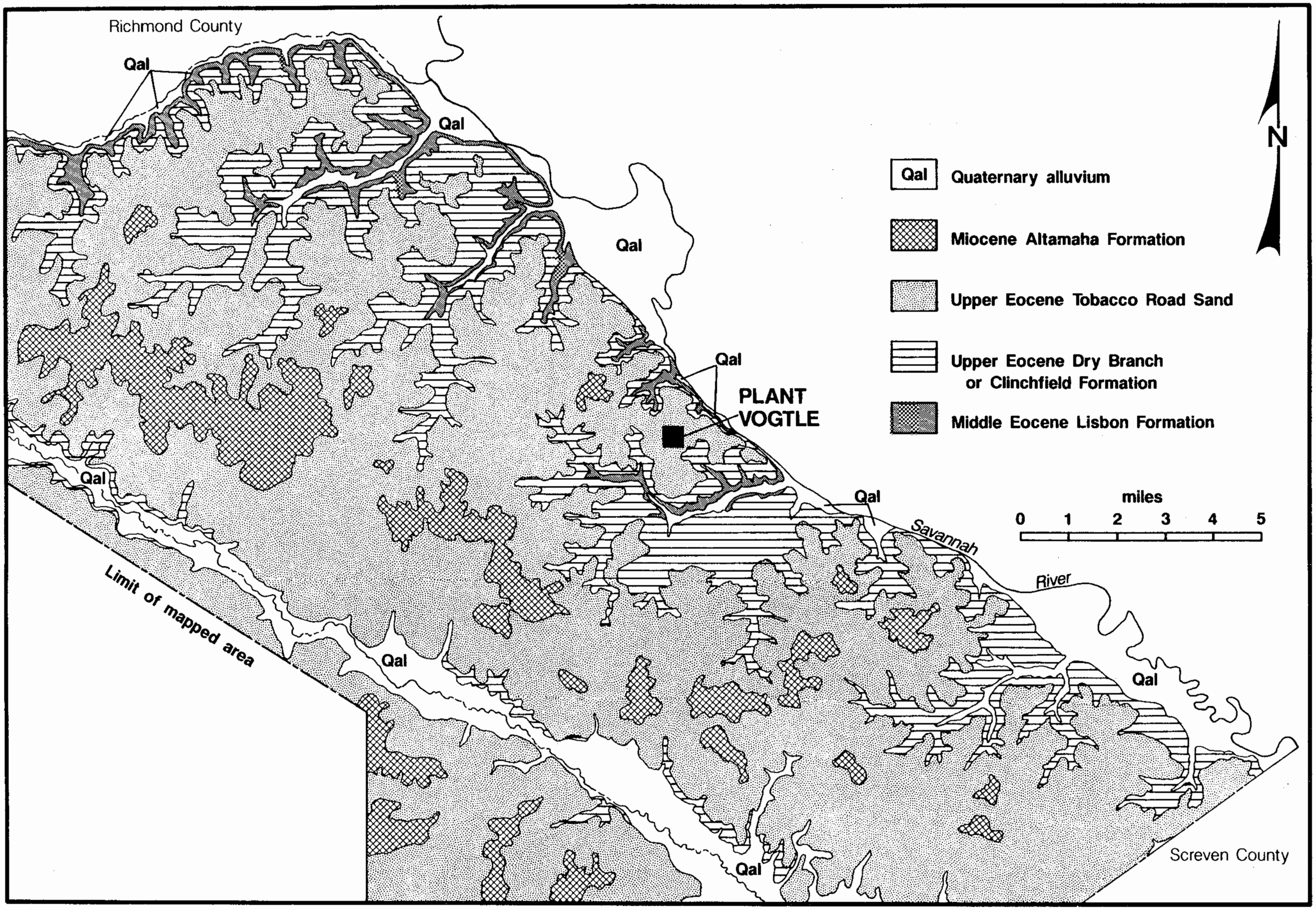

Figure 8. Geologic map of Barnwell Group (Tobacco Road Sand/Dry Branch Fm./Clinchfield Fm.) exposures in eastern Burke County, Georgia. Modified after Hetrick (1992).

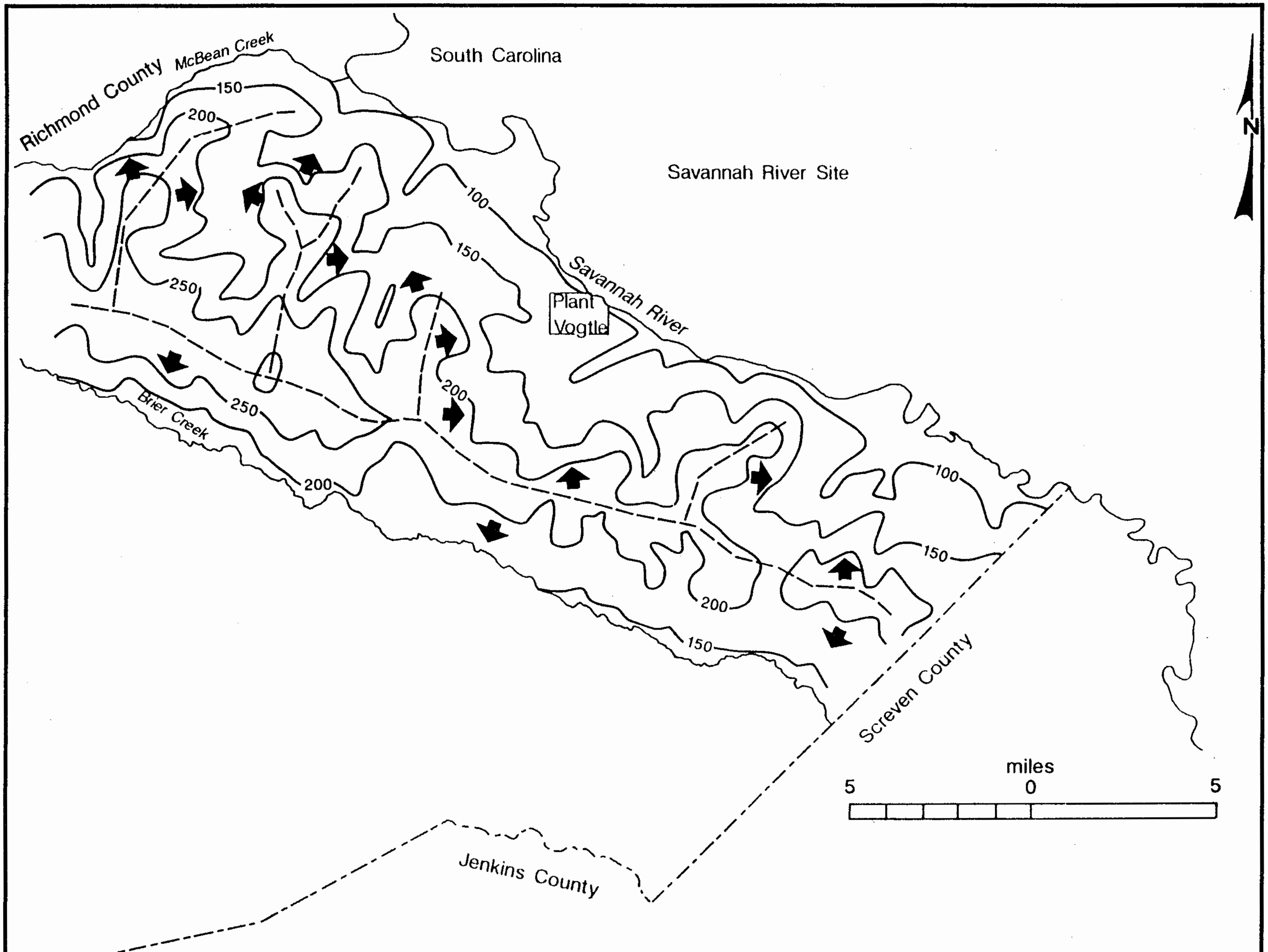

Figure 9. Water table surface map of the Upper Three Runs aquifer in eastern Burke County. Contours are in feet above mean sea level. Dashed lines represent ground-water "divides". From Summerour and others (1994).

below the water table, water moves downgradient and 1.) discharges to surface waters through springs or seeps; 2.) continues downgradient into the Upper Floridan aquifer (Clarke, et al, 1996); or 3.) discharges by natural leakage into the underlying confined Gordon aquifer.

In updip areas of Richmond County, recharge of the exposed Gordon aquifer occurs in a similar manner (Brooks, et al, 1985) and once below the water table, water either moves downgradient and discharges into springs and lowland seeps or continues downgradient into the confined portion of the Gordon aquifer south of McBean Creek.

Historical Data

Prior to the 1991 base flow study, the only known sampling of surface waters in Burke County for tritium was by Southern Company subsidiaries Georgia Power Company and Southern Nuclear Operating Company (Table 2). The four sites sampled were: 1.) a Savannah River bluff spring at River Mile 150.1; 2.) a Savannah River bluff spring at River Mile 150.9; 3.) springflow into Mallards Pond, on Plant Vogtle property (see Figure 11, Summerour, et al, 1994); and 4.) the Beaverdam Creek crossing of River Road immediately south of Plant Vogtle.

Site 3 at Mallards Pond was sampled as site 31Z09SE during the 1992 base flow study and Site 4 at Beaverdam Creek was sampled as site 32Y01NE during 1991 through 1995 base flow studies (Appendices 1 and 2). Sampling dates and results for sites 1 through 4 are in Table 2.

Acknowledgements

We wish to thank the property owners of Burke County, Georgia and adjacent areas for allowing collection of water samples from local springs and creeks.

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PROCEDURES

Planning Base Flow Studies

The first step in planning a base flow study is the monitoring of regional rainfall. In the Tritium Project study area, past and present rainfall data are available from the National Weather Service office at Bush Airport, Augusta, Georgia, Georgia Power Plant Vogtle in Burke County, and SRS Station 400-D (close to the Savannah River) (Figure 2). Station 400-D data are used for this report, as rainfall samples are collected daily (data courtesy of Mr. Chuck Tatum, Westinghouse Savannah River Co.). Plant Vogtle rainfall samples are collected only on weekdays (at approximately 11 A.M.), thus Monday measurements may represent a composite of rain which fell following the previous 11 A.M. Friday collection (Mr. Carl Carswell, Georgia Power Company Plant Vogtle, personal communication, 1992).

During the Fall in Burke County, precipitation is at its lowest level (Figure 3) (Baker, 1979) and soil moisture has been depleted by evapo-transpiration. During this time period, stream flow is typically very low and is primarily derived from base flow. Within the study area, water samples from springs and first-order streams during such periods provide a reasonable sample of water from the Upper Three Runs (water table) aquifer. Stream gaging is the most accurate method of measuring actual base flow conditions. During 1991-1995, stream flow data from two USGS gaging stations on Brier Creek, in eastern Burke County (Figure 2),

Table 2. Tritium values (in picoCuries/liter) of surface water samples collected by Ga. Power personnel prior to 1991 GGS base flow study with comparisons of 1991-1995 base flow results. "n/c"-not collected. Analyses (prior to base flow studies) courtesy of Southern Nuclear Operating Co. Modified from Summerour and others (1994).

Date	Blue Bluff Spring-River Mile 150.1	Plant Vogtle Spring-River Mile 150.9	Mallards Pond-Plant Vogtle Property	Beaverdam Creek at River Road 31Y01NE (G-1)
08/03/82	3810	n/c	n/c	n/c
08/10/82	n/c	n/c	1280	n/c
07/05/83	1610	n/c	2540	n/c
10/04/83	1480	n/c	2320	1910
01/03/84	1850	n/c	2290	n/c
04/03/84	n/c	3333	2120	n/c
07/10/84	n/c	2460	2120	n/c
10/08/84	n/c	2490	1820	n/c
03/05/85	n/c	3930	n/c	n/c
05/13/85	n/c	2820	2030	n/c
07/22/85	n/c	2000	n/c	n/c
10/15/85	n/c	2300	2080	n/c
01/16/86	n/c	2710	1810	n/c
04/03/86	n/c	2580	1670	n/c
07/14/86	n/c	2650	1850	n/c
10/07/86	n/c	2600	1850	n/c
01/12/87	n/c	3310	1750	n/c
04/09/87	n/c	3100	1700	n/c
10/22/91	n/c	2430	1660	1390
11/19/91[1]	n/c	n/c	n/c	1300[1]
10/27/92[1]	1400[1,2]	n/c	1400[1]	1100[1]
07/27/93	n/c	1800	n/c	n/c
10/20/93[1]	1300[1,2]	n/c	dry	800[1]
11/08/94[1]	1200[1,2]	n/c	n/c	700[1]
10/27/95[1]	1300[1,2]	n/c	n/c	500[1]

1. Collected during EPD base flow study. 2. Collected from nearby springs (32Z02NE-1 and 32Z02NE-2) on Blue Bluff at River Mile 149.5 (approximate).

were used to assess regional surface water flow conditions. Gaging station #02197830 (Latitude 33° 07' 05" N, Longitude 81° 57' 50" W) on Brier Creek (at the Ga. Hwy. 56 bridge, east of Waynesboro) (Figure 2) was used for the 1991 through 1994 base flow studies. The Waynesboro gaging station was taken out of service on January 20, 1995, due to bridge construction on Ga. Hwy. 56 at Brier Creek. Another USGS gaging station (#02198000), approximately 20 miles downstream on Brier Creek at Millhaven, Ga. (Figure 2) (Latitude

32^0 56' 00" N, Longitude 81^0 39' 05" W) was used for confirmation of local stream flow conditions for the time period of the 1995 base flow study. Data from these stream gaging stations are collected at six week intervals and (considering data processing time) therefore, are not available at the time of sample collection. Because of this time lag, these data are most useful as after-the-fact confirmation of stream flow conditions. At these particular USGS gaging stations, comparisons of past rainfall data and stream flow data indicate that during the Fall, favorable conditions for base flow sampling exist after approximately two weeks with no measurable rainfall (Roger McFarland, USGS, personal communication, 1992).

More detailed reports on Burke County/SRS area aquifer discharge/ streamflow relations are presented in Atkins and others (1996), Leeth and Nagle (1996) and Clarke (1997).

Preferred sampling locations for base flow studies are springs and small first-order streams. Second and third-order streams are less preferred sampling sites as these larger streams represent mixing of ground water from several sources, producing a composite sample. Areas immediately downstream from swamps, ponds, and lakes are least preferred sampling sites because tritium concentrations in these surface water bodies may be biased by recent rainfall and surface runoff. Second and third-order streams may be utilized, where more favorable sites are not available due to time, personnel, and accessibility constraints.

The USGS 7.5 minute quadrangles included in one or more of the 1991 through 1995 base flow studies are shown in Figure 10.

Base Flow Studies

Prior to the March 1992 formal initiation of the Tritium Project, the need for a base flow study was first recognized during a period of dry weather during the Fall of 1991. During the time period of October 19 through November 19, a total of 1.19 inches of rainfall was measured at SRS Station 400-D (Figure 11) from one-day rainfall events on September 26 and October 8. Stream discharge rates for Brier Creek for October 20 through November 20 are shown in Figure 12. During October 20 through November 18, the highest discharge rate of 384 cfs (cubic feet per second) was recorded on November 13. Discharge rates for November 19 and 20 were 282 cfs and 285 cfs, respectively. The 1991 base flow study was conducted by EPD Environmental Radiation Program personnel in an area covering parts of five USGS 7.5 minute quadrangles (Figure 13). Sampling sites of the initial base flow study are designated by capital latter-number combinations, e.g., "A-1" (Alexander quadrangle), "SBL-1" (Shell Bluff Landing quadrangle), and "G-1" (Girard quadrangle) (Appendices 1 & 2). Site SBL-12 was actually on the western edge of the Girard NW quadrangle and site G-17 was actually on the northern edge of the Hilltonia quadrangle. The 1991 base flow study sampled 51 sites (Figure 14), primarily from road crossings of area streams. The USGS 7.5 minute quadrangles showing 1991 (and subsequent) base flow sampling site locations are stored in the GGS Technical Files, in Atlanta. Estimated latitudes and longitudes for these sites are listed in Appendix 1 of this report.

With more time available for the planning of the 1992 Base Flow Study, the study area was expanded to cover a larger area in eastern Burke County.

During the planning stages, a map grid system was established to achieve a more uniform spacing of water sampling sites. Because the Shell Bluff Landing USGS 7.5 minute quadrangle map contained thirteen of the fifteen tritium-polluted residential water

			29BB Augusta West 1993 1994 1995				
		28AA Blythe 1993 1994	29AA Hephzibah 1993 1994 1995	30AA Mechanic Hill 1993 1994 1995			
26Z Wrens 1993	27Z Matthews 1993 1994	28Z Keysville 1993 1994	29Z Storys Millpond 1993 1994 1995	30Z McBean 1992 1993 1994 1995	31Z Shell Bluff Landing 1991 1992 1993 1994 1995	32Z Girard NW 1991 1992 1993 1994 1995	
26Y Louisville 1993	27Y Kellys Pond 1993 1994	28Y Gough 1993 1994 1995	29Y Waynes-boro 1993 1994 1995	30Y Idlewood 1992 1993 1994 1995	31Y Alexander 1991 1992 1993 1994 1995	32Y Girard 1991 1992 1993 1994 1995	33Y Millett 1992 1993 1994 1995
				30X Perkins 1993 1994	31X Sardis 1993 1994	32X Hilltonia 1991	

Figure 10. Grid showing locations of USGS 7.5 minute quadrangles covered by one or more of the 1991 through 1995 base flow studies (1991-1995). Quadrangle number/letter codes are from USGS well inventory.

wells identified during the Tritium Project (Summerour, et al, 1994), this area was designated as a "dense sampling zone" with four sites to be sampled per square mile, where possible. The dense sampling zone extended two to three miles into the margins of adjacent quadrangles and was surrounded by a "moderate sampling zone", approximately four miles wide, with one site to be sampled per square mile, where possible. Beyond this area, a "light sampling zone" was established, with one site per four square miles to be sampled, where possible. Using the gridded quadrangle maps and Burke County tax parcel maps, likely sampling sites were identified and property owners contacted for permission to collect water samples. Each sampling site was designated with a number identifying the quadrangle and the location within the established grid system. The quadrangle designation number, e.g. 31Z (Figure 10), was based on the USGS water well identification grid for Georgia. For example, base flow site 31Z13SE, is in the southeast portion of grid square 13, in the Shell Bluff Landing USGS 7.5 minute

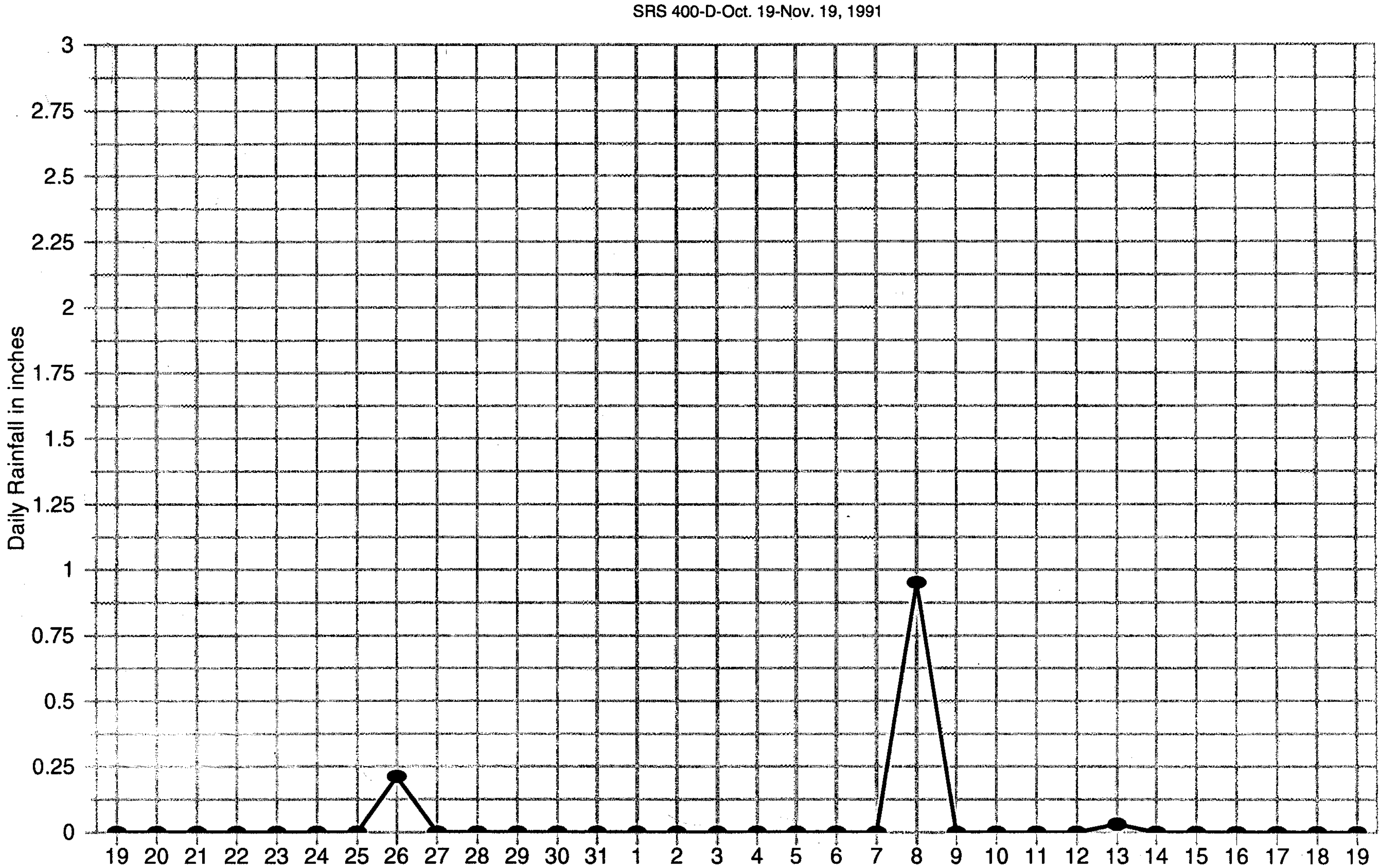

Figure 11. Daily rainfall totals from SRS Station 400-D, October 19 through November 19, 1991. Data courtesy of Westinghouse Savannah River Co.. Station location is shown in Figure 2.

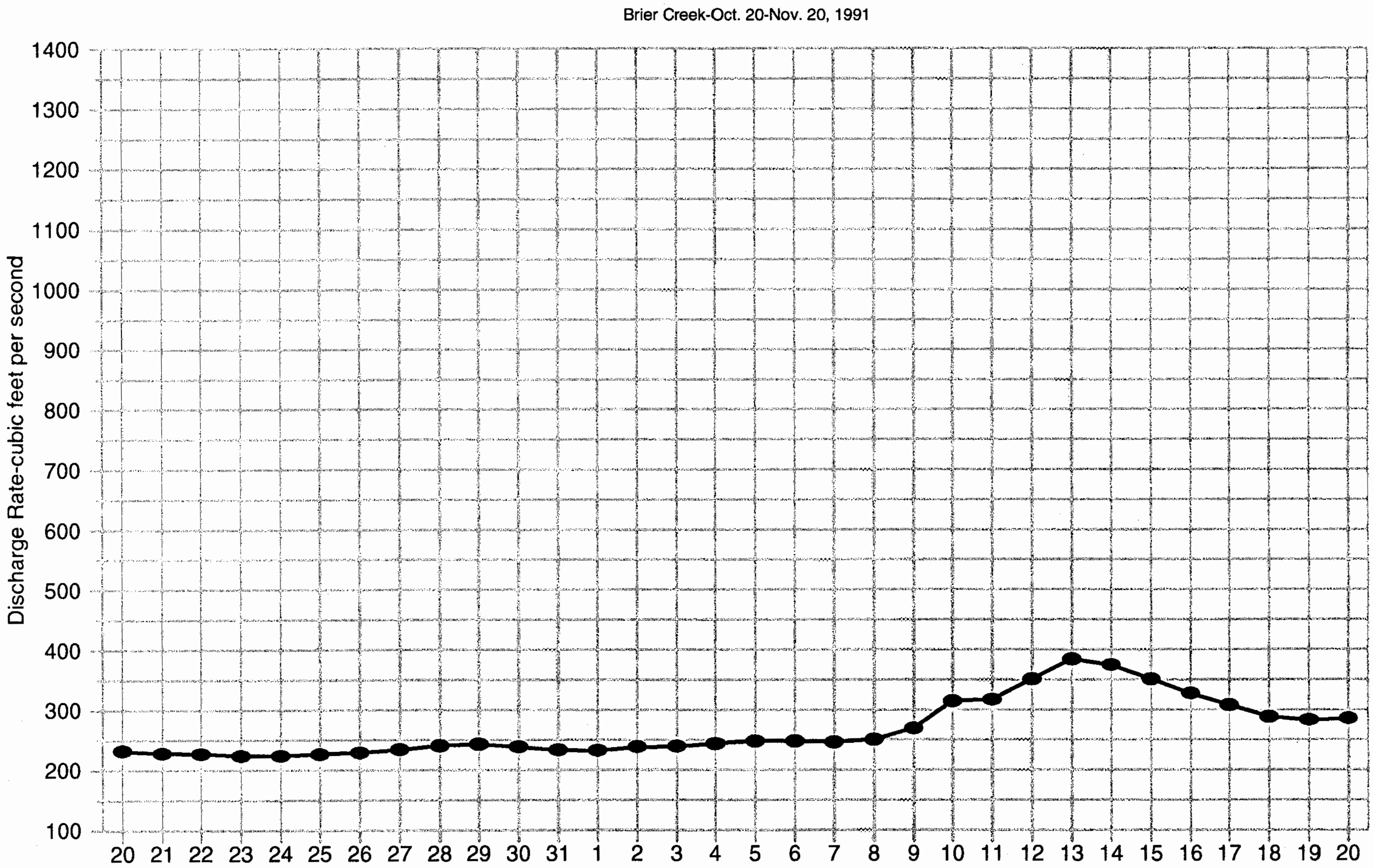

Figure 12. Daily discharge rate for Brier Creek (USGS gaging station #02197830), Burke County, Georgia, October 20 through November 20, 1991. Station location is shown in Figure 2.

					31Z Shell Bluff Landing 11 sites	32Z Girard NW 1 site	
					31Y Alexander 16 sites	32Y Girard 22 sites	
						32X Hilltonia 1 site	

Figure 13. Grid showing locations of USGS 7.5 minute quadrangles covered by the 1991 base flow study, with number of sites sampled per quadrangle. The blank quadrangles were not sampled during the 1991 base flow study.

quadrangle. Estimated latitudes and longitudes for each base flow site are listed in Appendix 1. The gridded quadrangle maps marked with site locations are stored in the GGS Technical Files in Atlanta.

The general boundaries of the 1992 study were the Burke-Screven County line to the southeast, the Savannah River to the east, McBean Creek to the north, the Norfolk Southern System Railroad tracks west of Ga. Hwy. 56 to the west, and U.S. Hwy. 25 to the southwest (Figure 2).

During the time period of September 28 through October 28, a total of 3.87 inches of rainfall was measured at SRS Station 400-D (Figure 15), from rainfall events on October 3-5, October 7, and October 11. Though this rainfall total was significantly higher than 1991, there had been no measurable rainfall from September 16 to September 25, i.e., dry conditions had existed through the latter half of September. The 1992 base flow study was conducted by EPD personnel in an area covering parts of seven USGS 7.5 minute quadrangles (Figure 16).

Stream discharge rates for Brier Creek for September 26 through October 28 are shown in Figure 17. During this time period, the highest discharge rate of 1250 cfs (cubic feet per second) was recorded on October 9 and discharge rates for October 26-28 were 332, 334, and 338 cfs, respectively.

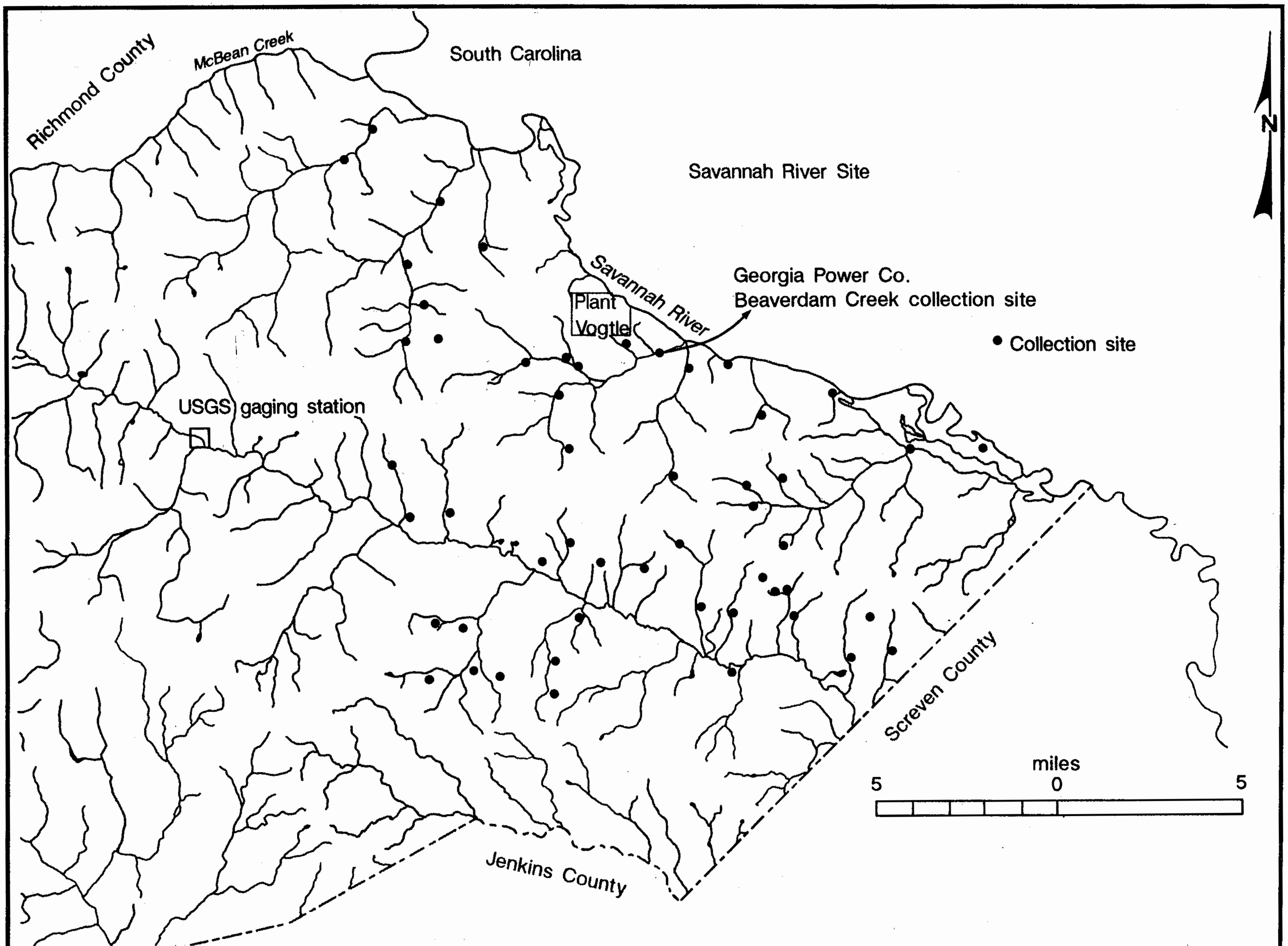

Figure 14. Locations of sampling sites for the 1991 base flow study. Closely spaced sites may be shown as one site. Modified from Summerour and others (1994).

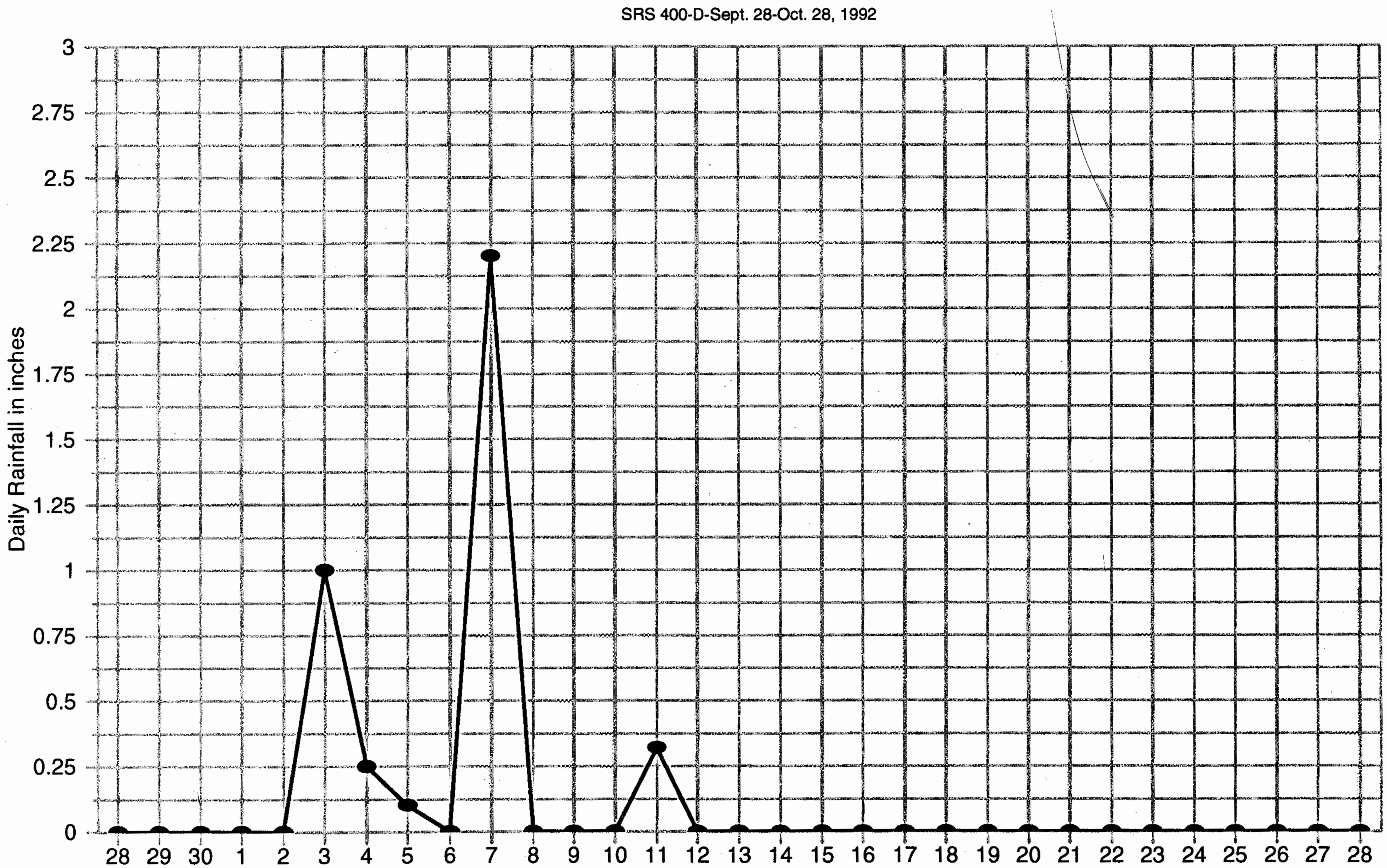

Figure 15. Daily rainfall totals from SRS Station 400-D, September 28 through October 28, 1992. Data courtesy of Westinghouse Savannah River Co.. Station location is shown in Figure 2.

				30Z **McBean** **11 sites**	**31Z** **Shell Bluff Landing** **48 sites**	**32Z** **Girard NW** **5 sites**	
				30Y **Idlewood** **6 sites**	**31Y** **Alexander** **29 sites**	**32Y** **Girard** **27 sites**	**33Y** **Millett** **4 sites**

Figure 16. Grid showing locations of USGS 7.5 minute quadrangles covered by the 1992 base flow study, with number of sites sampled per quadrangle. The blank quadrangles were not sampled during the 1992 base flow study.

The 1992 base flow study sampled 126 sites in the study area, primarily springs and first-order streams (Figure 18). Nineteen of the 126 sites were resampled from 1991 base flow study.

The parameters for the 1993 base flow study were primarily based on the grid system used for the 1992 base flow study, with an additional "zone" of new sites located beyond the boundaries of the 1992 study. These additional sites were added in order to locate the outer margin of measurable tritium concentrations. The general boundaries of the 1993 study were the Burke-Screven County line to the southeast, Savannah River to the east, Butler Creek (at Ga. Hwy. 56, south of Augusta) to the north, the cities of Blythe (southwest Richmond County), Wrens and Louisville (Jefferson County, to the northwest and southwest), Magnolia Springs State Park (to the south) and the Screven County line (to the southeast).

During the time period of September 20 through October 19, a total of .93 inches of rainfall was measured at SRS Station 400-D (Figure 19) from rainfall events of September 21 and October 16-17. Due to less rainfall, a few previously sampled sites were dry in 1993 (Appendix 2). A small amount of rain measured at SRS Station 400-D, on October 22, 25, and 26 (.11 inches, .05 inches, and .12 inches, respectively), briefly interrupted the

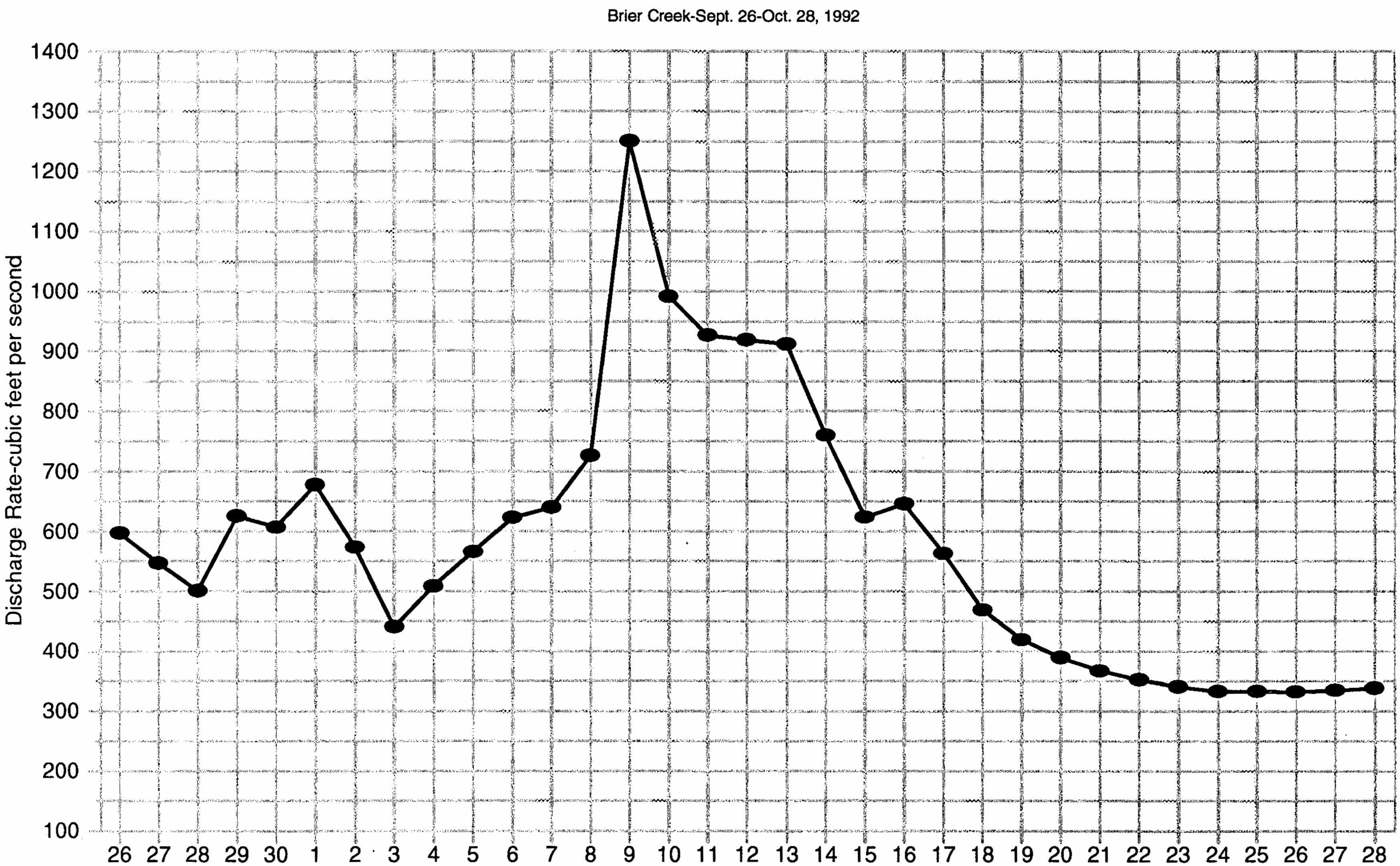

Figure 17. Daily discharge rate for Brier Creek (USGS gaging station #02197830), Burke County, Georgia, September 26 through October 28, 1992. Station location is shown in Figure 2.

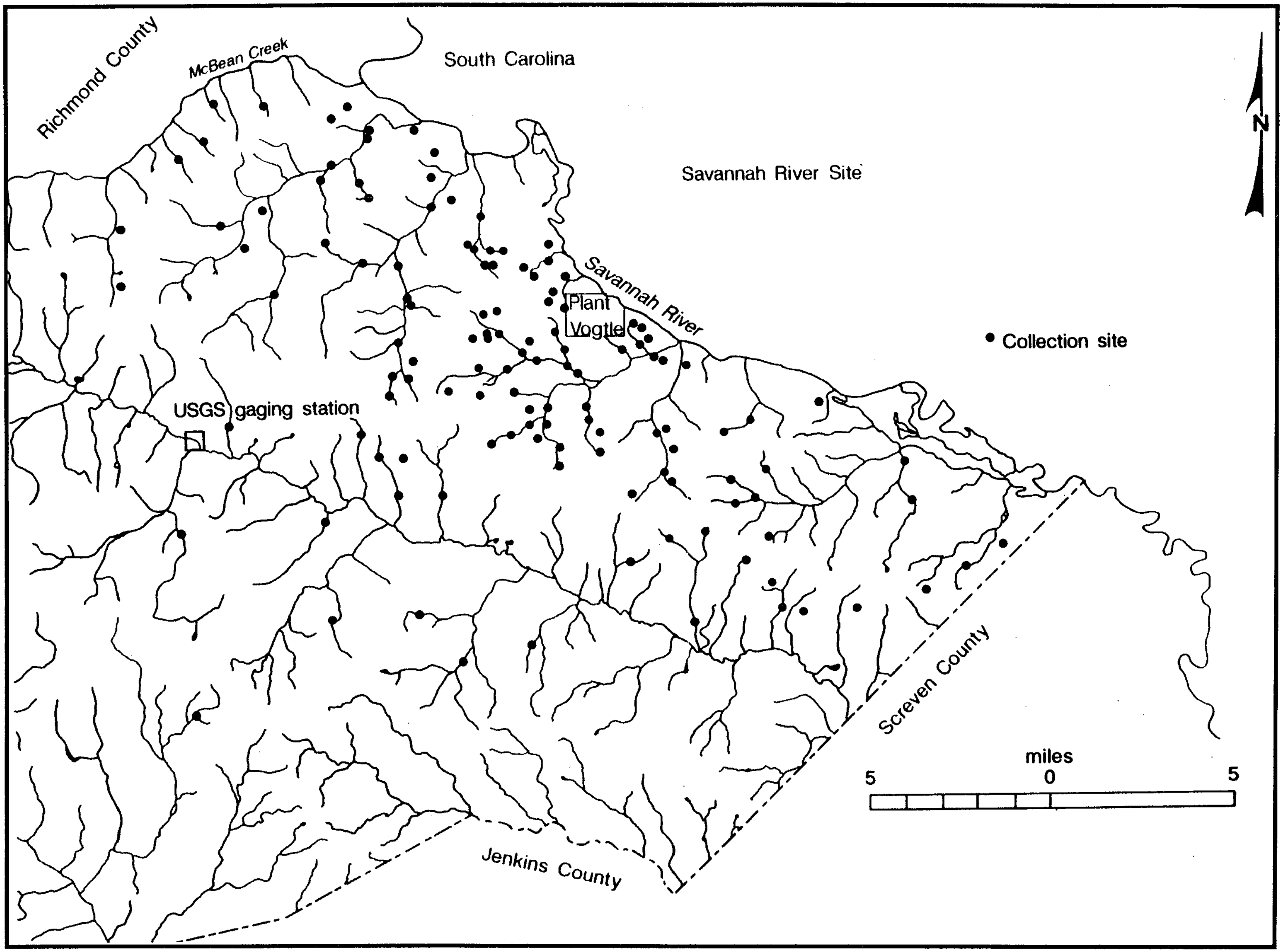

Figure 18. Locations of sampling sites for the 1992 base flow study. Closely spaced sites may be shown as one site. Modified from Summerour and others (1994).

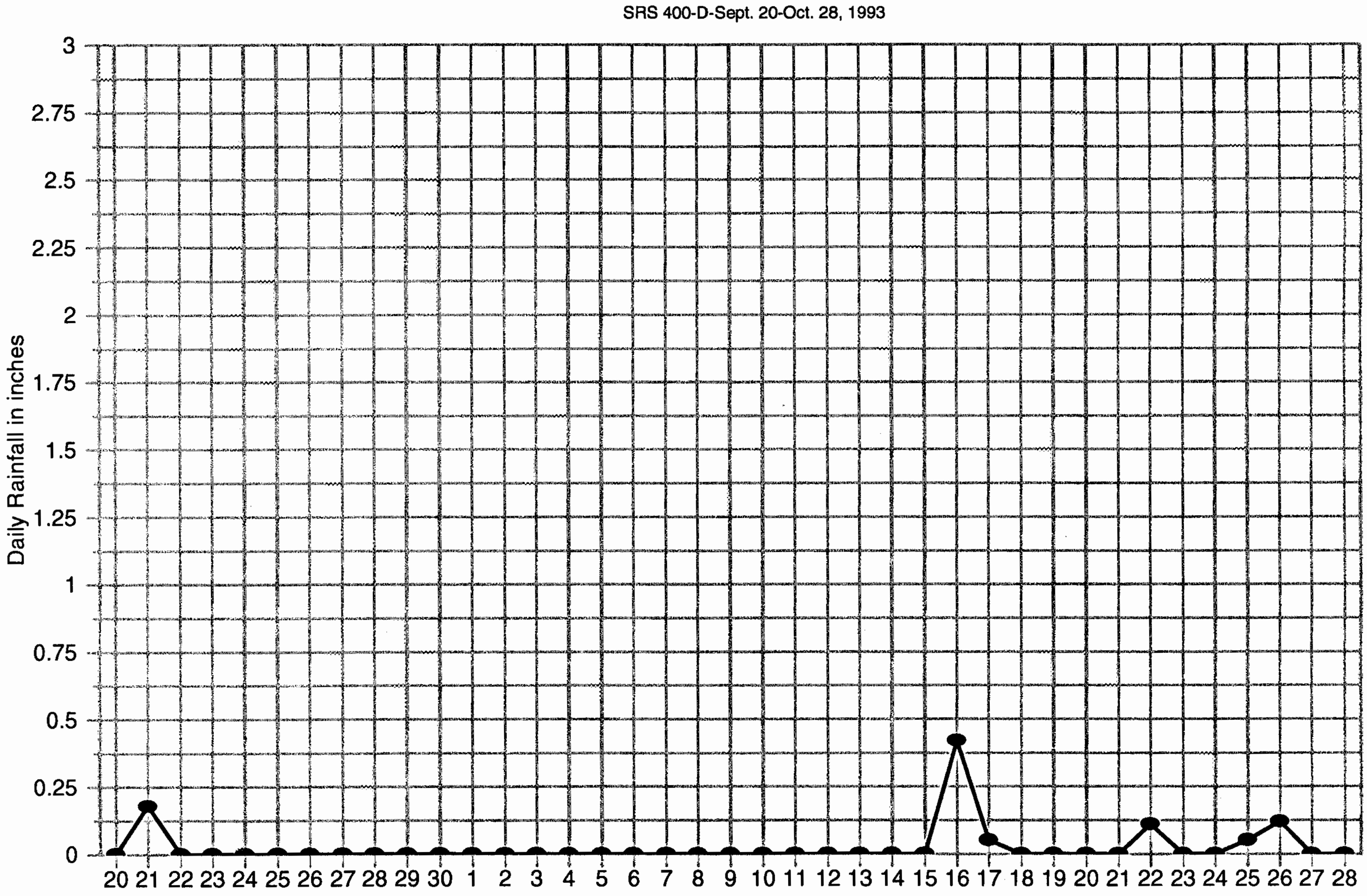

Figure 19. Daily rainfall totals from SRS Station 400-D, September 20 through October 28, 1993. Data courtesy of Westinghouse Savannah River Co.. Station location is shown in Figure 2.

base flow sampling. For the sake of comparison, six of the sites sampled during October 20-22 were resampled during October 27-28.

Stream discharge rates for Brier Creek for September 20 through October 28 are shown in Figure 20. Prior to the beginning of the 1993 base flow study, the highest discharge rate of 185 cfs was recorded on September 21. During the first three days of the base flow study (October 20-22), the discharge rates were 187, 190, and 197 cfs, respectively. Following the minor rainfall of October 22, 25, and 26, the discharge rates for October 27-28 were 187 and 181 cfs, respectively.

The 1993 base flow study was conducted by EPD and SRS personnel over parts of 21 USGS 7.5 minute quadrangles (Figure 21). Most of the 188 sites sampled are shown in Figure 22. The locations of sites outside of this area are shown on USGS 7.5 minute quadrangles in the GGS Technical Files, in Atlanta, Ga..

The 1994 base flow study covered parts of 19 USGS 7.5 minute quadrangles, most of the area sampled during the 1993 study (Figure 23). During the time period of October 8 through November 11, a total of 6.23 inches of rainfall was measured at SRS Station 400-D (Figure 24), from rainfall events of October 9-14, October 21-22, October 29-30, and November 10-11. This rainfall total was slightly more than double the approximate 3 inch (per month) average for October and November for the Augusta region (Figure 3). Because of this, the 1994 base flow sampling was conducted during November 7-10.

Stream discharge rates for Brier Creek, at Waynesboro, for October 7 through November 10, are shown in Figure 25, with the highest discharge rate of 2430 cfs recorded on October 16. The discharge rates for November 7-10 were 519 cfs, 450 cfs, 408 cfs, and 412 cfs, respectively.

The approximate locations of the 1994 base flow sites are shown in Figure 26. These sites as well as sites collected outside the map area (of Figure 27) are shown in detail on USGS 7.5 minute quadrangle maps in the GGS Technical Files in Atlanta, Georgia.

The 1995 base flow study concentrated primarily on the "core" of the Tritium Project study area, northward into southern Richmond County and westward to include the Waynesboro area, an area which covers parts of 13 USGS 7.5 minute quadrangles (Figure 27). The sampling was conducted by EPD personnel during October 25-27, 1995. During the time period of September 25 through October 27, a total of 1.23 inches of rainfall was measured at SRS Station 400-D (Figure 28), from rainfall events of September 26, October 4, and October 13-14.

Stream discharge rates of Brier Creek, near Millhaven, Ga., in Screven County (approximately 20 miles downstream from Waynesboro) are shown in Figure 29. During September 25 through October 27, the highest discharge rate of 1430 cfs (cubic feet per second) was recorded on September 30 and discharge rates for October 25-27 were 351 cfs, 327 cfs, and 318 cfs, respectively.

The 1995 base flow sampling sites are shown in Figure 30.

RESULTS

Tritium concentrations of the 1991 base flow samples ranged from 400 (+/- 100) to 1900 (+/-200) picoCuries per liter. The areal distribution of tritium, based on results of the 1991 base flow study, is shown as an isopleth (contour) map in Figure 31. The highest surface water tritium concentrations occur near the Savannah River, northwest and west of Hancock Landing on the Shell Bluff Landing USGS 7.5 minute quadrangle. From

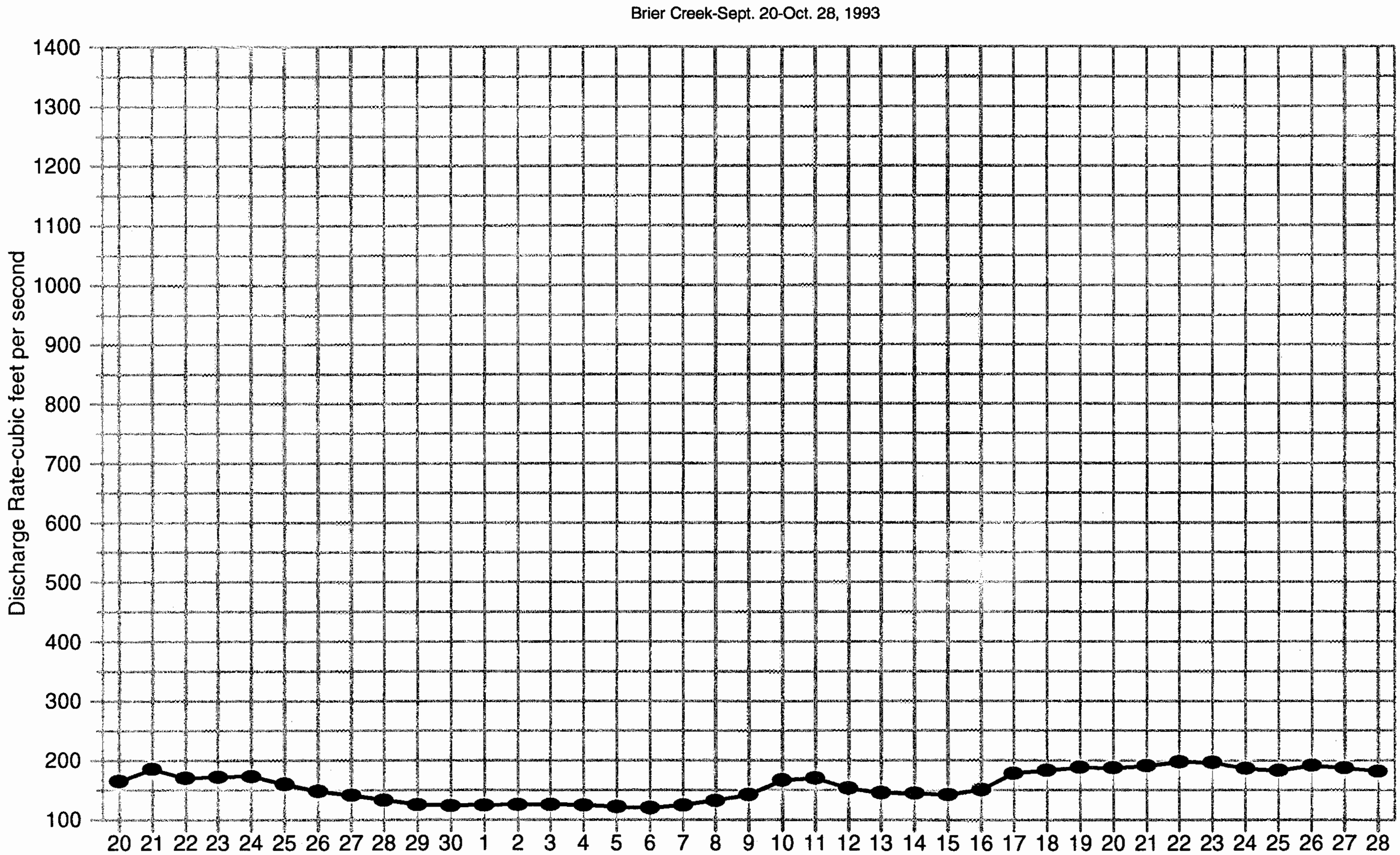

Figure 20. Daily discharge rate for Brier Creek (USGS gaging station #02197830), Burke County, Georgia, September 20 through October 28, 1993. Station location is shown in Figure 2.

			29BB Augusta West 1 site				
		28AA Blythe 3 sites	29AA Hephzibah 7 sites	30AA Mechanic Hill 5 sites			
26Z Wrens 1 site	27Z Matthews 6 sites	28Z Keysville 6 sites	29Z Storys Millpond 6 sites	30Z McBean 11 sites	31Z Shell Bluff Landing 53 sites	32Z Girard NW 5 sites	
26Y Louisville 2 sites	27Y Kellys Pond 5 sites	28Y Gough 5 sites	29Y Waynes-boro 4 sites	30Y Idlewood 7 sites	31Y Alexander 25 sites	32Y Girard 14 sites	33Y Millett 5 sites
				30X Perkins 2 sites	31X Sardis 2 sites		

Figure 21. Grid showing locations of USGS 7.5 minute quadrangles covered by the 1993 base flow study, with number of sites sampled per quadrangle. The blank quadrangles were not sampled during the 1993 base flow study.

this area, tritium concentrations decrease northwest, west, south, and southeast.

The results of the 1991 and subsequent base flow studies are listed in Appendix 2.

Tritium concentrations of the 1992 base flow samples ranged from below detection limits (<100) to 2200 picoCuries per liter. The areal distribution of tritium, based on results of the 1992 base flow study, is shown as an isopleth (contour) map in Figure 32. Because of advance planning, more favorable sampling sites (springs and first-order creeks versus road crossings of larger streams) were available for the 1992 collection. The larger area and greater density of sites yielded a 2000 picoCurie isopleth northwest of Hancock Landing and a better definition of existing isopleths, especially the 500 picoCurie isopleth. The highest tritium concentrations of the 1992 base flow study are in the same general area (north and northwest of Hancock Landing) as 1991. Similar to the 1991 isopleth map, tritium concentrations decrease to the northwest, west, south, and southeast. Comparisons of the 1991 and 1992 isopleth maps (Figures 31 and 32) indicate an apparent "contraction" of the 1500, 1000, and 500 picoCurie isopleths.

Tritium concentrations of the 1993 base flow samples ranged from below detection limits (<100) to 2100 (+/- 200) picoCuries per liter. The areal distribution of

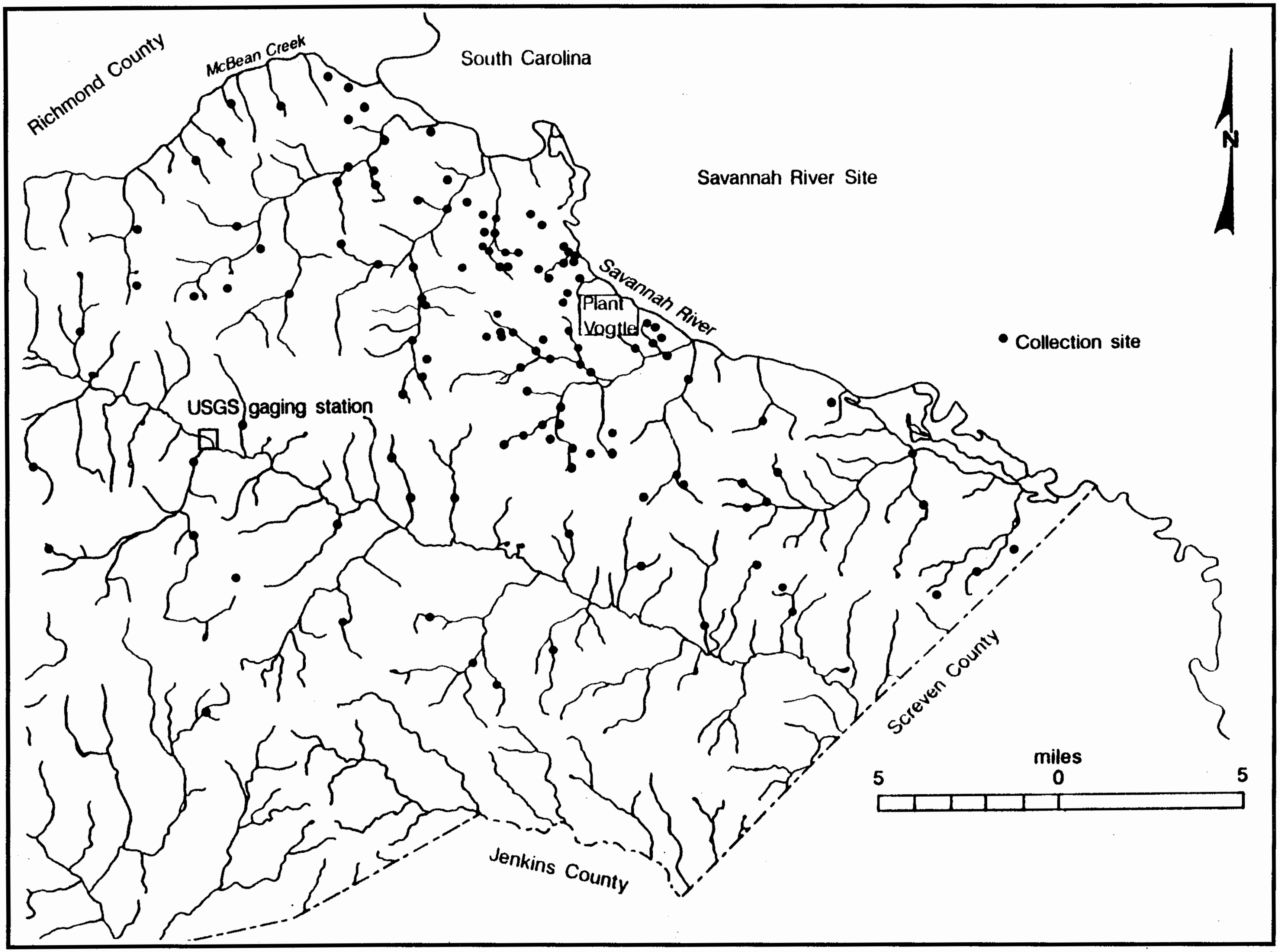

Figure 22. Approximate locations of sampling sites for the 1993 base flow study. Closely spaced sites may be shown as one site. Sites sampled outside of this map area are shown on USGS 7.5 minute quadrangles in GGS Technical Files.

			29BB Augusta West 1 site				
		28AA Blythe 2 sites	29AA Hephzibah 6 sites	30AA Mechanic Hill 5 sites			
	27Z Matthews 6 sites	28Z Keysville 6 sites	29Z Storys Millpond 3 sites	30Z McBean 11 sites	31Z Shell Bluff Landing 44 sites	32Z Girard NW 5 sites	
	27Y Kellys Pond 5 sites	28Y Gough 5 sites	29Y Waynes-boro 4 sites	30Y Idlewood 11 sites	31Y Alexander 26 sites	32Y Girard 27 sites	33Y Millett 5 sites
				30X Perkins 2 sites	31X Sardis 2 sites		

Figure 23. Grid showing locations of USGS 7.5 minute quadrangles covered by the 1994 base flow study, with number of sites sampled per quadrangle. The blank quadrangles were not sampled during the 1994 base flow study.

tritium, based on results of the 1993 base flow study, is shown as an isopleth map in Figure 34. The highest tritium concentrations are in the same area as the 1991 and 1992 base flow studies, north and northwest of Hancock Landing. Comparisons of the 1991, 1992, and 1993 isopleth maps indicate a continuation of the apparent "contraction" of the 2000, 1500, 1000, and 500 picoCurie isopleths. The addition of sampling sites around the city of Waynesboro resulted in the appearance of a 500-picoCurie "island" on the isopleth map (Figure 33). As previously mentioned, there was a small amount of rainfall between the two time periods of sample collection. Of the six sites resampled, five were within 100 picoCuries of the initial samples, while the sixth sample measured within 200 picoCuries.

The expansion of the sampling area enabled the identification of the "margin" of measurable tritium in surface waters and the Upper Three Runs aquifer. All samples from the geographic margins of the study area measured at or below the detection limit for tritium (100 picoCuries per liter +/- 100). As defined by the 1993 base flow study, the approximate margin of detectable tritium extends through the following USGS 7.5 minute quadrangles (Figure 21)-Millett, Girard, Sardis, Perkins (Jenkins County), Kellys Pond, Louisville, and Wrens (Jefferson

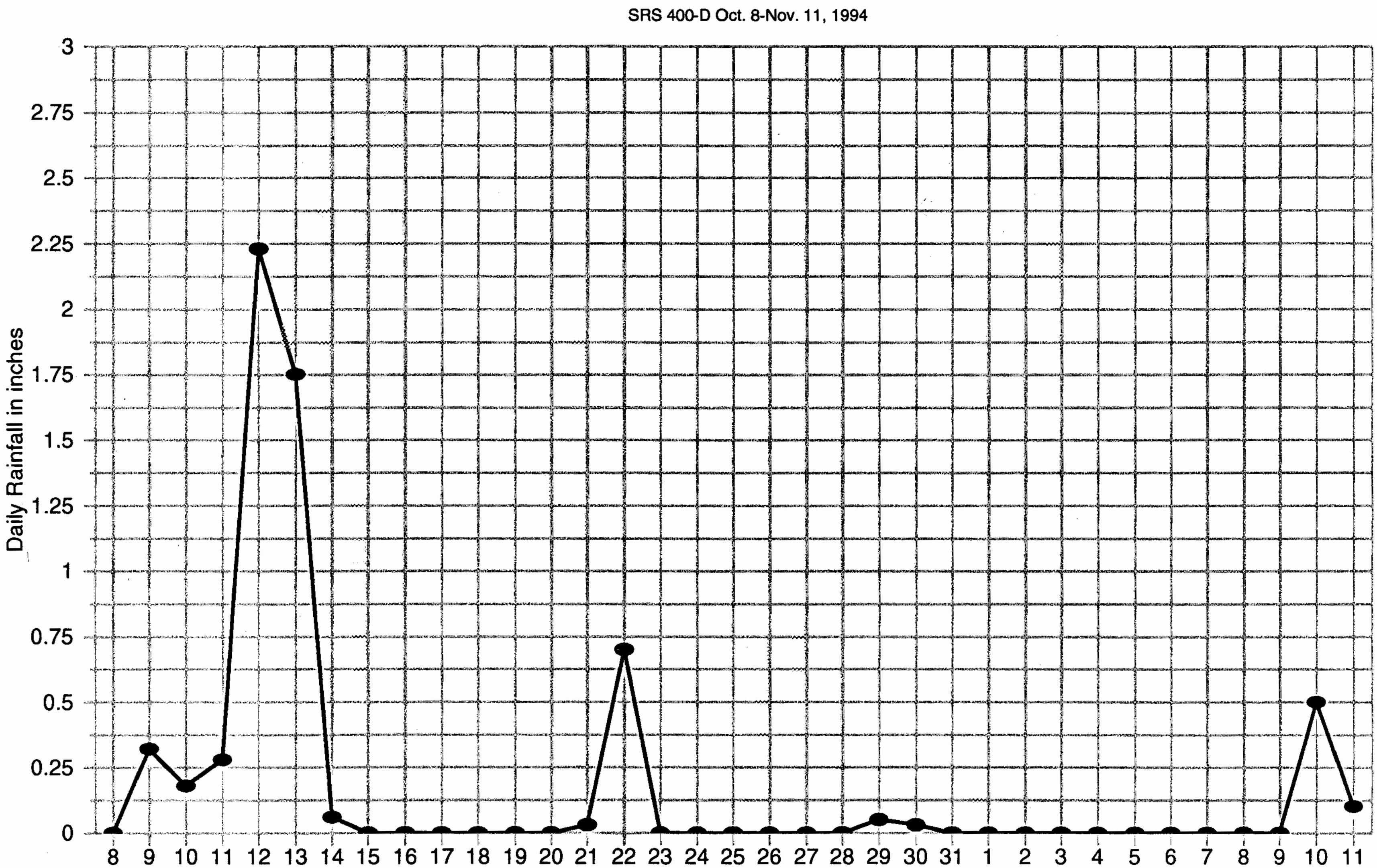

Figure 24. Daily rainfall totals from SRS Station 400-D, October 8 through November 11, 1994. Data courtesy of Westinghouse Savannah River Co.. Station location is shown in Figure 2.

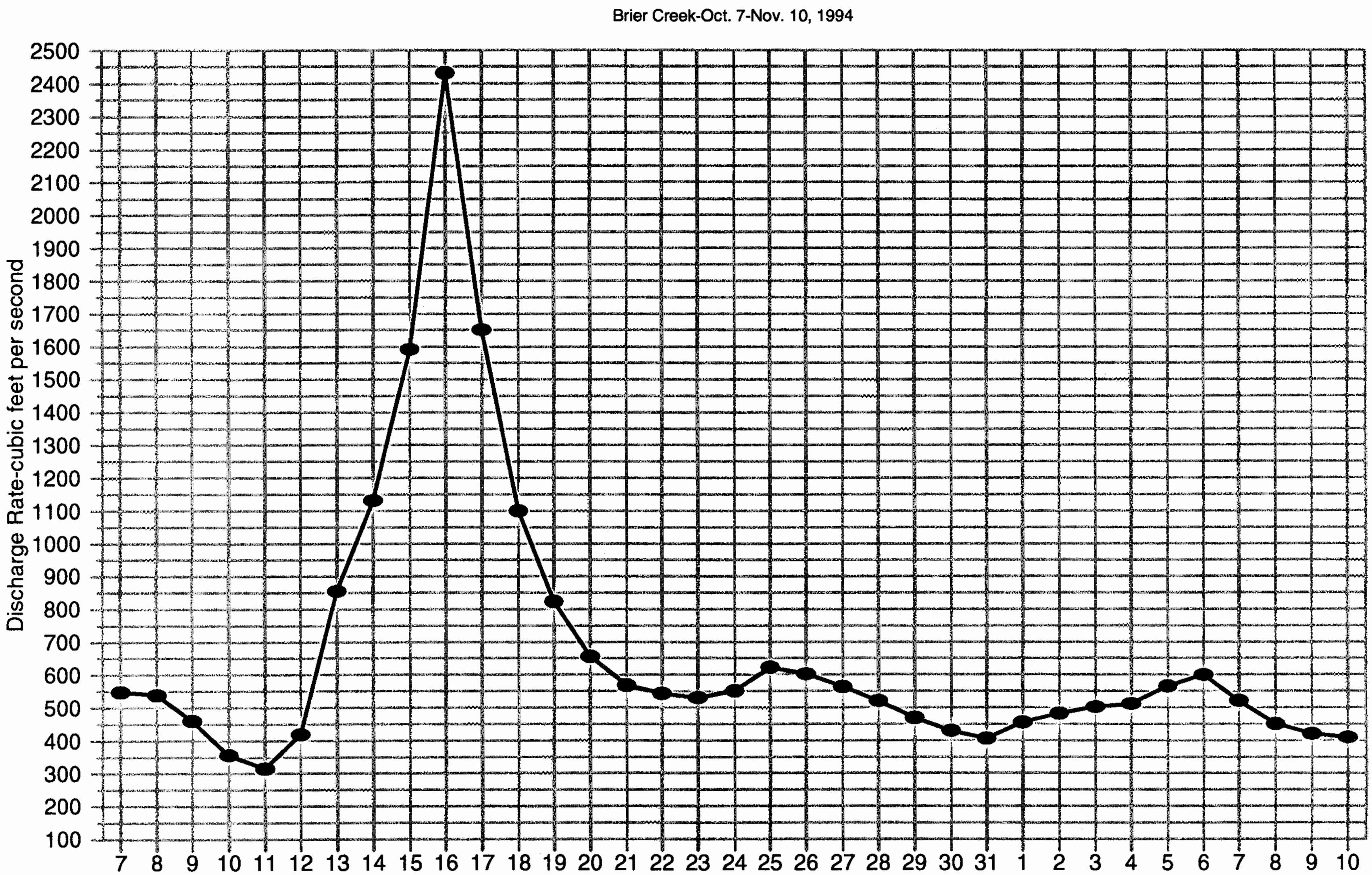

Figure 25. Daily discharge rate for Brier Creek (USGS gaging station #02197830), Burke County, Georgia, October 7 through November 10, 1994. Station location shown in Figure 2.

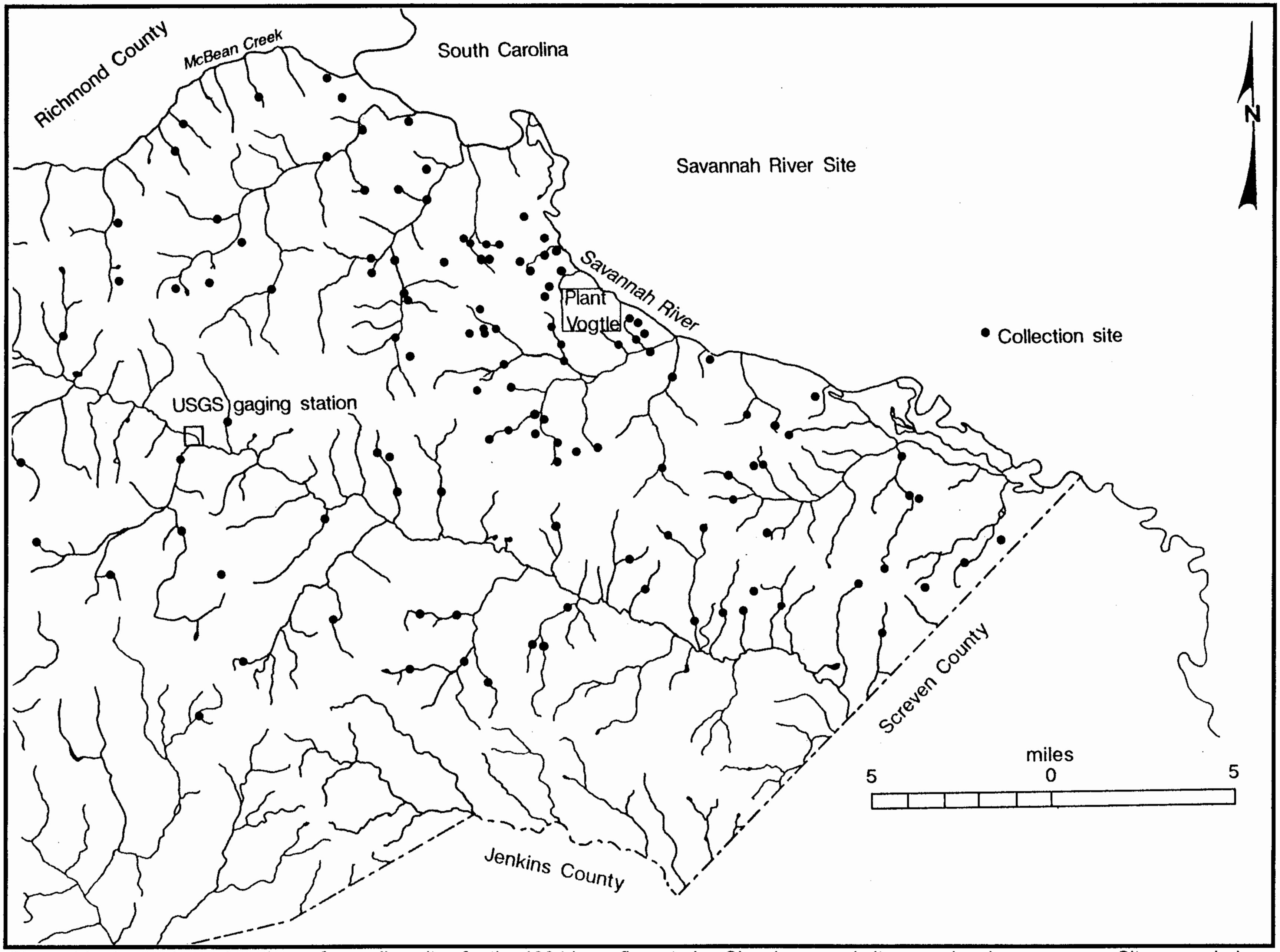

Figure 26. Approximate locations of sampling sites for the 1994 base flow study. Closely spaced sites may be shown as one. Sites sampled outside of this map area are shown on USGS 7.5 minute quadrangles in GGS Technical Files.

			29BB Augusta West 1 site				
			29AA Hephzibah 7 sites	30AA Mechanic Hill 2 sites			
			29Z Storys Millpond 4 sites	30Z McBean 9 sites	31Z Shell Bluff Landing 43 sites	32Z Girard NW 5 sites	
		28Y Gough 5 sites	29Y Waynes-boro 4 sites	30Y Idlewood 9 sites	31Y Alexander 26 sites	32Y Girard 23 sites	33Y Millett 5 sites

Figure 27. Grid showing locations of USGS 7.5 minute quadrangles covered by the 1995 base flow study, with number of sites sampled per quadrangle. The blank quadrangles were not collected during the 1995 base flow study.

County), Blythe and Augusta West (Richmond County).

With the northward expansion of the study area into southern Richmond County (Hephzibah and Mechanic Hill quadrangles), several base flow sample sites were within the recharge area of the Gordon aquifer (Brooks, et al, 1985; Gorday, 1985). Five sites sampled in southern Richmond County, measured between between 200 and 500 picoCuries per liter. In this area, north of the McBean Creek drainage basin, the Gordon aquitard (Lisbon Formation) is absent due to erosion and/or non-deposition in updip areas (see map, Hetrick, 1992). In these updip areas, close to the "Fall Line", the entire aquifer system is vertically connected and behaves as a single unconfined aquifer due to coarser-grained sediments and the absence of aquitards. This unconfined aquifer is recharged by rainfall infiltration into exposed outcrop areas and interstream drainage divides near outcrop areas (Brooks, et al, 1985; Gorday, 1985), which suggests that there is a potential pathway for tritium to enter the Gordon aquifer in southern Richmond County.

The 1994 base flow study was conducted by EPD personnel during the time period of November 8-11, 1994, later than usual because of an unusually wet October.

The tritium concentrations of the 1994 base flow samples ranged from below

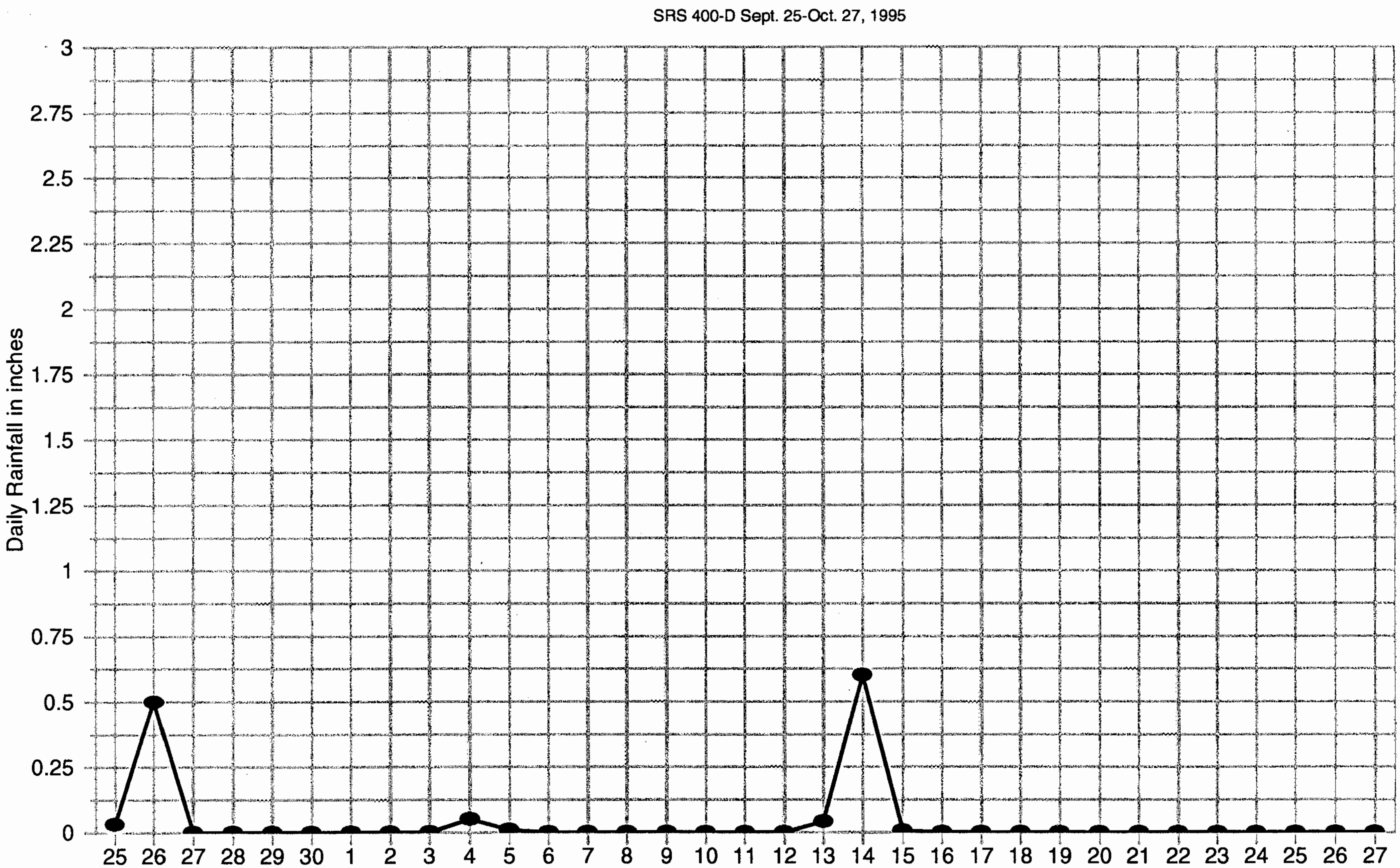

Figure 28. Daily rainfall totals from SRS Station 400-D, September 25 through October 27, 1995. Data courtesy of Westinghouse Savannah River Co.. Station location is shown in Figure 2.

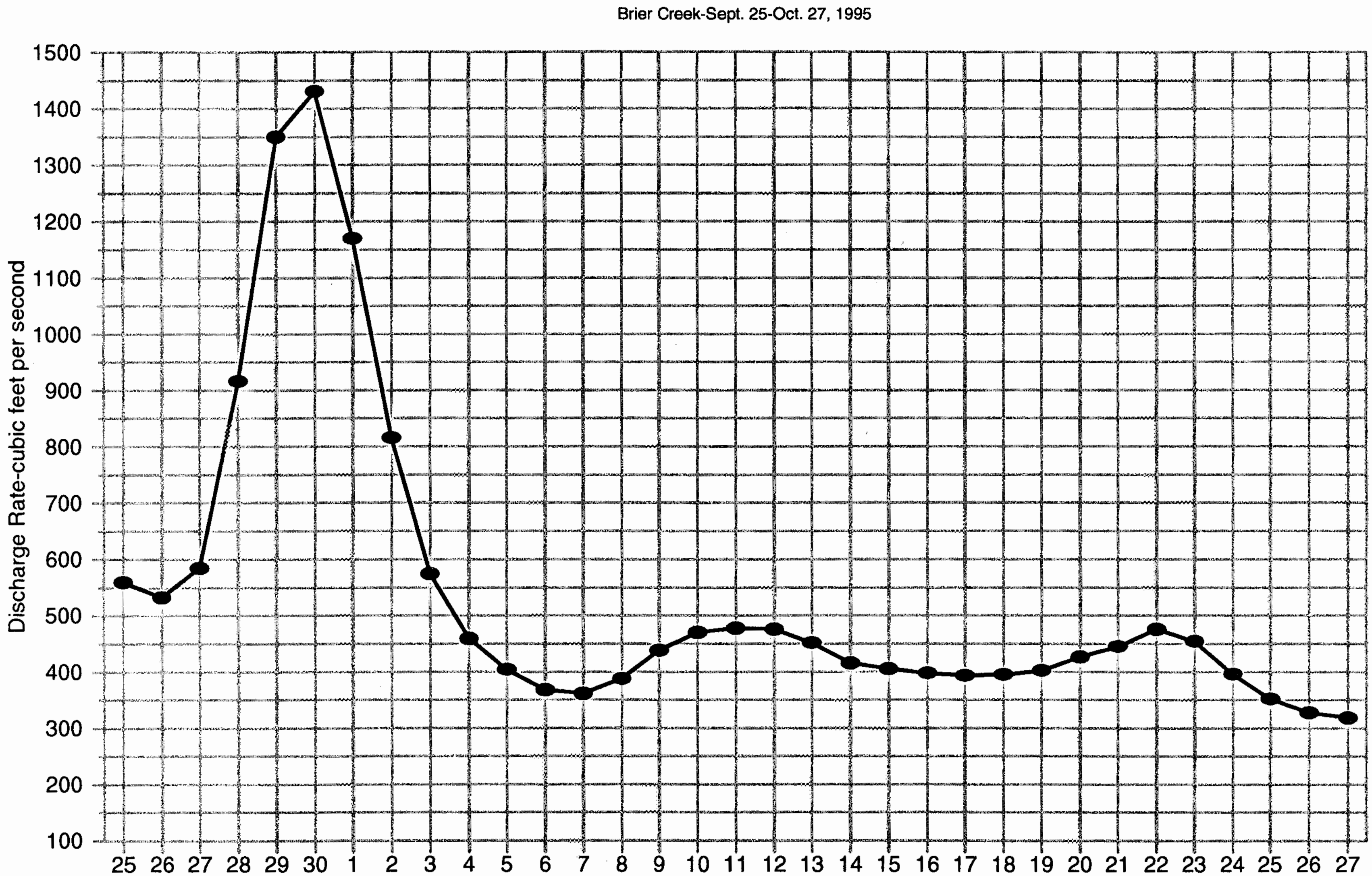

Figure 29. Daily discharge rate for Brier Creek (USGS gaging station #02198000), Screven County, Georgia, September 25 through October 27, 1995. Station location is shown in Figure 2.

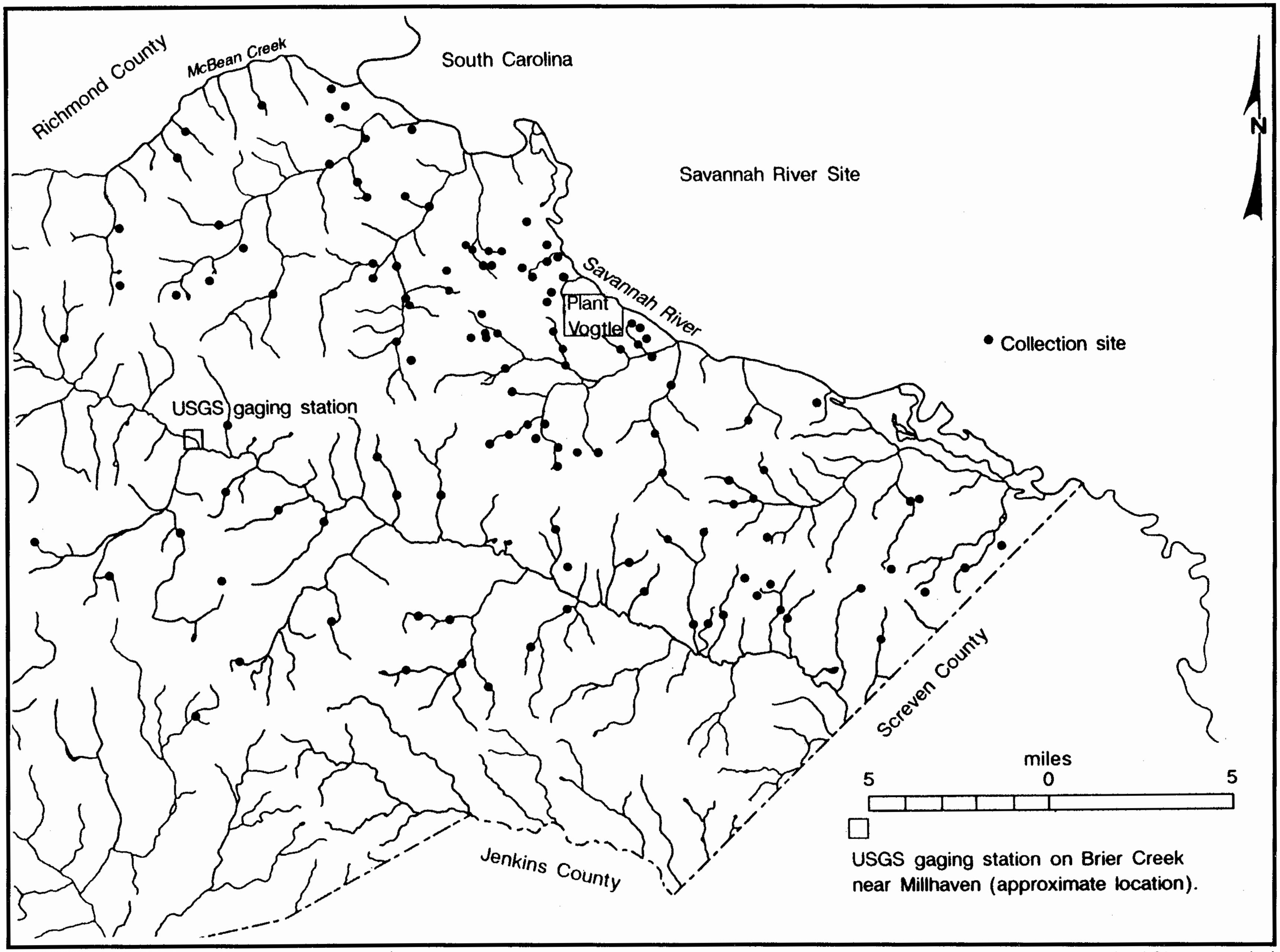

Figure 30. Approximate locations of sampling sites for the 1995 base flow study. Closely spaced sites may be shown as one site. Sites sampled outside of this map area are shown on USGS 7.5 minute quadrangles in GGS Technical Files.

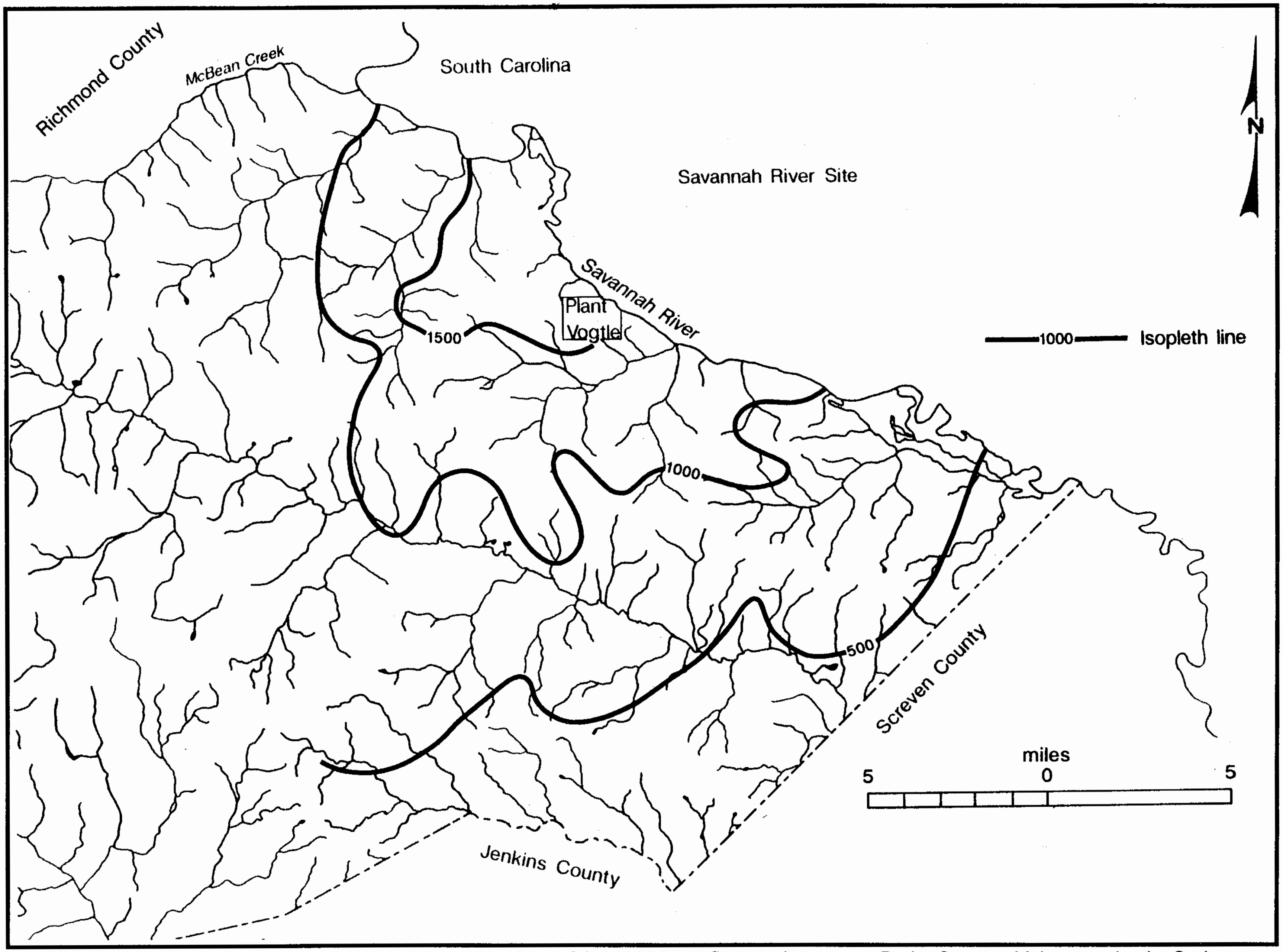

Figure 31. Isopleth map based on surface water tritium values of the 1991 base flow study, eastern Burke County. Values are in picoCuries per liter. Modified from Summerour and others (1994).

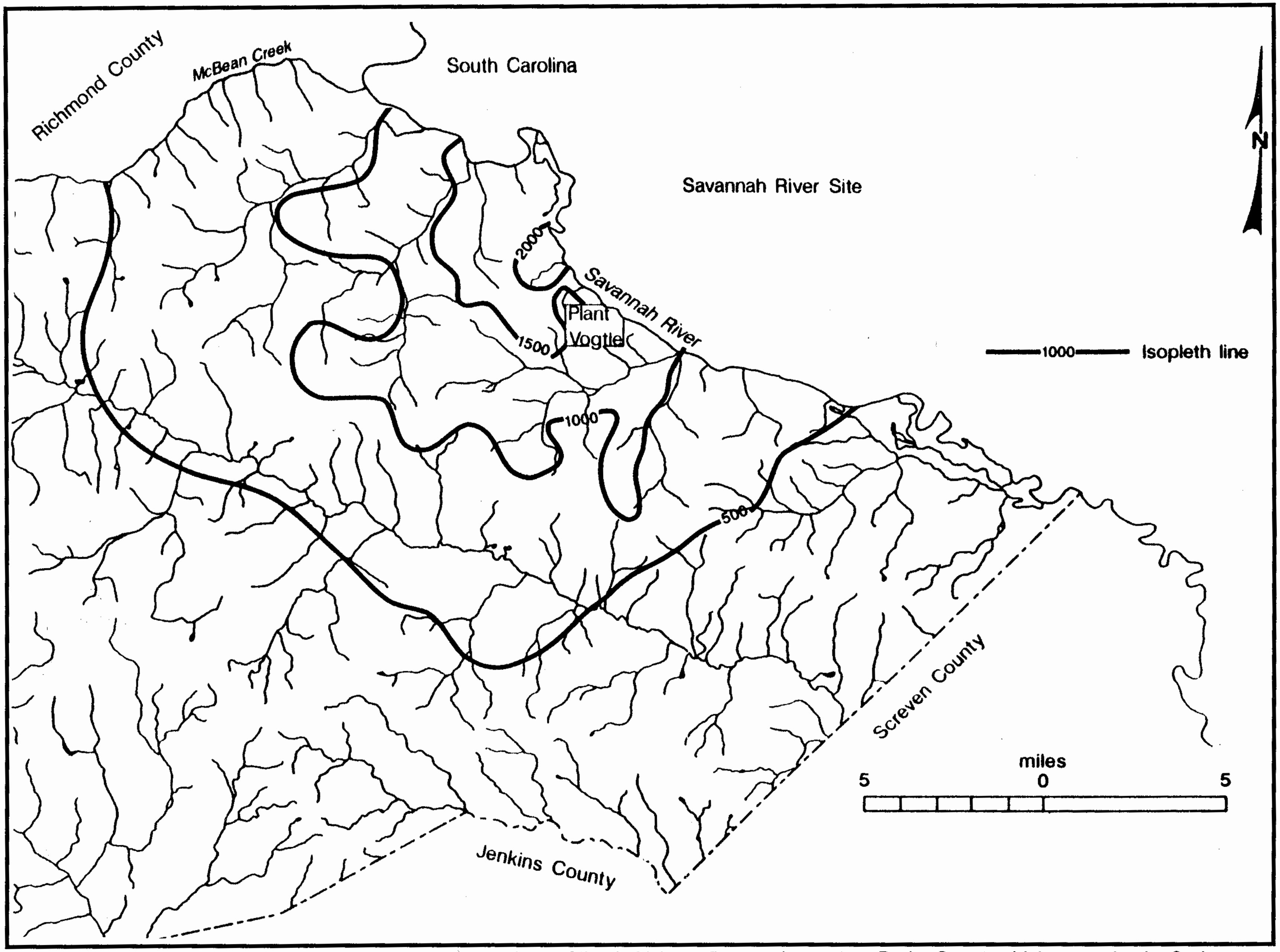

Figure 32. Isopleth map based on surface water tritium values of the 1992 base flow study, eastern Burke County. Values are in picoCuries per liter. Modified from Summerour and others (1994).

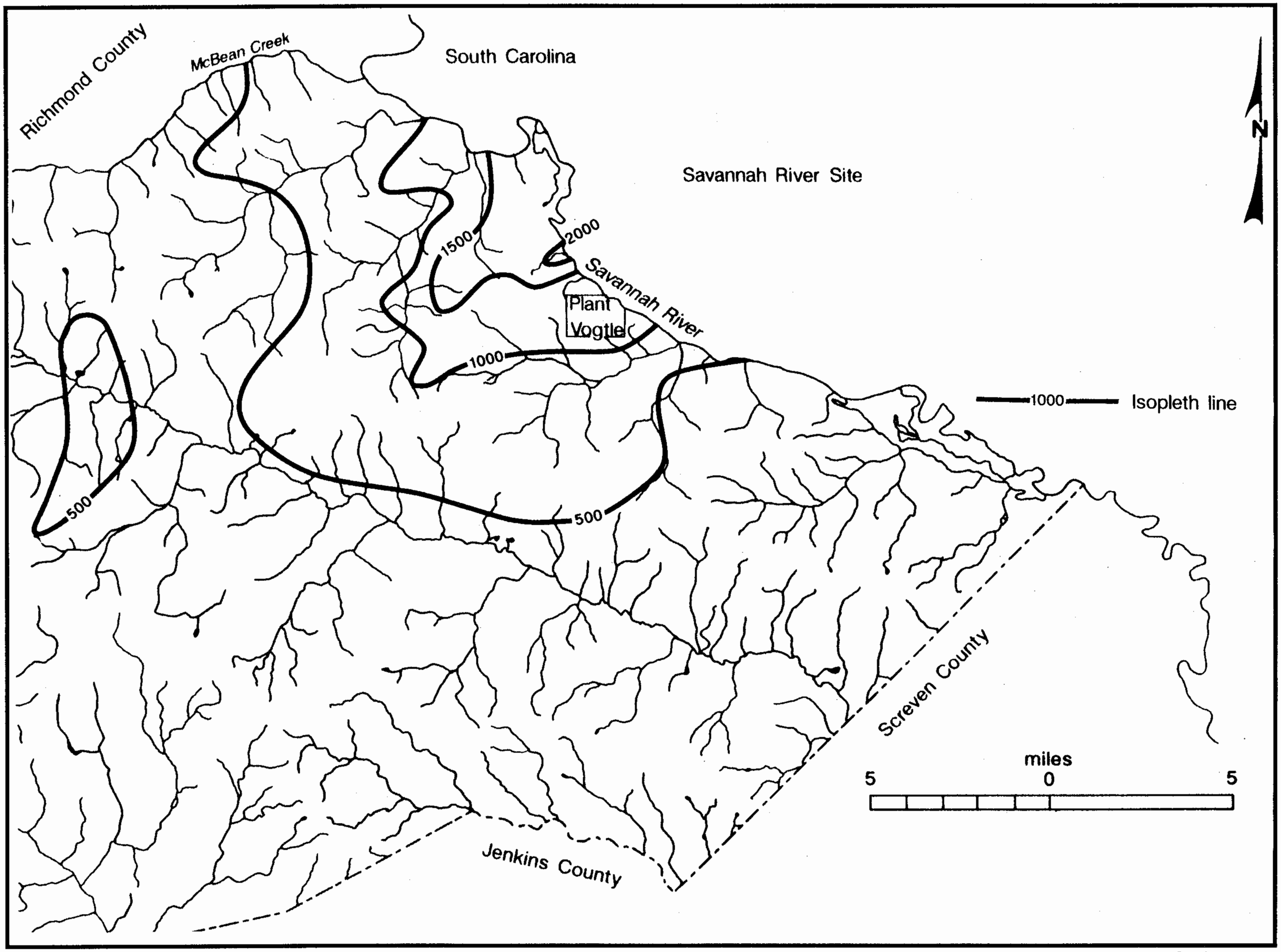

Figure 33. Isopleth map based on surface water tritium values of the 1993 base flow study, eastern Burke County. Values are in picoCuries per liter.

detection limits (<100) to 2200 picoCuries per liter. The areal distribution of tritium, based on results of the 1994 base flow study, is shown as an isopleth (contour) map in Figure 34.

The 1995 base flow study was conducted by EPD personnel during the time period of October 25-27, 1995. Some peripheral areas covered in the 1993 and 1994 base flow studies were not resampled. Most of these peripheral sites had shown no detectable values, i.e., <100 picoCuries per liter.

The tritium concentrations of the 1995 base flow samples ranged from below detection limits (<100) to 1600 picoCuries per liter. The areal distribution of tritium, based on results of the 1995 base flow study, is shown as an isopleth map in Figure 35.

CONCLUSIONS

Results of the five base flow studies (1991 through 1995) consistently showed the area of highest tritium values to be near the Savannah River, north of Hancock Landing Rd. and east of River Rd., northwest of Ga. Power Plant Vogtle (Figures 31 through 35). The areal distribution of tritium values in Georgia is similar to the rainfall tritium distribution pattern based on SRS rainfall collections and analyses from 1982 through 1986 (Figure 6). The expanded area of the 1993 base flow study approximated the current "margin" of measurable tritium in surface waters. As defined by the 1993 base flow study, the area of detectable surface water tritium is within the confines of Burke County and southernmost Richmond County.

The 500 picoCurie isopleths shown in Figure 36 illustrate an apparent "contraction" of the isopleths from 1991-1993. With +/- 100 picoCurie variations (20% of 500 picoCuries) possible with low resolution analyses of the samples, small "movements" of the 1994 and 1995 500 picoCurie isopleths (in comparison to the 1993 isopleth) indicate a possible stabilization of tritium values from 1993 through 1995. Longer term studies may be necessary to determine whether base flow tritium values have stabilized.

The improvement of technology in the processing and storage of tritium at SRS and the recent (since the late 1980's) decrease in SRS activity has resulted in decline of routine atmospheric releases of tritium from 595,000 Ci in 1987 to approximately 160,000 Ci in 1994 (Arnett and others, 1993; Arnett and others, 1995). If rainfall is the primary pathway for tritium migration, the decrease of atmospheric and rainfall tritium may result in a natural "flushing" of the Upper Three Runs and unconfined Gordon (north of McBean Creek) aquifers in the study area and a decline of surface water tritium concentrations. The process of radioactive decay of tritium also will contribute to the decline of surface water and groundwater tritium concentrations, though in a slower manner.

Vertical variations of tritium within the Upper Three Runs aquifer may influence base flow values. Investigations of vertical tritium distribution will be discussed in the Tritium Project Phase II report (Summerour, et al, *in preparation*). One other factor which may influence base flow values is the quantity of rainfall prior to the base flow sampling, though more years of data are needed for firm conclusions.

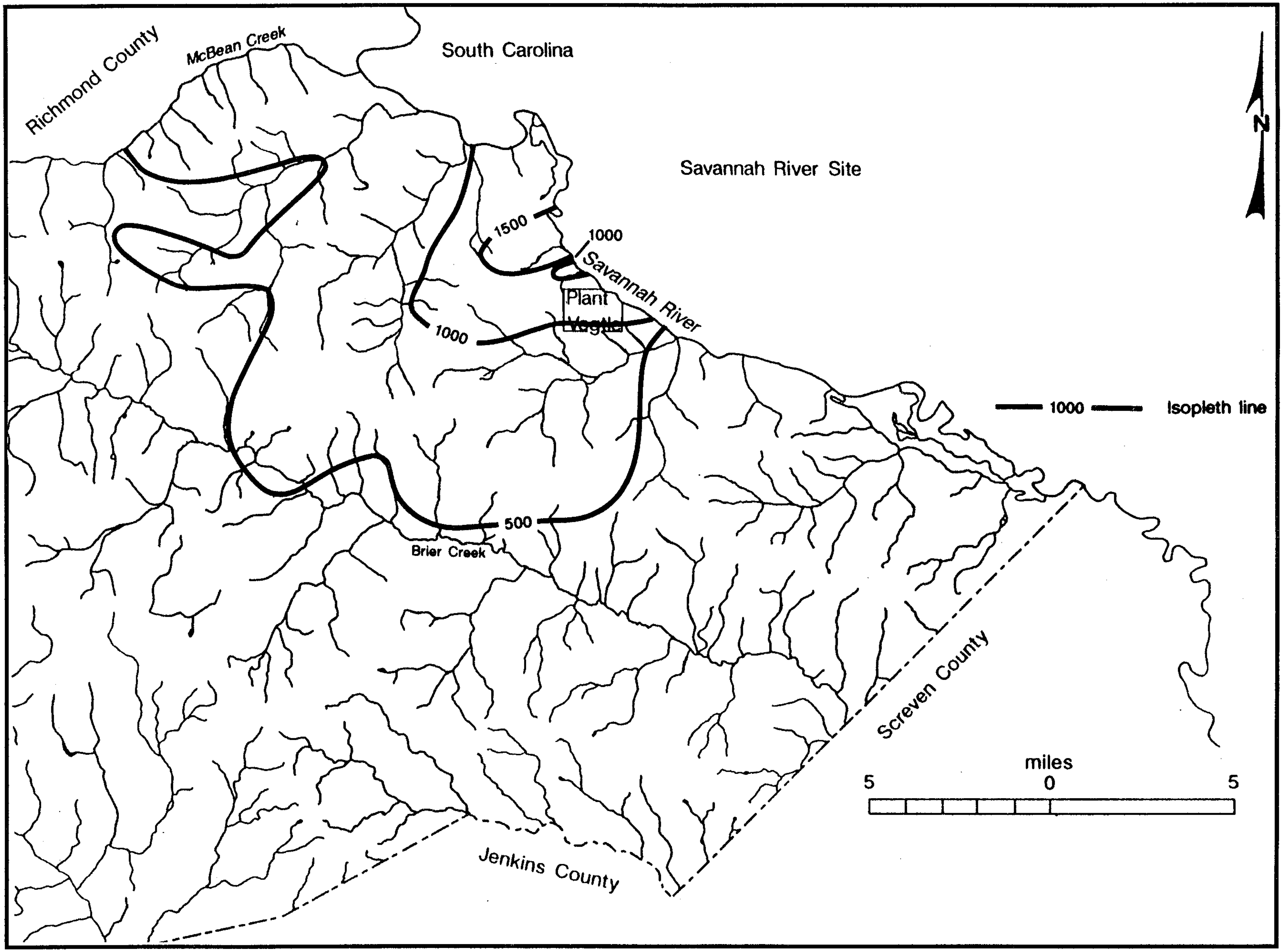

Figure 34. Isopleth map based on surface water tritium values of the 1994 base flow study, eastern Burke County. Values are in picoCuries per liter.

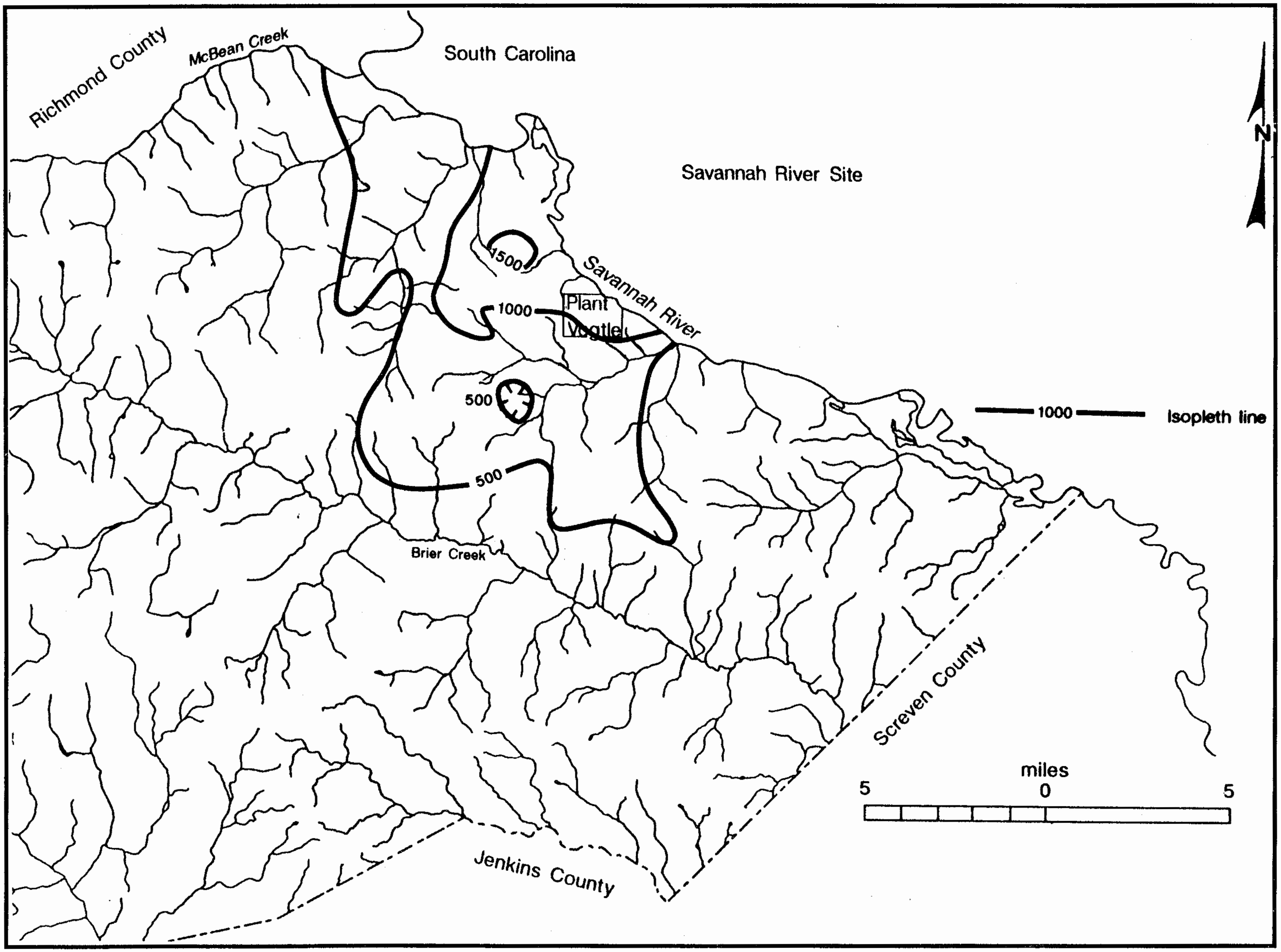

Figure 35. Isopleth map based on surface water tritium values of the 1995 base flow study, eastern Burke County. Values are in picoCuries per liter.

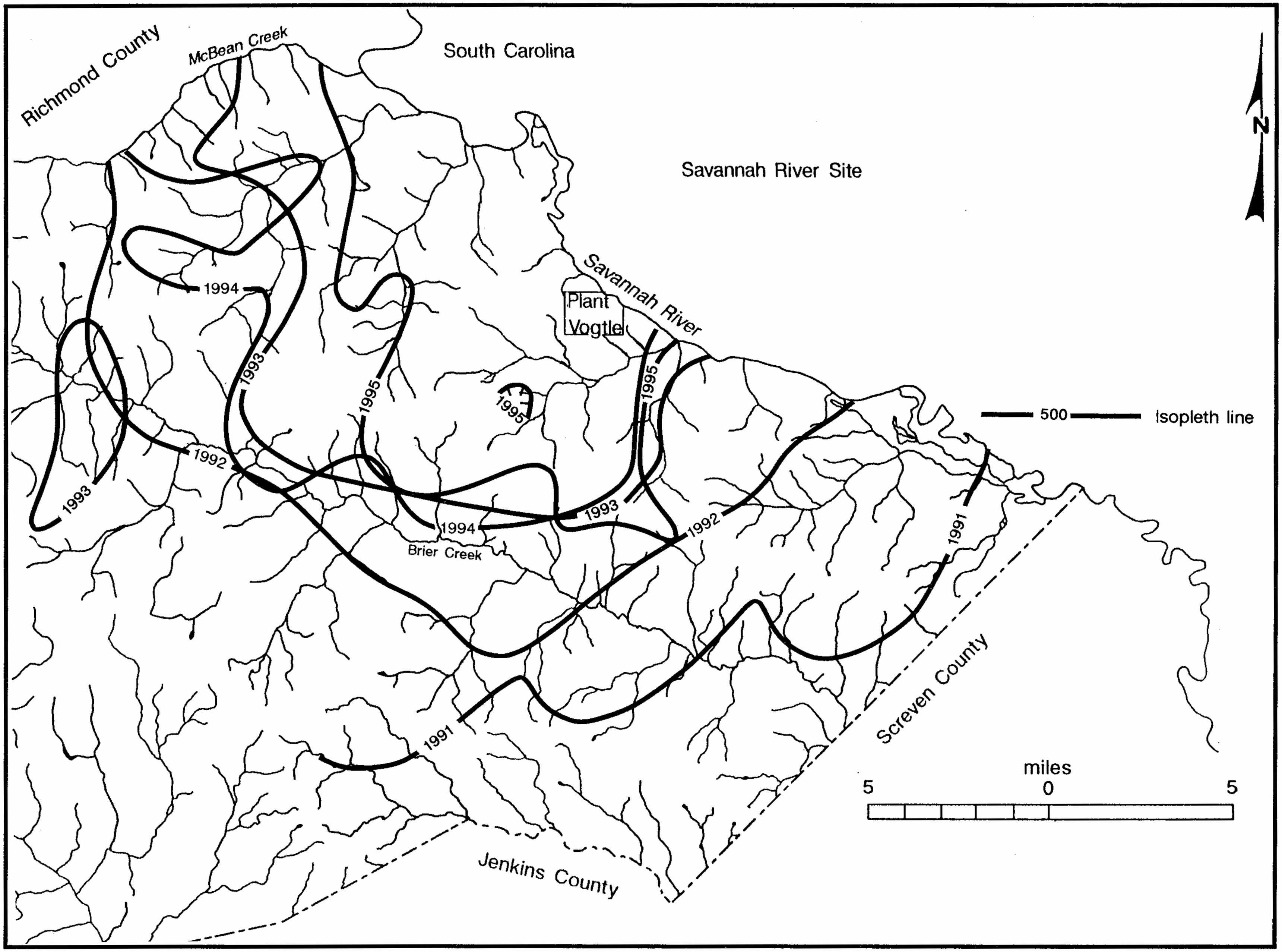

Figure 36. Isopleth map showing positions of 500 picoCurie (+/- 100) isopleths of 1991 through 1995 base flow studies.

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Appendix 1

Base Flow Sampling Sites-estimated Latitudes and Longitudes. Quadrangle numbers, e.g., 30Z) and sample numbers are based on USGS well grid number systems. Maps are on file in GGS Technical Files.

McBean Quadrangle (30Z)

Grid #	Latitude (est.)	Longitude (est.)
30Z14NE	33^0 10' 02" N	81^0 54' 36" W
30Z17NW	33^0 10' 37" N	81^0 58' 47" W
30Z21SW	33^0 10' 24" N	81^0 56' 22" W
30Z22SW	33^0 10' 17" N	81^0 57' 04" W
30Z26SE	33^0 11' 20" N	81^0 55' 25" W
30Z28NW	33^0 12' 07" N	81^0 58' 55" W
30Z31SE	33^0 12' 12" N	81^0 54' 25" W
30Z32SW	33^0 12' 00" N	81^0 55' 58" W
30Z34SE	33^0 12' 47" N	81^0 52' 45" W
30Z43NW	33^0 14' 12" N	81^0 56' 05" W
30Z44SE	33^0 13' 55" N	81^0 56' 45" W
30Z48SC	33^0 14' 45" N	81^0 54' 55" W
30Z49SW	33^0 14' 45" N	81^0 56' 00" W

Shell Bluff Landing Quadrangle (31Z)

Grid #	Latitude (est.)	Longitude (est.)
31Z02NW	33^0 08' 10" N	81^0 46' 45" W
31Z02SW-1 (SBL-11)	33^0 07' 43" N	81^0 46' 35" W
31Z02SW-2 (SBL-10)	33^0 07' 34" N	81^0 46' 35" W
31Z03NE	33^0 08' 04" N	81^0 47' 35" W
31Z03SE	33^0 07' 40" N	81^0 47' 29" W
31Z03SW	33^0 07' 46" N	81^0 47' 43" W
31Z04NE	33^0 08' 19" N	81^0 48' 28" W
31Z04NE-B spring	33^0 08' 16" N	81^0 48' 30" W
31Z04SE (SBL-9)	33^0 07' 33" N	81^0 48' 15" W
31Z06NW	33^0 08' 00" N	81^0 51' 00" W
31Z07NE	33^0 08' 00" N	81^0 51' 20" W
31Z09SE	33^0 08' 48" N	81^0 46' 20" W

Shell Bluff Landing Quadrangle (31Z) continued:

Grid #	Latitude (est.)	Longitude (est.)
31Z09NW-A spring	33^0 09' 03" N	81^0 46' 52" W
31Z09NW-1 spring	33^0 09' 11" N	81^0 46' 43" W
31Z11NE	33^0 08' 53" N	81^0 48' 22" W
31Z11SE	33^0 08' 26" N	81^0 48' 20" W
31Z11NW	33^0 08' 52" N	81^0 48' 41" W
31Z11SW	33^0 08' 25" N	81^0 48' 45" W
31Z13SE	33^0 08' 27" N	81^0 50' 30" W
31Z13SE-2 (SBL-7)	33^0 08' 36" N	81^0 50' 22" W
31Z14SE (SBL-8)	33^0 08' 35" N	81^0 51' 15" W
31Z16NE-1 creek	33^0 10' 06" N	81^0 46' 30" W
31Z16NE-2 spring, south of above	33^0 10' 04" N	81^0 46' 27" W
31Z16SE	33^0 09' 30" N	81^0 46' 07" W
31Z16NW spring, C. Overton	33^0 09' 51" N	81^0 46' 53" W
31Z16NW-2 dug pit, C. Overton	33^0 09' 49" N	81^0 46' 55" W
31Z16NW-3 creek, C. Overton	33^0 09' 51" N	81^0 46' 57" W
31Z16NW-4 spg, Thomson Oak Flring prop.	33^0 10' 03" N	81^0 47' 01" W
31Z17NE small creek, Thomson Oak Flring	33^0 10' 01" N	81^0 47' 11" W
31Z17NW spring, Roman Powell res.	33^0 09' 47" N	81^0 47' 32" W
31Z17SE	33^0 09' 33" N	81^0 47' 07" W
31Z18NE-1	33^0 09' 58" N	81^0 48' 20" W
31Z18NE-2	33^0 09' 56" N	81^0 48' 22" W
31Z19SE (near well site TR92-1)	33^0 09' 36" N	81^0 49' 30" W
31Z20SE (SBL-6)	33^0 09' 20" N	81^0 50' 35" W
31Z20SW	33^0 09' 27" N	81^0 50' 53" W
31Z22SW-1	33^0 10' 19" N	81^0 46' 40" W
31Z22SW-2 downstream	33^0 10' 17" N	81^0 46' 37" W
31Z22SE-1 small creek on logging road	33^0 10' 13" N	81^0 46' 32" W
31Z22SE-2 small creek on logging road	33^0 10' 10" N	81^0 46' 32" W
31Z23NE-1 spring	33^0 10' 48" N	81^0 47' 09" W
31Z23NE-2 spring	33^0 10' 57" N	81^0 47' 22" W

Shell Bluff Landing Quadrangle (31Z) continued:

Grid #	Latitude (est.)	Longitude (est.)
31Z23SW	33^0 10' 23" N	81^0 47' 57" W
31Z24SE	33^0 10' 25" N	81^0 48' 10" W
31Z24NE	33^0 10' 35" N	81^0 48' 30" W
31Z24NW-1 (SBL-4)	33^0 10' 35" N	81^0 48' 40" W
31Z24NW-2 Neal Moyers spring	33^0 10' 37" N	81^0 48' 47" W
31Z24NW-3	33^0 10' 41" N	81^0 48' 07" W
31Z24NW-4 spring	33^0 10' 44" N	81^0 48' 08" W
31Z25SE Eva Grubbs res.	33^0 10' 18" N	81^0 49' 18" W
31Z26SW (SBL-5)	33^0 10' 15" N	81^0 50' 53" W
31Z27NW	33^0 10' 35" N	81^0 51' 56" W
31Z27NW-A downstream from above	33^0 10' 32" N	81^0 51' 35" W
31Z27NW-B	33^0 10' 09" N	81^0 51' 38" W
31Z29SE-1	33^0 11' 12" N	81^0 48' 25" W
31Z29SE-2 spring	33^0 11' 13" N	81^0 48' 30" W
31Z30NE	33^0 11' 45" N	81^0 49' 22" W
31Z30NW (SBL-3)	33^0 11' 37" N	81^0 49' 52" W
31Z34NW spring	33^0 12' 30" N	81^0 49' 40" W
31Z35SE	33^0 12' 05" N	81^0 50' 25" W
31Z36SE	33^0 12' 18" N	81^0 51' 29" W
31Z36SE-2 driveway crossing	33^0 10' 57" N	81^0 51' 26" W
31Z38SE spring	33^0 12' 55" N	81^0 49' 35" W
31Z39NW	33^0 13' 36" N	81^0 51' 14" W
31Z40NE spring	33^0 13' 33" N	81^0 51' 23" W
31Z40NE-2 (SBL-1)	33^0 13' 31" N	81^0 51' 27" W
31Z40SE creek	33^0 12' 55" N	81^0 51' 44" W
31Z40SE-A spring	33^0 13' 08" N	81^0 51' 46" W
31Z40SW (SBL-2)	33^0 13' 04" N	81^0 52' 26" W
31Z41SW spring	33^0 13' 42" N	81^0 50' 05" W
31Z43NE spring	33^0 14' 18" N	81^0 51' 41" W
31Z43NE-2	33^0 14' 52" N	81^0 51' 41" W

Shell Bluff Landing Quadrangle (31Z) continued:

Grid #	Latitude (est.)	Longitude (est.)
31Z43NW	33° 14' 11" N	81° 52' 22" W
31Z43NW-2	33° 14' 58" N	81° 52' 11" W

Girard NW Quadrangle (32Z)

Grid #	Latitude (est.)	Longitude (est.)
32Z02NE-1	33° 08' 11" N	81° 44' 19" W
32Z02NE-2	33° 08' 08" N	81° 44' 16" W
32Z02SE-1	33° 07' 30" N	81° 44' 15" W
32Z02SE-2	33° 07' 32" N	81° 44' 05" W
32Z02NW (SBL-12)	33° 07' 40" N	81° 44' 57" W

Idlewood Quadrangle (30Y)

Grid #	Latitude (est.)	Longitude (est.)
30Y01SE	33° 06' 28" N	81° 52' 52" W
30Y02NW	33° 07' 19" N	81° 56' 24" W
30Y03SW	33° 06' 24" N	81° 58' 00" W
30Y05SW	33° 04' 20" N	81° 54' 12" W
30Y06SW	33° 04' 36" N	81° 56' 14" W
30Y07NE	33° 05' 18" N	81° 57' 05" W
30Y07SW	33° 04' 47" N	81° 58' 19" W
30Y10SC	33° 02' 30" N	81° 55' 06" W
30Y11NE	33° 03' 17" N	81° 57' 07" W
30Y13NW	33° 02' 01" N	81° 54' 25" W
30Y15NE	33° 01' 31" N	81° 57' 20" W
30Y16SE	33° 00' 28" N	81° 58' 50" W

Alexander Quadrangle (31Y)

Grid #	Latitude (est.)	Longitude (est.)
31Y02NE	33° 07' 28" N	81° 46' 37" W
31Y03SE (A-6)	33° 06' 45" N	81° 47' 07" W
31Y04NW	33° 07' 04" N	81° 49' 05" W
31Y04SE	33° 06' 56" N	81° 48' 18" W

Alexander Quadrangle (31Y) continued:

Grid #	Latitude (est.)	Longitude (est.)
31Y05NW	33^0 07' 22" N	81^0 49' 53" W
31Y07NW (A-4)	33^0 07' 20" N	81^0 51' 55" W
31Y08SW	33^0 06' 00" N	81^0 45' 47" W
31Y09NE	33^0 06' 21" N	81^0 46' 49" W
31Y09SE	33^0 06' 06" N	81^0 46' 49" W
31Y10NE	33^0 06' 25" N	81^0 47' 22" W
31Y10SE	33^0 06' 01" N	81^0 47' 29" W
31Y10NW	33^0 06' 14" N	81^0 47' 58" W
31Y10SW	33^0 06' 02" N	81^0 47' 59" W
31Y11SE	33^0 05' 50" N	81^0 48' 16" W
31Y11SW	33^0 05' 54" N	81^0 49' 08" W
31Y14SW	33^0 06' 00" N	81^0 52' 07" W
31Y14SW-2 (A-3)	33^0 05' 58" N	81^0 52' 20" W
31Y15SW	33^0 05' 09" N	81^0 45' 47" W
31Y16SE	33^0 05' 09" N	81^0 46' 49" W
31Y17NE (A-5)	33^0 05' 33" N	81^0 47' 09" W
31Y17NE-2	33^0 05' 44" N	81^0 47' 28" W
31Y17SE	33^0 05' 03" N	81^0 47' 23" W
31Y17NW	33^0 05' 42" N	81^0 47' 52" W
31Y21NE	33^0 05' 38" N	81^0 51' 40" W
31Y22SE	33^0 04' 08" N	81^0 45' 10" W
31Y27NW (A-2)	33^0 04' 45" N	81^0 50' 45" W
31Y28NW (A-1)	33^0 04' 50" N	81^0 51' 58" W
31Y31SC (A-7)	33^0 03' 19" N	81^0 47' 39" W
31Y36NW (A-9)	33^0 02' 30" N	81^0 45' 38" W
31Y37NW (A-8)	33^0 02' 55" N	81^0 46' 47" W
31Y43NE (A-10)	33^0 01' 50" N	81^0 45' 20" W
31Y44NE (A-12)	33^0 01' 28" N	81^0 48' 02" W
31Y44SW	33^0 00' 53" N	81^0 48' 50" W

Alexander Quadrangle (31Y) continued:

Grid #	Latitude (est.)	Longitude (est.)
31Y44SW-2 (A-11)	33° 00' 47" N	81° 48' 35" W
31Y45SW (A-15)	33° 00' 43" N	81° 51' 04" W
31Y45NW (A-18)	33° 01' 47" N	81° 51' 10" W
31Y46NE (A-17)	33° 02' 00" N	81° 51' 52" W
31Y46SE (A-16)	33° 00' 41" N	81° 51' 58" W
31Y49NW (A-14)	33° 00' 25" N	81° 50' 19" W

Girard Quadrangle (32Y)

Grid #	Latitude (est.)	Longitude (est.)
32Y01NE (G-1)	33° 07' 23" N	81° 44' 21" W
32Y02SE	33° 06' 53" N	81° 43' 24" W
32Y02SW	33° 06' 40" N	81° 43' 04" W
32Y02NW	33° 07' 18" N	81° 43' 58" W
32Y03SE (culvert)	33° 06' 46" N	81° 42' 03" W
32Y03SE-2 (G-10)	33° 06' 54" N	81° 42' 17" W
32Y11SE	33° 04' 58" N	81° 44' 11" W
32Y12SW	33° 05' 07" N	81° 43' 56" W
32Y13C	33° 05' 19" N	81° 42' 23" W
32Y14NW (G-3)	33° 05' 28" N	81° 41' 41" W
32Y15SW (G-4A)	33° 05' 10" N	81° 40' 45" W
32Y15SE (G-5A) borrow pit	33° 04' 58" N	81° 40' 02" W
32Y16NW (G-4)	33° 05' 41" N	81° 39' 35" W
32Y18NE (G-11)	33° 04' 33" N	81° 44' 20" W
32Y18SE	33° 04' 14" N	81° 44' 10" W
32Y19NW	33° 04' 44" N	81° 43' 57" W
32Y20SW (G-9)	33° 04' 08" N	81° 42' 02" W
32Y21SW spring	33° 04' 14" N	81° 41' 28" W
32Y21SW-2 (G-6) branch	33° 04' 11" N	81° 41' 23" W
32Y24SE (G-5)	33° 04' 12" N	81° 37' 39" W
32Y26SW (G-12)	33° 03' 15" N	81° 43' 34" W

Girard Quadrangle (32Y) continued:

32Y27SE (G-8)	33^0 03' 34" N	81^0 42' 17" W
32Y28NW (G-7)	33^0 03' 35" N	81^0 41' 50" W
32Y32NW (G-13)	33^0 03' 02" N	81^0 44' 43" W
32Y35SW (G-14)	33^0 02' 34" N	81^0 41' 50" W
32Y39SW	33^0 00' 58" N	81^0 44' 15" W
32Y39SW-2 (G-20)	33^0 01' 12" N	81^0 44' 18" W
32Y39SE (G-21)	33^0 01' 05" N	81^0 43' 22" W
32Y40NW	33^0 02' 11" N	81^0 42' 17" W
32Y40NW-2 (G-23)	33^0 01' 55" N	81^0 42' 32" W
32Y40SE (G-18)	33^0 00' 50" N	81^0 41' 45" W
32Y40SE-2 (G-18A)	33^0 00' 39" N	81^0 41' 02" W
32Y40SE-3 (G-18B)	33^0 00' 31" N	81^0 41' 21" W
32Y40SW (G-21A)	33^0 01' 00" N	81^0 42' 48" W
32Y40C (G-19)	33^0 01' 28" N	81^0 41' 58" W
32Y40W (G-22)	33^0 01' 28" N	81^0 42' 13" W
32Y41SE (G-15)	33^0 00' 53" N	81^0 39' 25" W
32Y42SW (G-15A)	33^0 01' 06" N	81^0 38' 26" W
32Y42SE	33^0 00' 58" N	81^0 37' 32" W
32Y45NE (G-16)	33^0 00' 04" N	81^0 38' 51" W

Waynesboro Quadrangle (29Y)

Grid #	**Latitude (est.)**	**Longitude (est.)**
29Y01	33^0 06' 42" N	82^0 02' 15" W
29Y02	33^0 05' 06" N	82^0 02' 20" W
29Y03	33^0 02' 25" N	82^0 04' 25" W
29Y04	33^0 03' 50" N	82^0 05' 40" W

Millett Quadrangle (33Y)

Grid #	**Latitude (est.)**	**Longitude (est.)**
33Y01SW	33^0 04' 02" N	81^0 37' 26" W
33Y05NW	33^0 02' 54" N	81^0 37' 20" W
33Y05NW-B	33^0 02' 57" N	81^0 37' 15" W

Millett Quadrangle (33Y) continued:

Grid #	Latitude (est.)	Longitude (est.)
33Y08SE	33° 01' 08" N	81° 37' 07" W
33Y09NE	33° 01' 45" N	81° 34' 48" W
33Y09NW	33° 01' 46" N	81° 36' 04" W

Mechanic Hill Quadrangle (30AA)

Grid #	Latitude (est.)	Longitude (est.)
30AA01	33° 16' 09" N	81° 57' 22" W
30AA02	33° 18' 23" N	81° 59' 29" W
30AA03	33° 18' 32" N	81° 55' 27" W
30AA04	33° 17' 00" N	81° 54' 24" W
30AA05	33° 15' 42" N	81° 54' 25" W

Hephzibah Quadrangle (29AA)

Grid #	Latitude (est.)	Longitude (est.)
29AA01	33° 20' 45" N	82° 03' 15" W
29AA02	33° 17' 22" N	82° 05' 09" W
29AA03	33° 16' 27" N	82° 05' 35" W
29AA04	33° 16' 48" N	82° 03' 43" W
29AA05	33° 16' 14" N	82° 02' 54" W
29AA06	33° 15' 16" N	82° 02' 49" W
29AA07	33° 20' 41" N	82° 00' 50" W

Blythe Quadrangle (28AA)

Grid #	Latitude (est.)	Longitude (est.)
28AA01	33° 20' 41" N	82° 09' 39" W
28AA02	33° 20' 41" N	82° 13' 12" W
28AA03	33° 20' 41" N	82° 08' 22" W

Storys Millpond Quadrangle (29Z)

Grid #	Latitude (est.)	Longitude (est.)
29Z01	33° 12' 32" N	82° 02' 32" W
29Z02	33° 09' 54" N	82° 00' 37" W
29Z03	33° 08' 21" N	82° 04' 55" W

Storys Millpond Quadrangle (29Z)

Grid #	Latitude (est.)	Longitude (est.)
29Z04	33^0 09' 17" N	82^0 05' 14" W
29Z05	33^0 14' 03" N	82^0 05' 35" W
29Z06	33^0 14' 19" N	82^0 05' 08" W

Keysville Quadrangle (28Z)

Grid #	Latitude (est.)	Longitude (est.)
28Z01	33^0 13' 03" N	82^0 13' 58" W
28Z02	33^0 10' 54" N	82^0 12' 23" W
28Z03	33^0 11' 08" N	82^0 11' 55" W
28Z04	33^0 09' 55" N	82^0 09' 43" W
28Z05	33^0 07' 44" N	82^0 09' 16" W
28Z06	33^0 11' 53" N	82^0 14' 40" W

Matthews Quadrangle (27Z)

Grid #	Latitude (est.)	Longitude (est.)
27Z01	33^0 08' 53" N	82^0 15' 10" W
27Z02	33^0 09' 40" N	82^0 19' 05" W
27Z03	33^0 09' 39" N	82^0 19' 02" W
27Z04	33^0 10' 51" N	82^0 20' 05" W
27Z05	33^0 12' 17" N	82^0 20' 40" W
27Z06	33^0 11' 10" N	82^0 15' 46" W

Kellys Pond Quadrangle (27Y)

Grid #	Latitude (est.)	Longitude (est.)
27Y01	33^0 02' 07" N	82^0 18' 08" W
27Y02	33^0 02' 48" N	82^0 18' 10" W
27Y03	33^0 01' 24" N	82^0 18' 23" W
27Y04	33^0 01' 06" N	82^0 20' 43" W
27Y05	33^0 03' 05" N	82^0 20' 22" W

Gough Quadrangle (28Y)

Grid #	Latitude (est.)	Longitude (est.)
28Y01	33^0 03' 07" N	82^0 10' 22" W
28Y02	33^0 03' 00" N	82^0 10' 53" W
28Y03	33^0 03' 33" N	82^0 12' 43" W
28Y04	33^0 03' 53" N	82^0 13' 52" W
28Y05	33^0 03' 24" N	82^0 14' 40" W

Perkins Quadrangle (30X)

Grid #	Latitude (est.)	Longitude (est.)
30X01	32^0 52' 41" N	81^0 57' 30" W
30X02	32^0 54' 30" N	81^0 55' 55" W

Sardis Quadrangle (31X)

Grid #	Latitude (est.)	Longitude (est.)
31X01 (A-13)	32^0 59' 52" N	81^0 48' 55" W
31Z02	32^0 57' 08" N	81^0 51' 25" W

Hilltonia Quadrangle (32X)

Grid #	Latitude (est.)	Longitude (est.)
32X01 (G-17)	32^0 54' 30" N	81^0 51' 25" W

Wrens Quadrangle (26Z)

Grid #	Latitude (est.)	Longitude (est.)
26Z01	33^0 14' 34" N	82^0 24' 47" W

Louisville Quadrangle (26Y)

Grid #	Latitude (est.)	Longitude (est.)
26Y01	33^0 06' 42" N	82^0 23' 22" W
26Y02	33^0 00' 11" N	81^0 23' 05" W

Augusta West Quadrangle (29BB)

Grid #	Latitude (est.)	Longitude (est.)
Butler Creek/Ga. Hwy. 56	33^0 23' 07" N	82^0 01' 37" W

Appendix 2
Base flow sampling results. Quadrangle (e.g., 30Z) and sample numbers are based on USGS well grid number system. Tritium values are in picoCuries per liter.
"n/c"-not collected

McBean Quadrangle (30Z)

Grid #	1991	1992	1993	1994	1995
30Z14NE	-----	800	300	500	200
30Z17NW	-----	600	300/400	300	200
30Z21SW	-----	-----	400	600	300
30Z22SW	-----	-----	400	500	300
30Z26SE	-----	500	300	400	100
30Z28NW	-----	500	300	500	dry
30Z31SE	-----	1000	n/c	n/c	n/c
30Z32SW	-----	600	300	400	200
30Z34SE	-----	900	n/c	600	n/c
30Z43NW	-----	900	500	600*	200
30Z44SE	-----	700	500	600	400
30Z48SC	-----	800	600	800	300
30Z49SW	-----	700	400	n/c	n/c

Shell Bluff Landing Quadrangle (31Z)

Grid #	1991	1992	1993	1994	1995
31Z02NW	-----	1500	1200	1000	900
31Z02SW-1 (SBL-11)	1600	1100	1100	900	700
31Z02SW-2 (SBL-10)	1400	1200	900/800	700	700
31Z03NE	-----	1100	n/c	n/c	n/c
31Z03SE	-----	1200	800	n/c	n/c
31Z03SW	-----	1400	n/c	n/c	n/c
31Z04NE	-----	1400	1100	1100	1100
31Z04NE-B spring	-----	-----	1200	1300	1100
31Z04SE (SBL-9)	1200	1100	700	600	600
31Z06NW	-----	1200	1000	n/c	n/c
31Z07NE	-----	1400	n/c	n/c	n/c
31Z09SE	-----	1400	dry	n/c	n/c

Shell Bluff Landing Quadrangle (31Z) continued:

Grid #	**1991**	**1992**	**1993**	**1994**	**1995**
31Z09NW-A spring	-----	1400	1300	1200	1100
31Z09NW-1 spring	-----	1700	1400	1100	1100
31Z11NE	-----	1500	n/c	n/c	n/c
31Z11SE	-----	1500	1100	1200	1000
31Z11NW	-----	1600	1300	1100	1000
31Z11SW	-----	1200	1200	1100	1000
31Z13SE	-----	1100	1000	900	900
31Z13SE-2 (SBL-7)	1500	n/c	n/c	n/c	n/c
31Z14SE (SBL-8)	1000	900	500	500	500
31Z16NE-1	-----	-----	1400	n/c	n/c
31Z16NE-2	-----	-----	1600	n/c	n/c
31Z16SE	-----	1800	1300	900	1100
31Z16NW	-----	2200	1400	1600	1400
31Z16NW-2	-----	-----	1600	n/c	n/c
31Z16NW-3	-----	-----	1000	1800	1100
31Z16NW-4	-----	-----	1300	n/c	n/c
31Z17NE	-----	-----	1500	n/c	n/c
31Z17NW	-----	2000	1700	1700	1600
31Z17SE	-----	1700	1600	1500	1300
31Z18NE-1	-----	1700	1100	1500	1200
31Z18NE-2	-----	2000	1800	1500	1400
31Z19SE (TR92-1)	-----	2000	1800	1500	1200
31Z20SE (SBL-6)	1800	n/c	n/c	1100	900
31Z20SW	-----	900	700	600	400
31Z22SW-1	-----	2200	1900	1700	1400
31Z22SW-2	-----	-----	1800	1300	n/c
31Z22SE-1	-----	-----	2200	1200	n/c
31Z23NE-1	-----	-----	1600	1500	1400
31Z23NE-2	-----	-----	1600	1400	n/c
31Z23SW	-----	-----	1900	1600	1600

Shell Bluff Landing Quadrangle (31Z)

Grid #	1991	1992	1993	1994	1995
31Z24SE	-----	1800	n/c	1500	1500
31Z24NE	-----	1700	n/c	n/c	n/c
31Z24NW-1 (SBL-4)	1900	1400	n/c	1200	1200
31Z24NW-2	-----	2000	1700	1200	1100
31Z24NW-3	-----	-----	1400	n/c	n/c
31Z24NW-4 spring	-----	-----	1200	n/c	n/c
31Z25SE	-----	-----	1400/1500	1300	1000
31Z26SW (SBL-5)	1200	900	800	700	500
31Z27NW	-----	1000	n/c	n/c	n/c
31Z27NW-A	-----	-----	800	700	600
31Z27NW-B	-----	-----	1000	800	800
31Z29SE-1	-----	1500	1400	n/c	n/c
31Z29SE-2 spring	-----	-----	1400	n/c	n/c
31Z30NE	-----	900	n/c	n/c	n/c
31Z30NW (SBL-3)	1300	1400	900	700	600
31Z34NW	-----	1400	1400	n/c	n/c
31Z35SE	-----	1200	900	1000	800
31Z36SE	-----	1300	n/c	n/c	n/c
31Z36SE-2	-----	-----	-----	800	600
31Z38SE spring	-----	1500	n/c	1000	n/c
31Z39NW	-----	1000	n/c	n/c	n/c
31Z40NE spring	-----	800/1000	700/800	700	700
31Z40NE-2 (SBL-1)	1000	n/c	n/c	n/c	n/c
31Z40SE creek	-----	900	900	n/c	500
31Z40SE-A spring	-----	-----	900	n/c	n/c
31Z40SW (SBL-2)	1000	700	600	500	300
31Z41SW spring	-----	1100	1000/900	700	900
31Z43NE spring	-----	800	500	800	600
31Z43NE-2	-----	-----	800	500	600

Shell Bluff Landing Quadrangle (31Z) continued:

Grid #	1991	1992	1993	1994	1995
31Z43NW	-----	1000	n/c	n/c	500
31Z43NW-2	-----	-----	800	n/c	n/c

Girard NW Quadrangle (32Z)

Grid #	1991	1992	1993	1994	1995
32Z02NE-1	-----	1400	1300	1300	1400
32Z02NE-2	-----	1400	1300	1200	1300
32Z02SE-1	-----	1300	1200/1200	800	900
32Z02SE-2	-----	1100	900	900	800
32Z02SW (SBL-12)	1400	1100/1100	1000/900 1200	900	900

Idlewood Quadrangle (30Y)

Grid #	1991	1992	1993	1994	1995
30Y01SE	-----	1000	dry	700	dry
30Y02NW	-----	800	500	500	300
30Y03SW	-----	-----	200	200	100
30Y05SW	-----	500	200	400	200
30Y05NE	-----	-----	-----	800	dry
30Y06SW	-----	-----	-----	500	dry
30Y07NE	-----	-----	-----	400	300
30Y07SW	-----	300	300	300	300
30Y10SC	-----	-----	<100	dry	<100
30Y11NE	-----	-----	100	300	100
30Y13NW	-----	400	100	300	100
30Y16SE	-----	300	dry	<100	200

Alexander Quadrangle (31Y)

Grid #	1991	1992	1993	1994	1995
31Y02NE	-----	1200	dry	n/c	n/c
31Y 03SE (A-6)	1200	n/c	n/c	n/c	n/c
31Y04SE	-----	1200	700	700	400
31Y04NW	-----	900	n/c	800	n/c

Alexander Quadrangle (31Y) continued:

Grid #	1991	1992	1993	1994	1995
31Y05NW	-----	1100	n/c	n/c	n/c
31Y07NW (A-4)	1100	1000	800	dry	800
31Y08SW	-----	1300	800	n/c	n/c
31Y09NE	-----	900	n/c	n/c	n/c
31Y09SE	-----	900	n/c	n/c	n/c
31Y10NE	-----	700/1000	500	600	500
31Y10SE	-----	900	600	600	600
31Y10NW	-----	900	n/c	n/c	n/c
31Y10SW	-----	700	200	n/c	n/c
31Y11SE	-----	1100	800	900	900
31Y11SW	-----	900	n/c	800	600
31Y14SW	-----	1000	dry	500	n/c
31Y14SW-2 (A-3)	1300	n/c	n/c	600	600
31Y15SW	-----	1200	800/800	900	800
31Y16SE	-----	-----	900	900	800
31Y17NE (A-5)	1000	1000	700	600	500
31Y17NE-2	-----	900	600	n/c	n/c
31Y17SE	-----	900	700	600	500
31Y17NW	-----	1100	700	900	700
31Y21NE	-----	900	dry	n/c	n/c
31Y22SE	-----	1100	500	n/c	n/c
31Y27NW (A-2)	900	800	600	800	500
31Y28NW (A-1)	1100	800	600	500	500
31Y31SC (A-7)	1100	n/c	n/c	500	500
31Y36NW (A-9)	600	800	300	400	300
31Y37NW (A-8)	900	n/c	n/c	100	300
31Y43NE (A-10)	600	n/c	n/c	200	300
31Y44NE (A-12)	500	n/c	n/c	900	400
31Y44SW	-----	500	dry	300	200
31Y44SW-2 (A-11)	500	n/c	n/c	200	200

Alexander Quadrangle (31Y) continued:

Grid #	**1991**	**1992**	**1993**	**1994**	**1995**
31Y45SW (A-15)	600	500	100	300	200
31Y45NW (A-18)	700	n/c	n/c	200	200
31Y46NE (A-17)	600	400	100	<100	100
31Y46SE (A-16)	700	n/c	n/c	400	200
31Y49NW (A-14)	500	500	100	300	300

Girard Quadrangle (32Y)

Grid #	**1991**	**1992**	**1993**	**1994**	**1995**
32Y01NE (G-1)	1300	1100	800	700	500
32Y02SE	-----	700	n/c	n/c	n/c
32Y02SW (G-2)	1100	1100	400	400	300
32Y02NW	-----	1100	n/c	n/c	n/c
32Y03SE culvert	-----	100	dry	n/c	n/c
32Y03SE-2 (G-10)	400	n/c	500	<100	dry
32Y11SE	-----	n/c	500	<100	dry
32Y12SW	-----	800	n/c	n/c	n/c
32Y13C	-----	800	n/c	n/c	n/c
32Y14NW (G-3)	900	600	300	400	300
32Y15SW	-----	-----	-----	100	n/c
32Y15SE	-----	-----	-----	<100	dry
32Y16NW (G-4)	1000	600	400	500	300
32Y18NE (G-11)	700	500	300	400	200
32Y18SE	-----	800	n/c	n/c	n/c
32Y19NW	-----	600	n/c	n/c	n/c
32Y20SW (G-9)	1000	700	300	400	400
32Y21SW spring	-----	500	300	300	n/c
32Y21SW-2 (G-6)	1100	n/c	n/c	300	200/<100
32Y24SE (G-5)	800	500	200	300	<100
32Y26SW (G-12)	700	300	dry	100	200
32Y27SE (G-8)	800	400	300	200	200
32Y28NW (G-7)	600	400	400	n/c	n/c

Girard Quadrangle (32Y) continued:

Grid #	**1991**	**1992**	**1993**	**1994**	**1995**
32Y32NW (G-13)	900	500	dry	200	600
32Y35SW (G-14)	600	300	dry	<100	100
32Y39SW	-----	400	n/c	n/c	n/c
32Y39SW-2 (G-20)	600	n/c	n/c	400	300
32Y39SE (G-21)	600	n/c	n/c	200	200
32Y40NW (G-23)	700	200	dry	<100/100	200
32Y40SE (G-18)	600	300	<100	<100	100
32Y40SE-2	-----	-----	-----	200	<100
32Y40SW	-----	-----	-----	<100	n/c
32Y40C (G-19)	600	200	dry	dry	<100
32Y40W (G-22)	500	n/c	n/c	100	<100
32Y41SE (G-15)	700	400	dry	<100	100
32Y42SW	-----	-----	-----	<100	100
32Y42SE	-----	300	100	200	<100
32Y45NE (G-16)	500	n/c	n/c	<100	<100

Millett Quadrangle (33Y)

Grid #	**1991**	**1992**	**1993**	**1994**	**1995**
33Y01SW	-----	100	dry	n/c	<100
33Y05NW	-----	300	100	<100	<100
33Y05NW-B	-----	-----	300	100	n/c
33Y08SE	-----	-----	100	<100	<100
33Y09NE	-----	200	<100	<100	100
33Y09NW	-----	400	<100/<100	<100	100

Mechanic Hill Quadrangle (30AA)

Grid #	**1991**	**1992**	**1993**	**1994**	**1995**
30AA01	-----	-----	400	300	n/c
30AA02	-----	-----	300	400	n/c
30AA03	-----	-----	500	200	n/c
30AA04	-----	-----	400	<100	n/c

Mechanic Hill Quadrangle (30AA) continued:

Grid #	1991	1992	1993	1994	1995
30AA05	-----	-----	500	400	n/c
30AA06	-----	-----	-----	-----	300

Hephzibah Quadrangle (29AA)

Grid #	1991	1992	1993	1994	1995
29AA01	-----	-----	100	<100	100
29AA02	-----	-----	200	100	200
29AA03	-----	-----	100	n/c	200
29AA04	-----	-----	100	100	200
29AA05	-----	-----	200	200	<100
29AA06	-----	-----	300	400	200
29AA07	-----	-----	<100	<100	<100

Blythe Quadrangle (28AA)

Grid #	1991	1992	1993	1994	1995
28AA01	-----	-----	100	<100	n/c
28AA02	-----	-----	<100	n/c	n/c
28AA03	-----	-----	100	200	n/c

Storys Millpond (29Z)

Grid #	1991	1992	1993	1994	1995
29Z01	-----	-----	100	n/c	n/c
29Z02	-----	-----	600	300	200
29Z03	-----	-----	300	200	<100
29Z04	-----	-----	300	200	<100
29Z05	-----	-----	100	n/c	<100
29Z06	-----	-----	<100	n/c	n/c

Keysville Quadrangle (28Z)

Grid #	1991	1992	1993	1994	1995
28Z01	-----	-----	<100	<100	n/c
28Z02	-----	-----	100	200	n/c
28Z03	-----	-----	100	<100	n/c

Keysville Quadrangle (28Z) continued:

Grid #	1991	1992	1993	1994	1995
28Z04	-----	-----	<100	<100	n/c
28Z05	-----	-----	<100	100	n/c
28Z06	-----	-----	<100	<100	n/c

Waynesboro Quadrangle (29Y)

Grid #	1991	1992	1993	1994	1995
29Y01	-----	-----	300	200	<100
29Y02	-----	-----	500	900	<100
29Y03	-----	-----	200	200	200
29Y04	-----	-----	100	200	100

Matthews Quadrangle (27Z)

Grid #	1991	1992	1993	1994	1995
27Z01	-----	-----	<100	<100	n/c
27Z02	-----	-----	<100	<100	n/c
27Z03	-----	-----	<100	<100	n/c
27Z04	-----	-----	<100	100	n/c
27Z05	-----	-----	<100	100	n/c
27Z06	-----	-----	300	200	n/c

Kellys Pond Quadrangle (27Y)

Grid #	1991	1992	1993	1994	1995
27Y01	-----	-----	100	<100	n/c
27Y02	-----	-----	200	<100	n/c
27Y03	-----	-----	200	100	n/c
27Y04	-----	-----	<100	<100	n/c
27Y05	-----	-----	<100	100	n/c

Gough Quadrangle (28Y)

Grid #	1991	1992	1993	1994	1995
28Y01	-----	------	200	<100	<100
28Y02	-----	-----	200	100	<100

Gough Quadrangle (28Y) continued:

Grid #	1991	1992	1993	1994	1995
28Y03	-----	-----	300	<100	<100
28Y04	-----	-----	<100	<100	100
28Y05	-----	-----	100	<100	<100

Perkins Quadrangle (30X)

Grid #	1991	1992	1993	1994	1995
30X01	-----	-----	100	100	n/c
30X02	-----	-----	100	n/c	n/c

Sardis Quadrangle (31X)

Grid #	1991	1992	1993	1994	1995
31X01 (A-13)	600	n/c	200	<100	n/c
31X02	-----	-----	<100	n/c	n/c

Hilltonia Quadrangle (32X)

Grid #	1991	1992	1993	1994	1995
32X01 (G-17)	500	n/c	n/c	n/c	n/c

Wrens Quadrangle (26Z)

Grid #	1991	1992	1993	1994	1995
26Z01	-----	-----	<100	n/c	n/c

Louisville Quadrangle (26Y)

Grid #	1991	1992	1993	1994	1995
26Y01	-----	-----	<100	n/c	n/c
26Y02	-----	-----	<100	n/c	n/c

Augusta West Quadrangle (29BB)

Grid #	1991	1992	1993	1994	1995
Butler Creek/Ga. Hwy. 56	-----	-----	<100	100	<100

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