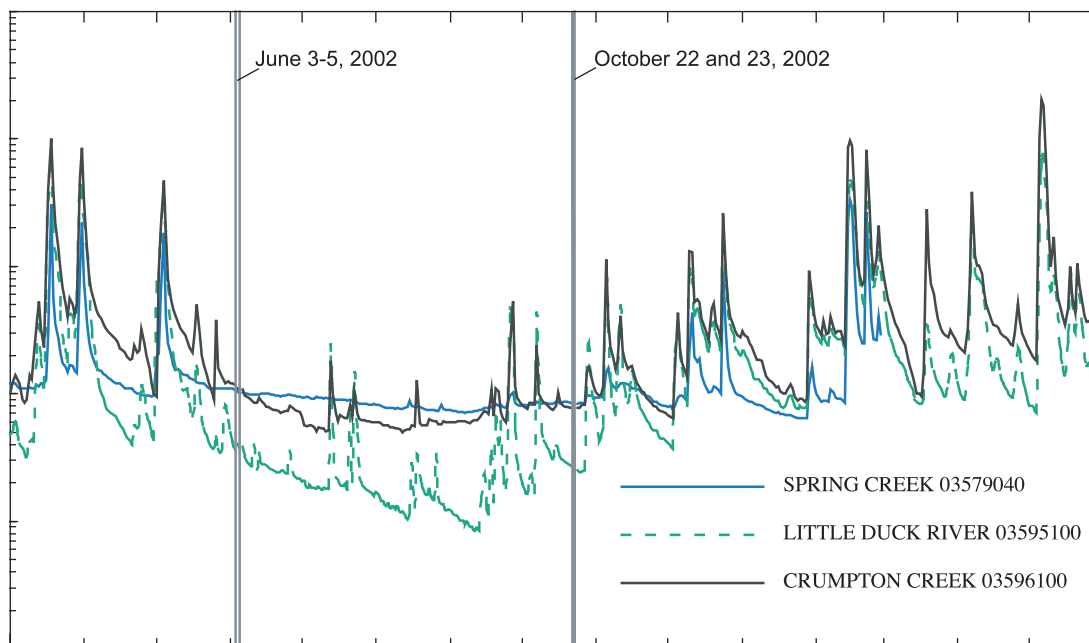


Prepared in cooperation with the  
United States Air Force,  
Arnold Air Force Base

## Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002



Open-File Report 2004-1318

**Cover.** See figure 2, page 10.

# **Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002**

By John A. Robinson and Connor J. Haugh

Prepared in cooperation with the  
United States Air Force,  
Arnold Air Force Base

Open-File Report 2004-1318

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

**U.S. Department of the Interior**  
Gale A. Norton, Secretary

**U.S. Geological Survey**  
Charles G. Groat, Director

**U.S. Geological Survey, Reston, Virginia: 2004**

For sale by U.S. Geological Survey, Information Services  
Box 25286, Denver Federal Center  
Denver, CO 80225

For more information about the USGS and its products:  
Telephone: 1-888-ASK-USGS  
World Wide Web: <http://www.usgs.gov/>

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual copyright owners to reproduce any copyrighted materials contained within this report.

*Suggested citation:*

Robinson, J.A., and Haugh, C.J., 2004, Base-flow data in the Arnold Air Force Base Area, Tennessee, June and October 2002: U.S. Geological Survey Open-File Report 2004-1318, 26 p.

## Contents

|  |    |
|--|----|
| Executive summary .....                  | 1  |
| Introduction .....                       | 1  |
| Purpose and scope .....                  | 3  |
| Study area .....                         | 3  |
| Base-flow data .....                     | 3  |
| Discharge data .....                     | 3  |
| Temperature data .....                   | 10 |
| Specific conductance data .....          | 16 |
| Areas of surplus or deficient flow ..... | 16 |
| Summary .....                            | 26 |
| References cited .....                   | 26 |

## Figures

|  |    |
|--|----|
| 1. Map showing location of the study area in Middle Tennessee .....  | 2  |
| 2. Hydrograph showing daily mean discharge on Spring Creek, Little Duck River,<br>and Crumpton Creek .....             | 10 |
| 3-4. Maps of the Arnold Air Force Base area showing stream and spring measurement<br>sites and discharge measurements: |    |
| 3. High base flow, June 3 through 5, 2002 .....  | 11 |
| 4. Low base flow, October 22 and 23, 2002 .....  | 12 |
| 5-6. Maps of the Arnold Air Force Base area showing areas of<br>surplus or deficient flow during:                      |    |
| 5. High base flow, June 3 through 5, 2002 .....  | 24 |
| 6. Low base flow, October 22 and 23, 2002 .....  | 25 |

## Tables

|  |    |
|--|----|
| 1. Site and station numbers, station names, and locations of stream and spring measurement<br>sites in the Arnold Air Force Base area, Tennessee ..... | 4  |
| 2. High base-flow data for streams in the Arnold Air Force Base area,<br>Tennessee, June 3 through 5, 2002 .....                                       | 7  |
| 3. High base-flow data for springs in the Arnold Air Force Base area,<br>Tennessee, June 3 through 5, 2002 .....                                       | 9  |
| 4. Low base-flow data for streams in the Arnold Air Force Base area,<br>Tennessee, October 22 and 23, 2002 .....                                       | 13 |
| 5. Low base-flow data for springs in the Arnold Air Force Base area,<br>Tennessee, October 22 and 23, 2002 .....                                       | 16 |
| 6. High base-flow data for drainage areas in the Arnold Air Force Base area,<br>Tennessee, June 3 through 5, 2002 .....                                | 17 |
| 7. Low base-flow data for drainage areas in the Arnold Air Force Base area,<br>Tennessee, October 22 and 23, 2002 .....                                | 20 |
| 8. Downstream sites used to calculate total flow per square mile in study area .....   | 23 |
| 9. Flow per square mile for tributary basins in the Arnold Air Force Base area, Tennessee .....  | 23 |

## Conversion Factors, Horizontal Datum, and Site-Numbering System

| Multiply  | By      | To obtain  |
|---|---------|--|
| inch (in.)  | 25.4    | millimeter (mm)  |
| foot (ft)   | 0.3048  | meter (m)  |
| mile (mi)   | 1.609   | kilometer (km)   |
| acre  | 4,047   | square kilometer (km <sup>2</sup> )  |
| acre  | 0.4047  | hectare (ha)   |
| square mile (mi <sup>2</sup> )  | 2.590   | square kilometer (km <sup>2</sup> )  |
| cubic foot per second (ft <sup>3</sup> /s)                                    | 0.02832 | cubic meter per second (m <sup>3</sup> /s)   |
| cubic foot per second per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] | 0.01093 | cubic meter per second per square kilometer [(m <sup>3</sup> /s)/km <sup>2</sup> ] |
| gallon per minute (gal/min)   | 0.06309 | liter per second (L/s)   |

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C), and temperature in °C to °F, as follows:

$$^{\circ}\text{F} = 1.8^{\circ}\text{C} + 32$$

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Site numbering system for surface-water sites: Each surface-water station in this report is assigned a unique identification number. The number is assigned when a station is first established and is retained for that station indefinitely. The station numbers indicate downstream-order position. A station on a tributary that enters between two mainstream stations is assigned a number between them. A similar order is followed in listing stations on first rank, second rank, and other ranks of tributaries.

Gaps are left in the series of numbers to allow for new stations that may be established; hence, the numbers are not consecutive. The complete number for each station such as 03578500...., includes a 2-digit part number "03" plus the multi-digit downstream order number "578500...." This downstream numbering system is used in most cases; however, in some cases latitude and longitude numbers are assigned to hydrologic stations as a means of identification.

# Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002

By John A. Robinson and Connor J. Haugh

## Executive Summary

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee. The primary mission of AAFB is to support the development of aerospace systems. This mission is accomplished through test facilities at Arnold Engineering Development Center (AEDC), which occupies about 4,000 acres in the center of AAFB. Base-flow data including discharge, temperature, and specific conductance were collected for basins in and near AAFB during high base-flow and low base-flow conditions. Data representing high base-flow conditions from 109 sites were collected on June 3 through 5, 2002, when discharge measurements at sites with flow ranged from 0.005 to 46.4 ft<sup>3</sup>/s. Data representing low base-flow conditions from 109 sites were collected on October 22 and 23, 2002, when discharge measurements at sites with flow ranged from 0.02 to 44.6 ft<sup>3</sup>/s. Discharge from the basin was greater during high base-flow conditions than during low base-flow conditions. In general, major tributaries on the north side and southeastern side of the study area (Duck River and Bradley Creek, respectively) had the highest flows during the study.

Discharge data were used to categorize stream reaches and sub-basins. Stream reaches were categorized as gaining, losing, wet, dry, or unobserved for each base-flow measurement period. Gaining stream reaches were more common during the high base-flow period than during the low base-flow period. Dry stream reaches were more common during the low base-flow period than during the high base-flow period. Losing reaches were more predominant in Bradley Creek and Crumpton Creek.

Values of flow per square mile for the study area of 0.55 and 0.37 (ft<sup>3</sup>/s)/mi<sup>2</sup> were calculated using discharge data collected on June 3 through 5, 2002, and October 22 and 23, 2002, respectively. Sub-basin areas with surplus or deficient flow were defined within the basin. Drainage areas for each stream measurement site were delineated and measured from topographic maps. Change in flow per square mile for each sub-basin was calculated using data from each base-flow measurement period. The calculated values were used to define the areas of surplus or deficient flow for high and low base-flow conditions. Many areas of deficient flow were present throughout the

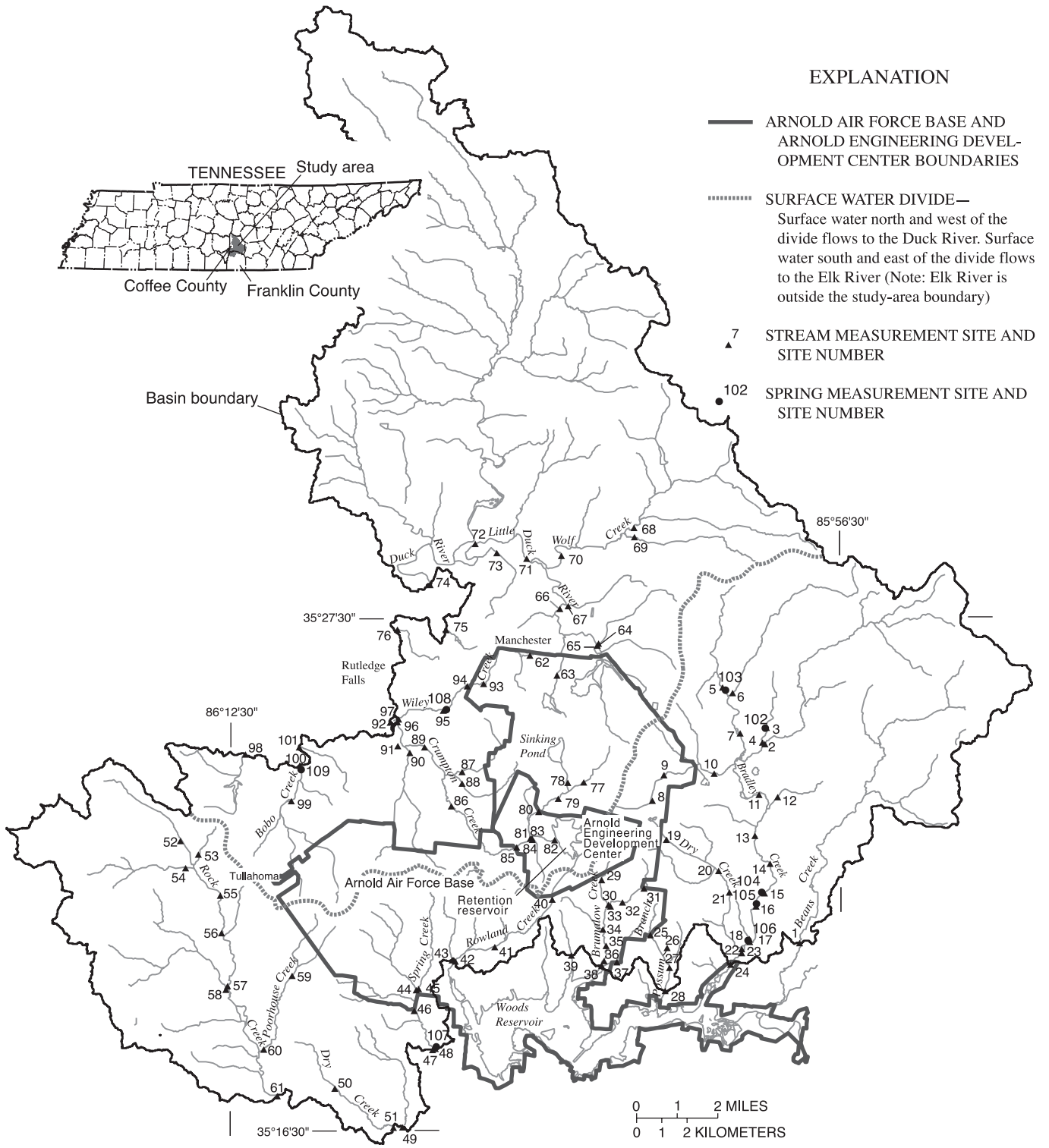
study area under high and low base-flow conditions. Most areas of deficient flow were in the headwater basins. Fewer areas of surplus flow were present under low base-flow conditions than during the high base-flow conditions. The flow per square mile for each major tributary basin in the study area also was calculated. The values of flow per square mile for the Dry Creek, Spring Creek, and Wiley Creek basins were greatest under both high and low base-flow conditions.

## Introduction

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee (fig. 1). The primary mission of AAFB is to support the development of aerospace systems. The mission is accomplished in part through test facilities at Arnold Engineering Development Center (AEDC), which occupies about 4,000 acres in the center of AAFB.

Numerous site-specific ground-water contamination investigations have been conducted at designated Solid Waste Managements Units (SWMUs) at AAFB. Several synthetic volatile organic compounds (VOCs), primarily chlorinated solvents, have been identified in the ground water at AEDC. In 2002, the U.S. Geological Survey (USGS), in cooperation with the U.S. Air Force, AAFB, began this study to better understand the occurrence and movement of ground-water resources in the AAFB area. Base-flow data including stream and spring discharge, water temperature, and specific conductance were collected from selected sites within basins in and near AAFB during June and October 2002. Discharge measurements help identify gains and losses of flow along stream channels (Riggs, 1972) and aid in the comparison of high base-flow and low base-flow conditions. Specific conductance and temperature measurements were used to help identify sites where ground water discharged to the streams. The Bradley Creek, Rock Creek, Duck River, and Crumpton Creek drainage basins (fig. 1) compose the study area, which includes most of AAFB and areas to the east, west, and north. The AAFB area is located in a fractured carbonate terrain that is covered with regolith derived from the in-situ weathering of Mississippian carbonates. The geologic units are (in descending order) the

2 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002



Base from U.S. Geological Survey digital data, 1972, 1:2,000,000 Albers Equal-Area Conic Projection Standard parallels 29°30'N and 45°30'N, Standard meridian 96°00'W

Figure 1. Location of the study area in Middle Tennessee.



St. Louis Limestone, the Warsaw Limestone, and the Fort Payne Formation (Wilson, 1976).

## Purpose and Scope

This report presents base-flow data collected during the course of this investigation. Gaining and losing reaches of the stream channels are delineated for high and low base-flow conditions. Sub-basins within the study area with surplus or deficient flow also are defined. The data for the study were collected in June and October 2002 to help refine the understanding of the regional ground-water-flow system (Mahoney and Robinson, 1993; Haugh and Mahoney, 1994). Collectively, the comprehensive results of the investigation may aid in the development of corrective measures and long-term monitoring plans for AAFB.

## Study Area

The AAFB area lies on the eastern Highland Rim Physiographic Province of Tennessee (Miller, 1974) and ranges from poorly drained, flat uplands to valley-dissected, sloping escarpments. A major surface-water divide separating the Duck and Elk River drainage basins bisects AAFB extending from southwest to northeast (fig. 1). Surface-water drainage patterns are well-defined dendritic patterns south and west of AEDC. Surface-water drainage patterns are less well-defined in the wetland area north and northeast of AEDC where wetlands and internally drained depressions exist.

The natural headwaters of several streams have been ditched and extended into AEDC to receive discharge water from the testing facilities. Most of the AEDC facility water is discharged to Rowland Creek, which has been ditched to extend across the natural drainage divide into AEDC (fig. 1). A retention reservoir at AEDC, constructed in the headwaters of a tributary to Crumpton Creek, also drains through engineered gates across the natural divide to the ditched part of Rowland Creek. The headwaters of Brumalow Creek and a tributary to Bradley Creek also have been extended into AEDC and receive small amounts of AEDC discharge water.

AAFB is surficially drained by streams on both sides of the natural divide. Surface drainage from the wetland area north of AEDC flows to the southwest to Crumpton Creek and north to tributaries of the Little Duck River. Stream channels in this area are poorly defined and dry throughout most of the summer and fall. Some of the wetlands in this area, most notably Sinking Pond, are internally drained depressions. The wetlands are typically filled with water during the wet part of the year and become dry during late summer and fall. Some wetlands have surface flow outlets (Wolfe and League, 1996; Wolfe, 1996). The southwestern part of the AAFB is drained by Spring Creek.

The lower reaches of Spring Creek are well incised into chert gravels and support a sustained base flow.

## Base-Flow Data

Base flow is that part of stream discharge derived from ground-water discharge to the stream. Base flow supports stream discharge during the periods between rainfall events. Most base flow to streams in the study area is probably from the regolith and shallow bedrock (the Manchester aquifer) (Burchett, 1977).

Base-flow data including discharge, temperature, and specific conductance were collected for basins in and near AAFB during high base-flow and low base-flow conditions. Streams were assumed to be at base flow if no significant rainfall had occurred for 4 days. Discharge measurements were made by standard USGS methods (Buchanan and Somers, 1969). Data representing high base-flow conditions were collected on June 3 through 5, 2002. Data representing low base-flow conditions were collected on October 22 and 23, 2002. Names and locations of base-flow measurement sites within the study area are given in table 1. A hydrograph showing daily mean discharge for Spring Creek (site 47, fig. 1), Little Duck River (site 66, fig. 1), and Crumpton Creek at Rutledge Falls (station number 03596100 located about 100 feet downstream of sites 92 and 96) and dates when base-flow data were collected are shown in figure 2. Comparing these three sites, Spring Creek has higher flows during low base-flow periods than either the Little Duck River or Crumpton Creek, even though Spring Creek has the smallest drainage area. Crumpton Creek shows the greatest response to rainfall. Spring Creek shows a response to greater amounts of rainfall only in the winter and spring and shows little or no response to rainfall in the summer and fall.

## Discharge Data

Discharge measurements were made at 109 sites (101 stream sites and 8 springs) on June 3 through 5, 2002 (tables 2 and 3). The measurements were made during high base-flow conditions, and 31 of the measurement sites (28 percent) had zero flow. About 58 percent of the dry measurement sites lie along Bradley and Crumpton Creeks and their tributaries (fig. 3). Flows at the most downstream measurement sites along the major streams in the basin were 42.8 ft<sup>3</sup>/s for Duck River (site 74), 34.5 ft<sup>3</sup>/s for Bradley Creek (site 24), 19 ft<sup>3</sup>/s for Rock Creek (site 61), 12.7 ft<sup>3</sup>/s for Crumpton Creek (site 97), 10.4 ft<sup>3</sup>/s for Spring Creek (site 47), 7.09 ft<sup>3</sup>/s for Dry Creek (site 51), 5.88 ft<sup>3</sup>/s for Beans Creek (site 1), and 1.36 ft<sup>3</sup>/s for Brumalow Creek (site 36). Discharge measurements at sites with flow ranged from an estimated 0.005 ft<sup>3</sup>/s (site 84) to 46.4 ft<sup>3</sup>/s (site 17). Measurement sites with discharge values for June 3 through 5, 2002, and dry, gaining, wet, and losing reaches are shown in figure 3.

#### 4 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002

**Table 1.** Site and station numbers, station names, and locations of stream and spring measurement sites in the Arnold Air Force Base area, Tennessee.

[D, degree; M, minute; S, second]

| Site no. | Station no. | Station name  | Location |    |    |           |    |    |
|----------|-------------|---|----------|----|----|-----------|----|----|
|          |             |   | Latitude |    |    | Longitude |    |    |
|          |             |   | D        | M  | S  | D         | M  | S  |
| 1        | 03578300    | Beans Creek at Prairie Plains, Tenn.                                    | 35       | 20 | 34 | 85        | 57 | 37 |
| 2        | 03578395    | Bradley Creek at SR 41 near Hillsboro, Tenn.                            | 35       | 24 | 50 | 85        | 58 | 31 |
| 3        | 03578399    | Bradley Creek Tributary above Pond Spring at Hillsboro, Tenn.           | 35       | 25 | 11 | 85        | 58 | 28 |
| 4        | 03578404    | Bradley Creek Tributary at SR 41 near Hillsboro, Tenn.                  | 35       | 24 | 52 | 85        | 58 | 35 |
| 5        | 03578445    | Blue Spring Creek above Blue Spring, Tenn.                              | 35       | 26 | 03 | 85        | 59 | 38 |
| 6        | 03578449    | Warren Branch near Blue Spring near Hillsboro, Tenn.                    | 35       | 25 | 55 | 85        | 59 | 22 |
| 7        | 03578452    | Blue Spring Creek at Old Hillsboro Hwy near Hillsboro, Tenn.            | 35       | 25 | 04 | 85        | 59 | 10 |
| 8        | 03578458    | Bradley Creek Tributary near Cow Pond, Tenn.                            | 35       | 23 | 34 | 86        | 01 | 29 |
| 9        | 03578460    | Unnamed Branch to Bradley Creek near access road near Manchester, Tenn. | 35       | 24 | 10 | 86        | 01 | 10 |
| 10       | 03578465    | Bradley Creek Tributary near Hillsboro, Tenn.                           | 35       | 24 | 12 | 85        | 59 | 51 |
| 11       | 03578467    | Bradley Creek at Hwy 127 near Hillsboro, Tenn.                          | 35       | 23 | 45 | 85        | 58 | 40 |
| 12       | 03578468    | Collier Branch at Prairie Plains Road near Hillsboro, Tenn.             | 35       | 23 | 42 | 85        | 58 | 10 |
| 13       | 03578469    | Bradley Creek at I-24 near Hillsboro, Tenn.                             | 35       | 22 | 52 | 85        | 58 | 46 |
| 14       | 03578470    | Bradley Creek near I-24 near Prairie Plains, Tenn.                      | 35       | 22 | 16 | 85        | 58 | 23 |
| 15       | 03578485    | Bradley Creek near Unnamed Spring near Prairie Plains, Tenn.            | 35       | 21 | 38 | 85        | 58 | 32 |
| 16       | 03578500    | Bradley Creek near Prairie Plains, Tenn.                                | 35       | 21 | 21 | 85        | 58 | 45 |
| 17       | 035785002   | Bradley Creek at Prairie Plains, Tenn.                                  | 35       | 20 | 32 | 85        | 59 | 01 |
| 18       | 035785003   | Bradley Creek Tributary at Prairie Plains, Tenn.                        | 35       | 20 | 39 | 85        | 58 | 55 |
| 19       | 035785015   | Dry Creek at AEDC near Manchester, Tenn.                                | 35       | 22 | 47 | 86        | 01 | 06 |
| 20       | 035785016   | Dry Creek near Miller Church near Manchester, Tenn.                     | 35       | 22 | 07 | 85        | 59 | 44 |
| 21       | 035785017   | Dry Creek at Miller Crossroad near Prairie Plains, Tenn.                | 35       | 21 | 39 | 85        | 59 | 27 |
| 22       | 035785018   | Dry Creek at mouth at Prairie Plains, Tenn.                             | 35       | 20 | 26 | 85        | 59 | 07 |
| 23       | 035785019   | Bradley Creek below Mill Dam near Prairie Plains, Tenn.                 | 35       | 20 | 21 | 85        | 59 | 07 |
| 24       | 03578502    | Bradley Creek near Calls, Tenn.   | 35       | 20 | 07 | 85        | 59 | 25 |
| 25       | 03578508    | Unnamed Tributary to Possum Branch at SR 127 near Duncantown, Tenn.     | 35       | 20 | 44 | 86        | 01 | 31 |
| 26       | 03578509    | Possum Branch Tributary at Wimbley Road, Tenn.                          | 35       | 20 | 27 | 86        | 01 | 04 |
| 27       | 03578510    | Possum Branch at Calls Circle near Duncantown, Tenn.                    | 35       | 20 | 02 | 86        | 01 | 01 |
| 28       | 03578515    | Possum Branch near Duncantown, Tenn.                                    | 35       | 19 | 32 | 86        | 01 | 08 |
| 29       | 03578610    | Brumalow Creek near Arnold Center Road near Duncantown, Tenn.           | 35       | 21 | 55 | 86        | 02 | 48 |
| 30       | 03578625    | Brumalow Creek above Brumalow Creek Tributary near Duncantown, Tenn.    | 35       | 21 | 23 | 86        | 02 | 37 |
| 31       | 03578630    | Brumalow Creek Tributary at Hwy 127 at Banes Rd. near Duncantown, Tenn. | 35       | 21 | 44 | 86        | 01 | 41 |
| 32       | 03578635    | Brumalow Creek Tributary near Hwy 127 near Duncantown, Tenn.            | 35       | 21 | 26 | 86        | 02 | 15 |
| 33       | 03578640    | Brumalow Creek Tributary North of Old Brick Church Road, Tenn.          | 35       | 21 | 21 | 86        | 02 | 34 |
| 34       | 03578670    | Brumalow Creek Tributary, Tenn.   | 35       | 20 | 51 | 86        | 02 | 46 |
| 35       | 03578680    | Brumalow Creek above Old Brick Church Road near Duncantown, Tenn.       | 35       | 20 | 30 | 86        | 02 | 41 |
| 36       | 03578700    | Brumalow Creek at Old Brick Church Road near Duncantown, Tenn.          | 35       | 20 | 11 | 86        | 02 | 43 |
| 37       | 03578714    | Brumalow Creek Tributary at Old Brick Church Road, Tenn.                | 35       | 20 | 09 | 86        | 02 | 24 |
| 38       | 03578716    | Brumalow Creek Tributary at Woods Reservoir, Tenn.                      | 35       | 20 | 04 | 86        | 02 | 45 |
| 39       | 03578725    | Hardaway Branch at Old Brick Church Road, Tenn.                         | 35       | 20 | 18 | 86        | 03 | 35 |
| 40       | 03578975    | Rowland Creek at Arnold Center Road, Tenn.                              | 35       | 21 | 29 | 86        | 04 | 05 |

**Table 1.** Site and station numbers, station names, and locations of stream and spring measurement sites in the Arnold Air Force Base area, Tennessee.—Continued

[D, degree; M, minute; S, second]

| Site no. | Station no. | Station name   | Location |    |    |           |    |    |
|----------|-------------|--|----------|----|----|-----------|----|----|
|          |             |  | Latitude |    |    | Longitude |    |    |
|          |             |  | D        | M  | S  | D         | M  | S  |
| 41       | 03578980    | Rowland Creek at UTSI Road at AEDC near Manchester, Tenn.            | 35       | 20 | 28 | 86        | 05 | 35 |
| 42       | 03578987    | Rowland Creek at end of roadway at AEDC near Manchester, Tenn.       | 35       | 20 | 10 | 86        | 06 | 37 |
| 43       | 03578988    | Rowland Creek Tributary at Rowland Creek near Manchester, Tenn.      | 35       | 20 | 11 | 86        | 06 | 42 |
| 44       | 03579020    | Spring Creek in Saltwell Hollow, Tenn.                               | 35       | 19 | 33 | 86        | 07 | 39 |
| 45       | 03579028    | Spring Creek Tributary in Saltwell Hollow, Tenn.                     | 35       | 19 | 06 | 86        | 07 | 42 |
| 46       | 03579035    | Spring Creek below Spring Creek Cemetery near Saltwell Hollow, Tenn. | 35       | 19 | 06 | 86        | 07 | 41 |
| 47       | 03579040    | Spring Creek off Spring Creek Road at AEDC near Manchester, Tenn.    | 35       | 18 | 16 | 86        | 07 | 13 |
| 48       | 03579050    | Spring Creek Tributary off Spring Creek Road near Manchester, Tenn.  | 35       | 18 | 17 | 86        | 07 | 08 |
| 49       | 03579502    | Taylor Creek at Hwy 41A at Estill Springs, Tenn.                     | 35       | 16 | 36 | 86        | 07 | 59 |
| 50       | 03579503    | Dry Creek Northwest of Estill Springs, Tenn.                         | 35       | 17 | 26 | 86        | 09 | 46 |
| 51       | 035795035   | Dry Creek at Estill Springs, Tenn.                                   | 35       | 16 | 35 | 86        | 08 | 14 |
| 52       | 035796182   | North Fork Rock Creek at Tullahoma, Tenn.                            | 35       | 22 | 44 | 86        | 13 | 49 |
| 53       | 035796185   | North Fork Rock Creek Tributary at Hwy 41 at Tullahoma, Tenn.        | 35       | 22 | 27 | 86        | 13 | 21 |
| 54       | 035796188   | West Fork Rock Creek at Tullahoma, Tenn.                             | 35       | 22 | 10 | 86        | 13 | 41 |
| 55       | 03579620    | Rock Creek at Tullahoma, Tenn.                                       | 35       | 21 | 34 | 86        | 12 | 47 |
| 56       | 03579623    | Rock Creek above sewer outfall at Tullahoma, Tenn.                   | 35       | 20 | 46 | 86        | 12 | 44 |
| 57       | 03579635    | North Fork Rock Creek near Confluence of West Branch, Tenn.          | 35       | 19 | 37 | 86        | 12 | 35 |
| 58       | 03579640    | Blue Creek near Tullahoma, Tenn.                                     | 35       | 19 | 33 | 86        | 12 | 38 |
| 59       | 03579655    | Poorhouse Creek at Hwy 41A near Tullahoma, Tenn.                     | 35       | 19 | 51 | 86        | 10 | 54 |
| 60       | 03579660    | Poorhouse Creek near Tullahoma, Tenn.                                | 35       | 18 | 16 | 86        | 11 | 38 |
| 61       | 03579680    | Rock Creek near Tullahoma, Tenn.                                     | 35       | 17 | 16 | 86        | 11 | 17 |
| 62       | 03595020    | Huckleberry Creek Tributary near Hill Cemetery, Tenn.                | 35       | 26 | 44 | 86        | 04 | 40 |
| 63       | 03595030    | Huckleberry Creek near Huckleberry Creek Dam, Tenn.                  | 35       | 26 | 18 | 86        | 03 | 58 |
| 64       | 03595040    | Hunt Creek near dam near I-24, Tenn.                                 | 35       | 26 | 57 | 86        | 02 | 54 |
| 65       | 03595050    | Hunt Creek Tributary at I-24, Tenn.                                  | 35       | 26 | 59 | 86        | 02 | 53 |
| 66       | 03595100    | Little Duck River southeast of Manchester, Tenn.                     | 35       | 27 | 44 | 86        | 03 | 54 |
| 67       | 03595110    | Hickory Flat Creek near White Oaks at Manchester, Tenn.              | 35       | 27 | 48 | 86        | 03 | 40 |
| 68       | 03595150    | Wolf Creek at Shedd Road near Manchester, Tenn.                      | 35       | 29 | 28 | 86        | 01 | 57 |
| 69       | 03595160    | Roan Buck Branch at Shedd Road near Manchester, Tenn.                | 35       | 29 | 17 | 86        | 01 | 56 |
| 70       | 03595200    | Wolf Creek near Manchester, Tenn.                                    | 35       | 28 | 52 | 86        | 03 | 51 |
| 71       | 03595300    | Little Duck River at Hwy 55, at Manchester, Tenn.                    | 35       | 28 | 49 | 86        | 04 | 46 |
| 72       | 03595510    | Little Duck River at Grindstone Hollow at Manchester, Tenn.          | 35       | 29 | 08 | 86        | 06 | 07 |
| 73       | 03595520    | Grindstone Hollow Creek at Manchester, Tenn.                         | 35       | 28 | 56 | 86        | 05 | 32 |
| 74       | 03596000    | Duck River below Manchester, Tenn.                                   | 35       | 28 | 15 | 86        | 07 | 18 |
| 75       | 03596023    | Cat Creek near Cat Creek Road, Tenn.                                 | 35       | 27 | 17 | 86        | 06 | 52 |
| 76       | 03596025    | Bates Spring Branch near Manchester, Tenn.                           | 35       | 27 | 17 | 86        | 08 | 9  |
| 77       | 035960745   | Crumpton Creek at AEDC near Old Hillsboro Road, Tenn.                | 35       | 24 | 00 | 86        | 03 | 15 |
| 78       | 035960755   | Sinking Pond outfall at AEDC near Manchester, Tenn.                  | 35       | 24 | 00 | 86        | 03 | 40 |
| 79       | 035960758   | Crumpton Creek southwest of Sinking Pond at AEDC, Tenn.              | 35       | 23 | 40 | 86        | 03 | 56 |
| 80       | 03596076    | Crumpton Creek near Chapel Hill Cemetery, Tenn.                      | 35       | 23 | 23 | 86        | 04 | 26 |

**6 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002**

**Table 1.** Site and station numbers, station names, and locations of stream and spring measurement sites in the Arnold Air Force Base area, Tennessee.—Continued

[D, degree; M, minute; S, second]

| Site no. | Station no. | Station name   | Location |    |    |           |    |    |
|----------|-------------|--|----------|----|----|-----------|----|----|
|          |             |  | Latitude |    |    | Longitude |    |    |
|          |             |  | D        | M  | S  | D         | M  | S  |
| 81       | 035960765   | Crumpton Creek above retention pond outflow, Tenn.                     | 35       | 22 | 54 | 86        | 04 | 41 |
| 82       | 03596077    | Unnamed Tributary to Crumpton Creek below AEDC near Manchester, Tenn.  | 35       | 22 | 46 | 86        | 04 | 01 |
| 83       | 035960772   | Crumpton Creek Tributary from retention pond, Tenn.                    | 35       | 22 | 49 | 86        | 04 | 32 |
| 84       | 035960775   | Crumpton Creek Tributary at confluence, Tenn.                          | 35       | 22 | 45 | 86        | 04 | 33 |
| 85       | 03596078    | Crumpton Creek near Arnold Airport at AEDC near Manchester, Tenn.      | 35       | 22 | 37 | 86        | 05 | 01 |
| 86       | 03596079    | Crumpton Creek at Old Hillsboro Road near Hickerson Station, Tenn.     | 35       | 23 | 30 | 86        | 06 | 43 |
| 87       | 03596081    | Crumpton Creek Tributary at Belmont Road near Hickerson Station, Tenn. | 35       | 24 | 14 | 86        | 06 | 27 |
| 88       | 03596082    | Unnamed Tributary to Crumpton Creek at Belmont Road, Tenn.             | 35       | 23 | 59 | 86        | 06 | 27 |
| 89       | 03596086    | Crumpton Creek at Old Manchester Hwy near Hickerson Station, Tenn.     | 35       | 24 | 45 | 86        | 07 | 26 |
| 90       | 035960875   | Hickerson Spring Branch at Old Manchester Hwy, Tenn.                   | 35       | 24 | 38 | 86        | 07 | 49 |
| 91       | 03596088    | Crumpton Creek Tributary at Rutledge Falls, Tenn.                      | 35       | 24 | 47 | 86        | 08 | 08 |
| 92       | 03596090    | Crumpton Creek above Rutledge Falls, Tenn.                             | 35       | 25 | 18 | 86        | 08 | 08 |
| 93       | 035960910   | Wiley Creek above landfill, Tenn.                                      | 35       | 26 | 10 | 86        | 05 | 49 |
| 94       | 03596092    | Wiley Creek at Old Manchester Hwy, Tenn.                               | 35       | 24 | 45 | 86        | 07 | 26 |
| 95       | 03596096    | Wiley Creek below Wiley Spring at Belmont, Tenn.                       | 35       | 25 | 33 | 86        | 06 | 56 |
| 96       | 03596099    | Wiley Creek at Rutledge Falls, Tenn.                                   | 35       | 25 | 21 | 86        | 08 | 07 |
| 97       | 03596120    | Crumpton Creek below Rutledge Falls, Tenn.                             | 35       | 25 | 18 | 86        | 06 | 20 |
| 98       | 03596201    | Ovoca (Calanthe) Lake overflow near Tullahoma, Tenn.                   | 35       | 24 | 36 | 86        | 12 | 08 |
| 99       | 03596295    | Bobo Creek at Carter Blake Road, Tenn.                                 | 35       | 23 | 36 | 86        | 10 | 55 |
| 100      | 03596298    | Bobo Creek above Short Spring, Tenn.                                   | 35       | 24 | 21 | 86        | 10 | 42 |
| 101      | 03596304    | Machine Falls Branch above falls near Mt. Vernon, Tenn.                | 35       | 24 | 45 | 86        | 10 | 43 |
| 102      | 03578400    | Pond Spring at Hillsboro, Tenn.  | 35       | 25 | 10 | 85        | 58 | 29 |
| 103      | 03578448    | Blue Spring at Blue Spring Creek, Tenn.                                | 35       | 25 | 59 | 85        | 59 | 34 |
| 104      | 03578490    | Joe Marlow Spring near Prairie Plains, Tenn.                           | 35       | 21 | 38 | 85        | 58 | 35 |
| 105      | 03578495    | Unnamed Spring near Prairie Plains, Tenn.                              | 35       | 21 | 23 | 85        | 58 | 43 |
| 106      | 035785004   | Unnamed Spring at Bradley Creek near Prairie Plains, Tenn.             | 35       | 20 | 36 | 85        | 58 | 56 |
| 107      | 03579045    | Spring Creek Spring off Spring Creek Road near Manchester, Tenn.       | 35       | 18 | 18 | 86        | 07 | 08 |
| 108      | 03596094    | Wiley Spring at Belmont, Tenn.   | 35       | 24 | 34 | 86        | 06 | 52 |
| 109      | 03596300    | Short Spring near Tullahoma, Tenn.                                     | 35       | 24 | 16 | 86        | 10 | 41 |

**Table 2.** High base-flow data for streams in the Arnold Air Force Base area, Tennessee, June 3 through 5, 2002.

[ft<sup>3</sup>/s, cubic foot per second; mi<sup>2</sup>, square mile; °C, degrees Celsius; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; --, not applicable; e, estimated]

| Site no.        | Station no. | Stream discharge,<br>instantaneous (ft <sup>3</sup> /s) | Drainage<br>area (mi <sup>2</sup> ) | Temperature (°C) | Specific conductance<br>(µS/cm at 25 °C) |
|-----------------|-------------|---|-------------------------------------|------------------|--|
| Beans Creek     |             |   |                                     |                  |  |
| 1               | 03578300    | 5.88  | 17.6                                | 21.1             | 285                                      |
| Bradley Creek   |             |   |                                     |                  |  |
| 2               | 03578395    | 2.71  | 11.8                                | 19.5             | 140                                      |
| 3               | 03578399    | 0   | 1.53                                | --               | --                                       |
| 4               | 03578404    | 6.60  | 1.75                                | 20.5             | --                                       |
| 5               | 03578445    | 0   | 3.98                                | --               | --                                       |
| 6               | 03578449    | 0   | 5.84                                | --               | --                                       |
| 7               | 03578452    | 3.27  | 10.96                               | --               | --                                       |
| 8               | 03578458    | 0   | 1.62                                | --               | --                                       |
| 9               | 03578460    | 0   | 2.16                                | --               | --                                       |
| 10              | 03578465    | 0   | 5.73                                | --               | --                                       |
| 11              | 03578467    | 10.7  | 32.5                                | 22.0             | 300                                      |
| 12              | 03578468    | 0.15  | 1.61                                | 20.5             | 180                                      |
| 13              | 03578469    | 11.6  | 36.17                               | 20.5             | 302                                      |
| 14              | 03578470    | 10.8  | 36.8                                | 20.7             | 447                                      |
| 15              | 03578485    | 8.10  | 37.97                               | 21.4             | 301                                      |
| 16              | 03578500    | 27.2  | 38.53                               | 17.5             | 469                                      |
| 17              | 035785002   | 46.4  | 39.73                               | 20.5             | 300                                      |
| 18              | 035785003   | 0   | 0.31                                | --               | --                                       |
| 19              | 035785015   | 0   | 0.68                                | --               | --                                       |
| 20              | 035785016   | 0   | 3.68                                | --               | --                                       |
| 21              | 035785017   | 0   | 4.17                                | --               | --                                       |
| 22              | 035785018   | 8.26  | 5.11                                | 18.7             | 282                                      |
| 23              | 035785019   | 27.8  | 45.29                               | 18.2             | 297                                      |
| 24              | 03578502    | 34.5  | 45.49                               | 18.1             | 298                                      |
| Possum Creek    |             |   |                                     |                  |  |
| 25              | 03578508    | 0   | 0.43                                | --               | --                                       |
| 26              | 03578509    | 0.20  | 0.20                                | 16.2             | 71                                       |
| 27              | 03578510    | 0.27  | 1.53                                | 25.2             | 84                                       |
| 28              | 03578515    | 0.32  | 1.90                                | 23.2             | 82                                       |
| Brumalow Creek  |             |   |                                     |                  |  |
| 29              | 03578610    | 0.04  | 0.55                                | 19.3             | 165                                      |
| 30              | 03578625    | 0.31  | 0.84                                | 20.0             | 134                                      |
| 31              | 03578630    | 0.01  | 0.58                                | 20.1             | 440                                      |
| 32              | 03578635    | 0.30  | 1.40                                | 18.1             | 18                                       |
| 33              | 03578640    | 0.50  | 1.59                                | 18.3             | 74                                       |
| 34              | 03578670    | 0.02  | 0.67                                | 17.1             | 67                                       |
| 35              | 03578680    | 1.31  | 3.92                                | 19.8             | --                                       |
| 36              | 03578700    | 1.36  | 4.13                                | 21.1             | --                                       |
| 37              | 03578714    | 0   | 0.81                                | --               | --                                       |
| 38              | 03578716    | 0   | 1.06                                | --               | --                                       |
| Hardaway Branch |             |   |                                     |                  |  |
| 39              | 03578725    | 0   | 0.75                                | --               | --                                       |
| Rowland Creek   |             |   |                                     |                  |  |
| 40              | 03578975    | 38.1  | 0.81                                | 29.1             | 146                                      |

## 8 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002

**Table 2.** High base-flow data for streams in the Arnold Air Force Base area, Tennessee, June 3 through 5, 2002.—Continued

[ft<sup>3</sup>/s, cubic foot per second; mi<sup>2</sup>, square mile; °C, degrees Celsius; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; --, not applicable; e, estimated]

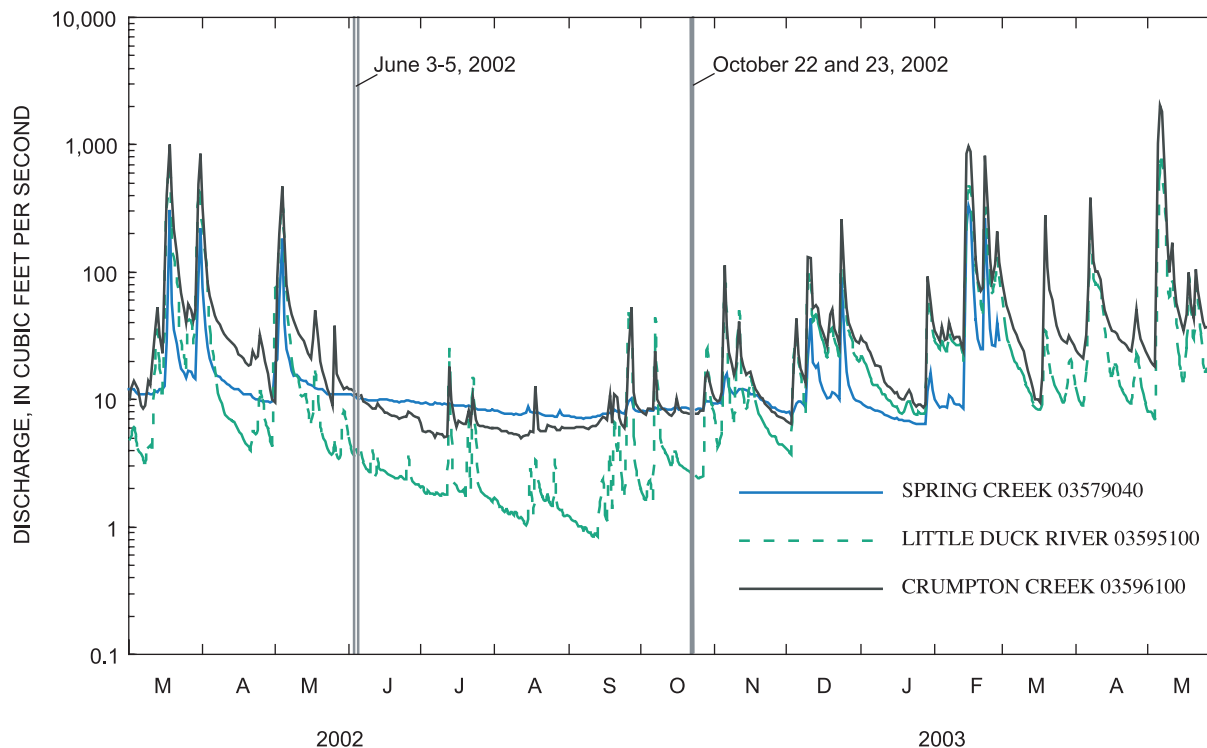
| Site no.            | Station no. | Stream discharge,<br>instantaneous (ft <sup>3</sup> /s) | Drainage<br>area (mi <sup>2</sup> ) | Temperature (°C) | Specific conductance<br>(µS/cm at 25 °C) |
|---------------------|-------------|---|-------------------------------------|------------------|--|
| 41                  | 03578980    | 38.0  | 3.11                                | 25.2             | 161                                      |
| 42                  | 03578987    | 34.1  | 5.19                                | 24.6             | 162                                      |
| 43                  | 03578988    | 0   | 1.02                                | --               | --                                       |
| Spring Creek        |             |   |                                     |                  |  |
| 44                  | 03579020    | 0   | 2.75                                | --               | --                                       |
| 45                  | 03579028    | 0   | 2.82                                | --               | --                                       |
| 46                  | 03579035    | 6.09  | 7.67                                | 16.1             | 99                                       |
| 47                  | 03579040    | 10.4  | 9.29                                | 16.8             | 105                                      |
| 48                  | 03579050    | 0.36  | 0.28                                | 18.1             | 100                                      |
| Taylor Creek        |             |   |                                     |                  |  |
| 49                  | 03579502    | 5.42  | 2.92                                | 15.9             | 118                                      |
| Dry Creek           |             |   |                                     |                  |  |
| 50                  | 03579503    | 0   | 3.05                                | --               | --                                       |
| 51                  | 035795035   | 7.09  | 4.75                                | 16.6             | 85                                       |
| Rock Creek          |             |   |                                     |                  |  |
| 52                  | 035796182   | 0   | 2.65                                | --               | --                                       |
| 53                  | 035796185   | 0.03  | 0.73                                | 25.3             | 250                                      |
| 54                  | 035796188   | 0.51  | 7.43                                | 22.2             | 131                                      |
| 55                  | 03579620    | 2.65  | 12.22                               | 20.6             | 116                                      |
| 56                  | 03579623    | 2.40  | 13.02                               | 20.8             | 130                                      |
| 57                  | 03579635    | 7.49  | 16.35                               | 21.6             | 437                                      |
| 58                  | 03579640    | 0.36  | 9.11                                | 17.2             | 98                                       |
| 59                  | 03579655    | 0.02  | 2.79                                | 23.3             | 258                                      |
| 60                  | 03579660    | 3.73  | 5.17                                | 19.0             | 106                                      |
| 61                  | 03579680    | 19.0  | 36.5                                | 22.6             | 218                                      |
| Duck River          |             |   |                                     |                  |  |
| 62                  | 03595020    | 0   | 0.84                                | --               | --                                       |
| 63                  | 03595030    | 0   | 0.75                                | --               | --                                       |
| 64                  | 03595040    | 0.28  | 6.16                                | 31.3             | 66                                       |
| 65                  | 03595050    | 0   | 2.46                                | --               | --                                       |
| 66                  | 03595100    | 3.32  | 13.02                               | 20.7             | 185                                      |
| 67                  | 03595110    | 0.05  | 1.67                                | 21.2             | 206                                      |
| 68                  | 03595150    | 2.83  | 12.12                               | 23.0             | 210                                      |
| 69                  | 03595160    | 0.09  | 3.36                                | 23.6             | 111                                      |
| 70                  | 03595200    | 4.69  | 19.32                               | 23.0             | 182                                      |
| 71                  | 03595300    | 10.4  | 35.58                               | 20.1             | --                                       |
| 72                  | 03595510    | 14.9  | 40.87                               | 22.7             | 177                                      |
| 73                  | 03595520    | 0   | 2.17                                | --               | --                                       |
| 74                  | 03596000    | 42.8  | 112.20                              | 23.5             | 176                                      |
| Cat Creek           |             |   |                                     |                  |  |
| 75                  | 03596023    | 0.36  | 1.24                                | 20.3             | 72                                       |
| Bates Spring Branch |             |   |                                     |                  |  |
| 76                  | 03596025    | 0.59  | 1.30                                | 18.0             | --                                       |
| Crumpton Creek      |             |   |                                     |                  |  |
| 77                  | 035960745   | 0   | 1.47                                | --               | --                                       |
| 78                  | 035960755   | 0   | 1.60                                | --               | --                                       |

**Table 2.** High base-flow data for streams in the Arnold Air Force Base area, Tennessee, June 3 through 5, 2002.—Continued[ft<sup>3</sup>/s, cubic foot per second; mi<sup>2</sup>, square mile; °C, degrees Celsius; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; --, not applicable; e, estimated]

| Site no. | Station no. | Stream discharge,<br>instantaneous (ft <sup>3</sup> /s) | Drainage<br>area (mi <sup>2</sup> ) | Temperature (°C) | Specific conductance<br>(µS/cm at 25 °C) |
|----------|-------------|---|-------------------------------------|------------------|--|
| 79       | 035960758   | 0.11  | 3.58                                | 20.6             | 62                                       |
| 80       | 03596076    | 0.15  | 4.16                                | 20.2             | 36                                       |
| 81       | 035960765   | 0   | 5.29                                | --               | --                                       |
| 82       | 03596077    | 0.04  | 1.05                                | 19.0             | 175                                      |
| 83       | 035960772   | 0.05  | 1.35                                | 21.4             | 87                                       |
| 84       | 035960775   | 0.005e  | 0.69                                | --               | --                                       |
| 85       | 03596078    | 0   | 7.74                                | --               | --                                       |
| 86       | 03596079    | 0.95  | 10.45                               | 18.3             | 148                                      |
| 87       | 03596081    | 0   | 1.49                                | --               | --                                       |
| 88       | 03596082    | 0   | 1.62                                | --               | --                                       |
| 89       | 03596086    | 0.65  | 15.9                                | 20.8             | 148                                      |
| 90       | 035960875   | 0.95  | 4.79                                | 21.0             | --                                       |
| 91       | 03596088    | 0.52  | 1.08                                | 14.3             | 167                                      |
| 92       | 03596090    | 4.60  | 22.36                               | 18.5             | 102                                      |
| 93       | 035960910   | 0   | 1.53                                | --               | 146                                      |
| 94       | 03596092    | 0   | 1.74                                | --               | --                                       |
| 95       | 03596096    | 3.78  | 3.08                                | 15.0             | 155                                      |
| 96       | 03596099    | 5.81  | 4.65                                | 16.7             | 157                                      |
| 97       | 03596120    | 12.7  | 27.04                               | 18.8             | 153                                      |
|          |             | Ovoca Lake  |                                     |                  |  |
| 98       | 03596201    | 1.43  | 3.68                                | 24.8             | 101                                      |
|          |             | Bobo Creek  |                                     |                  |  |
| 99       | 03596295    | 0.77  | 6.35                                | 17.1             | 105                                      |
| 100      | 03596298    | 1.19  | 8.32                                | 21.7             | 111                                      |
|          |             | Machine Falls   |                                     |                  |  |
| 101      | 03596304    | 0.61  | 1.43                                | 18.1             | 64                                       |

**Table 3.** High base-flow data for springs in the Arnold Air Force Base area, Tennessee, June 3 through 5, 2002.[ft<sup>3</sup>/s, cubic foot per second; °C, degrees Celsius; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius]

| Site no. | Station no. | Spring name         | Stream discharge,<br>instantaneous (ft <sup>3</sup> /s) | Temperature<br>(°C) | Specific<br>conductance<br>(µS/cm at 25 °C) |
|----------|-------------|---------------------|---|---------------------|---|
| 102      | 03578400    | Pond Spring         | 6.02  | 15.3                | 150   |
| 103      | 03578448    | Blue Spring         | 3.96  | 16.0                | 355   |
| 104      | 03578490    | Joe Marlow Spring   | 7.00  | 15.0                | 340   |
| 105      | 03578495    | Unnamed Spring      | 5.28  | 15.0                | 329   |
| 106      | 035785004   | Unnamed Spring      | 6.87  | 16.8                | 205   |
| 107      | 03579045    | Spring Creek Spring | 0.20  | 18.4                | 88  |
| 108      | 03596094    | Wiley Spring        | 2.28  | 14.7                | 164   |
| 109      | 03596300    | Short Spring        | 9.22  | 16.6                | 148   |



**Figure 2.** Daily mean discharge on Spring Creek, Little Duck River, and Crumpton Creek.

Discharge measurements were made at 108 sites (101 stream sites and 7 springs) on October 22 and 23, 2002 (tables 4 and 5). The measurements were made during low base-flow conditions, and 46 of the measurement sites (43 percent) had zero flow. About 57 percent of the dry measurement sites lie along Bradley and Crumpton Creeks and their tributaries (fig. 4). Flows at the farthest downstream sites along the major streams in the basin were 44.6 ft<sup>3</sup>/s for Duck River (site 74), 13.5 ft<sup>3</sup>/s for Rock Creek (site 61), 13 ft<sup>3</sup>/s for Bradley Creek (site 24), 8.32 ft<sup>3</sup>/s for Spring Creek (site 47), 7.45 ft<sup>3</sup>/s for Dry Creek (site 51), 7.62 ft<sup>3</sup>/s for Crumpton Creek (site 97), 0.5 ft<sup>3</sup>/s for Beans Creek (site 1), and 0.28 ft<sup>3</sup>/s for Brumalow Creek (site 36). Discharge measurements at sites with flow ranged from 0.02 ft<sup>3</sup>/s (site 29) to 44.6 ft<sup>3</sup>/s (site 74). Measurement sites with discharge values for October 22 and 23, 2002, and dry, gaining, wet, and losing reaches are shown in figure 4.

Total discharge leaving the study area was greater during high base-flow conditions than during low base-flow conditions. During the high base-flow period, site 17 on Bradley Creek (fig. 1) had the greatest discharge, 46.4 ft<sup>3</sup>/s (table 2). During the low base-flow period, site 74 on the Duck River had the greatest discharge, 44.6 ft<sup>3</sup>/s (table 4).

Discharge data were used to categorize stream reaches as gaining, losing, wet (little to no change in flow), dry, or unobserved. Gaining, losing, and dry stream reaches are bounded by one or more upstream and one downstream measurement sites.

For this report, a gaining reach is defined as a reach in which flow has increased by at least 10 percent of its downstream discharge value. A losing reach is defined as a reach in which flow has decreased by at least 10 percent of its upstream discharge value. A wet reach is a reach in which the change in flow is less than 10 percent of its greater discharge value. A reach is categorized as dry if its upstream and downstream measurements are 0 ft<sup>3</sup>/s. A reach not bounded by both upstream and downstream measurement sites is categorized as unobserved. Gaining stream reaches were more common during the high base-flow period (fig. 3) than during the low base-flow periods (fig. 4). Dry stream reaches were more common during the low base-flow period (fig. 4) than during the high base-flow period (fig. 3). Most of the losing stream reaches were more predominant along Bradley and Crumpton Creeks (figs. 3 and 4).

## Temperature Data

Water temperature data also were collected at most of the sites that had flow when discharge measurements were taken. On June 3 through 5, 2002, water temperatures ranged from 14.3 to 31.3 °C at 76 of the 78 sites with flow (tables 2 and 3). On October 22 and 23, 2002, water temperature data was collected at 61 of the 62 sites with flow, and the measured temperatures ranged from 12.6 to 19.3 °C (tables 4 and 5).



EXPLANATION

STREAM REACH

- AT LEAST 10-PERCENT GAIN IN FLOW
- AT LEAST 10-PERCENT LOSS IN FLOW
- WET, WITH LESS THAN 10-PERCENT CHANGE IN FLOW
- UNOBSERVED
- - - DRY

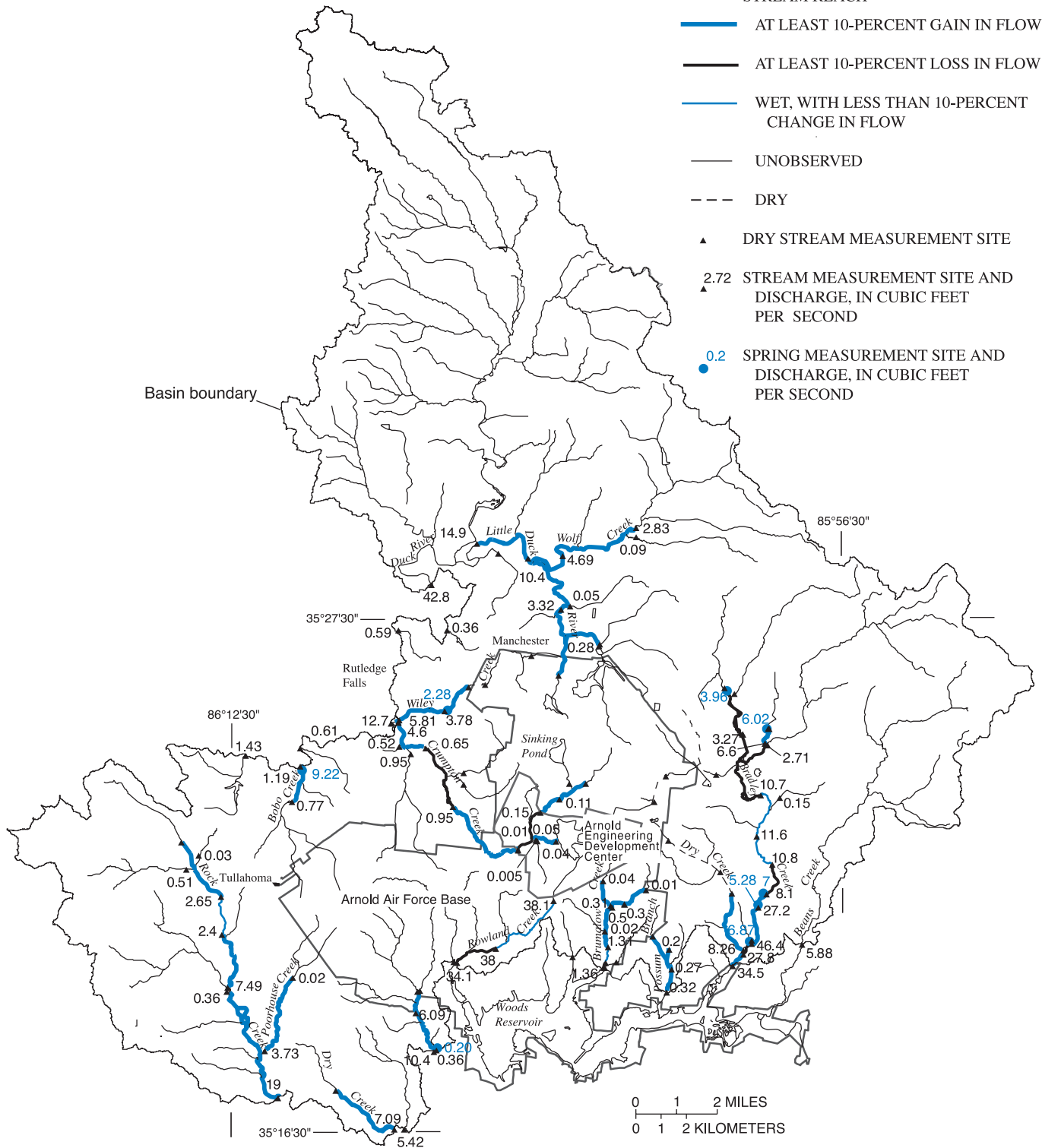
▲ DRY STREAM MEASUREMENT SITE

▲ 2.72 STREAM MEASUREMENT SITE AND DISCHARGE, IN CUBIC FEET PER SECOND

▲ DRY STREAM MEASUREMENT SITE

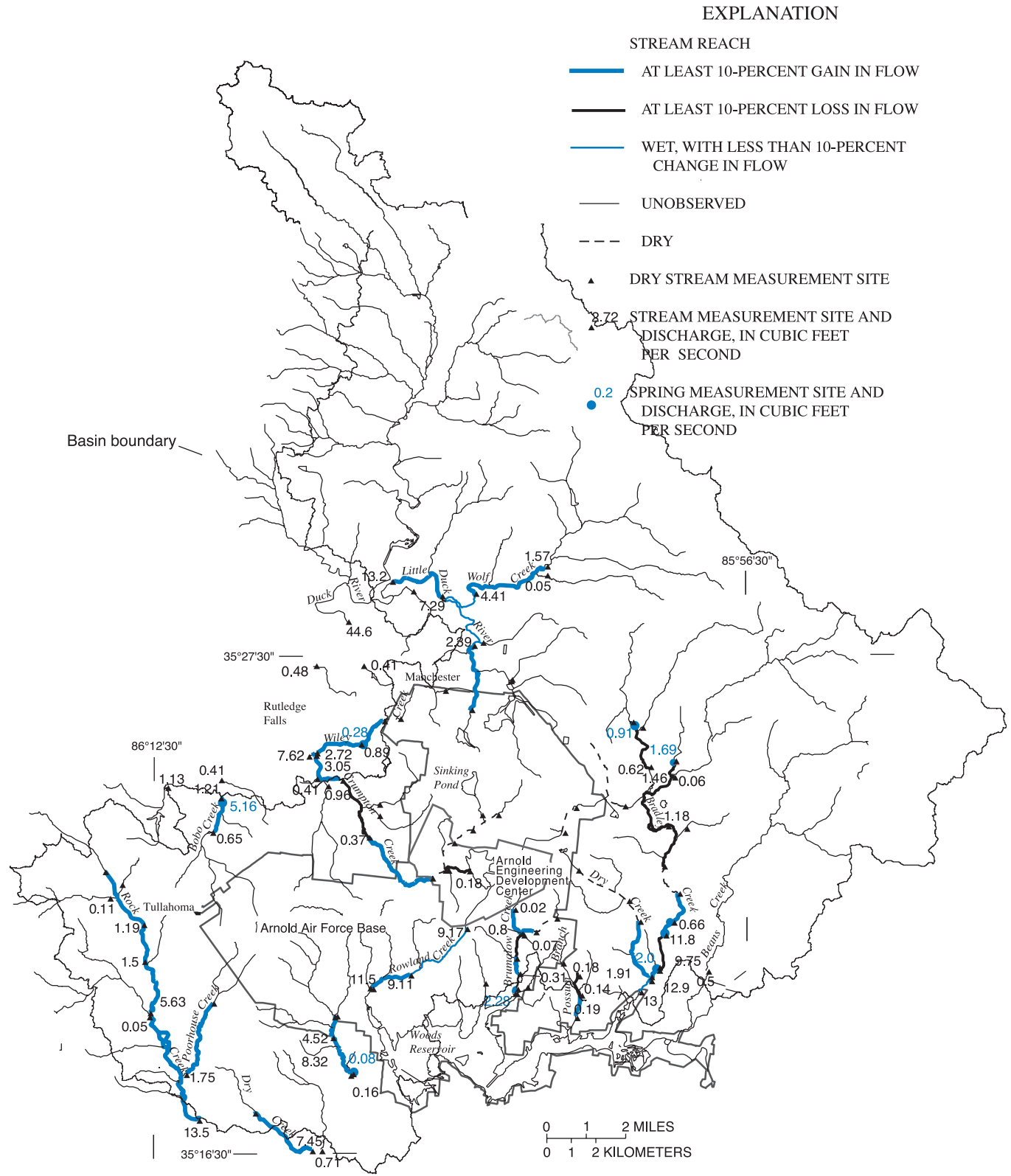
▲ 2.72 STREAM MEASUREMENT SITE AND DISCHARGE, IN CUBIC FEET PER SECOND

● 0.2 SPRING MEASUREMENT SITE AND DISCHARGE, IN CUBIC FEET PER SECOND



Base from U.S. Geological Survey digital data, 1972, 1:2,000,000 Albers Equal-Area Conic Projection Standard parallels 29°30'N and 45°30'N, Standard meridian 96°00'W

**Figure 3.** Arnold Air Force Base area showing high base-flow stream and spring measurement sites and discharge measurements, June 3 through 5, 2002.



Base from U.S. Geological Survey digital data, 1972, 1:2,000,000 Albers Equal-Area Conic Projection Standard parallels 29°30'N and 45°30'N, Standard meridian 96°00'W

**Figure 4.** Arnold Air Force Base area showing low base-flow stream and spring measurement sites and discharge measurements, October 22 and 23, 2002.

**Table 4.** Low base-flow data for streams in the Arnold Air Force Base area, Tennessee, October 22 and 23, 2002.[ft<sup>3</sup>/s, cubic foot per second; mi<sup>2</sup>, square mile; °C, degrees Celsius; μS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; --, not applicable]

| Site no.        | Station no. | Stream discharge,<br>instantaneous (ft <sup>3</sup> /s) | Drainage<br>area (mi <sup>2</sup> ) | Temperature (°C) | Specific conductance<br>(μS/cm at 25 °C) |
|-----------------|-------------|---|-------------------------------------|------------------|--|
| Beans Creek     |             |   |                                     |                  |  |
| 1               | 03578300    | 0.50  | 17.6                                | 16.0             | 366                                      |
| Bradley Creek   |             |   |                                     |                  |  |
| 2               | 03578395    | 0.06  | 11.8                                | 18.9             | 310                                      |
| 3               | 03578399    | 0   | 1.53                                | --               | --                                       |
| 4               | 03578404    | 1.46  | 1.75                                | 15.5             | 407                                      |
| 5               | 03578445    | 0   | 3.98                                | --               | --                                       |
| 6               | 03578449    | 0   | 5.84                                | --               | --                                       |
| 7               | 03578452    | 0.62  | 10.96                               | 15.5             | 445                                      |
| 8               | 03578458    | 0   | 1.62                                | --               | --                                       |
| 9               | 03578460    | 0   | 2.16                                | --               | --                                       |
| 10              | 03578465    | 0   | 5.73                                | --               | --                                       |
| 11              | 03578467    | 1.18  | 32.5                                | 17.5             | 380                                      |
| 12              | 03578468    | 0   | 1.61                                | --               | --                                       |
| 13              | 03578469    | 0   | 36.17                               | --               | --                                       |
| 14              | 03578470    | 0   | 36.8                                | --               | --                                       |
| 15              | 03578485    | 0.66  | 37.97                               | 15.7             | 435                                      |
| 16              | 03578500    | 11.8  | 38.53                               | 15.6             | 411                                      |
| 17              | 035785002   | 9.75  | 39.73                               | 15.0             | 372                                      |
| 18              | 035785003   | 0   | 0.31                                | --               | --                                       |
| 19              | 035785015   | 0   | 0.68                                | --               | --                                       |
| 20              | 035785016   | 0   | 3.68                                | --               | --                                       |
| 21              | 035785017   | 0   | 4.17                                | --               | --                                       |
| 22              | 035785018   | 1.91  | 5.11                                | 14.5             | 307                                      |
| 23              | 035785019   | 12.9  | 45.29                               | 14.5             | 325                                      |
| 24              | 03578502    | 13  | 45.49                               | 14.0             | 331                                      |
| Possum Creek    |             |   |                                     |                  |  |
| 25              | 03578508    | 0   | 0.43                                | --               | --                                       |
| 26              | 03578509    | 0.18  | 0.20                                | 15.5             | 76                                       |
| 27              | 03578510    | 0.14  | 1.53                                | 17.9             | 96                                       |
| 28              | 03578515    | 0.19  | 1.90                                | 16.3             | 102                                      |
| Brumalow Creek  |             |   |                                     |                  |  |
| 29              | 03578610    | 0.02  | 0.55                                | 14.5             | 286                                      |
| 30              | 03578625    | 0.18  | 0.84                                | 15.0             | 198                                      |
| 31              | 03578630    | 0   | 0.58                                | --               | --                                       |
| 32              | 03578635    | 0   | 1.40                                | --               | --                                       |
| 33              | 03578640    | 0.07  | 1.59                                | 14.5             | 125                                      |
| 34              | 03578670    | 0   | 0.67                                | --               | --                                       |
| 35              | 03578680    | 0.31  | 3.92                                | 14.7             | 152                                      |
| 36              | 03578700    | 0.28  | 4.13                                | 14.7             | 142                                      |
| 37              | 03578714    | 0   | 0.81                                | --               | --                                       |
| 38              | 03578716    | 0   | 1.06                                | --               | --                                       |
| Hardaway Branch |             |   |                                     |                  |  |
| 39              | 03578725    | 0   | 0.75                                | --               | --                                       |
| Rowland Creek   |             |   |                                     |                  |  |
| 40              | 03578975    | 9.17  | 0.81                                | 18.3             | 179                                      |

**14 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002**

**Table 4.** Low base-flow data for streams in the Arnold Air Force Base area, Tennessee, October 22 and 23, 2002.—Continued

[ft<sup>3</sup>/s, cubic foot per second; mi<sup>2</sup>, square mile; °C, degrees Celsius; μS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; --, not applicable]

| Site no.            | Station no. | Stream discharge, instantaneous (ft <sup>3</sup> /s) | Drainage area (mi <sup>2</sup> ) | Temperature (°C) | Specific conductance (μS/cm at 25 °C) |
|---------------------|-------------|--|----------------------------------|------------------|---------------------------------------|
| 41                  | 03578980    | 9.11   | 3.11                             | 19.3             | 173                                   |
| 42                  | 03578987    | 11.5   | 5.19                             | 18.9             | 161                                   |
| 43                  | 03578988    | 0  | 1.02                             | --               | --                                    |
| Spring Creek        |             |  |                                  |                  |                                       |
| 44                  | 03579020    | 0  | 2.75                             | --               | --                                    |
| 45                  | 03579028    | 0  | 2.82                             | --               | --                                    |
| 46                  | 03579035    | 4.52   | 7.67                             | 14.2             | 115                                   |
| 47                  | 03579040    | 8.32   | 9.29                             | 14.5             | 113                                   |
| 48                  | 03579050    | 0.16   | 0.28                             | 15.5             | 113                                   |
| Taylor Creek        |             |  |                                  |                  |                                       |
| 49                  | 03579502    | 0.71   | 2.92                             | 14.9             | 126                                   |
| Dry Creek           |             |  |                                  |                  |                                       |
| 50                  | 03579503    | 0  | 3.05                             | --               | --                                    |
| 51                  | 035795035   | 7.45   | 4.75                             | 15.7             | 91                                    |
| Rock Creek          |             |  |                                  |                  |                                       |
| 52                  | 035796182   | 0  | 2.65                             | --               | --                                    |
| 53                  | 035796185   | 0  | 0.73                             | --               | --                                    |
| 54                  | 035796188   | 0.11   | 7.43                             | 14.7             | 133                                   |
| 55                  | 03579620    | 1.19   | 12.22                            | 15.5             | 142                                   |
| 56                  | 03579623    | 1.50   | 13.02                            | 15.7             | 154                                   |
| 57                  | 03579635    | 5.63   | 16.35                            | 17.4             | 464                                   |
| 58                  | 03579640    | 0.05   | 9.11                             | 17.0             | 100                                   |
| 59                  | 03579655    | 0  | 2.79                             | --               | --                                    |
| 60                  | 03579660    | 1.75   | 5.17                             | 14.6             | 111                                   |
| 61                  | 03579680    | 13.5   | 36.5                             | 15.9             | 260                                   |
| Duck River          |             |  |                                  |                  |                                       |
| 62                  | 03595020    | 0  | 0.84                             | --               | --                                    |
| 63                  | 03595030    | 0  | 0.75                             | --               | --                                    |
| 64                  | 03595040    | 0  | 6.16                             | --               | --                                    |
| 65                  | 03595050    | 0  | 2.46                             | --               | --                                    |
| 66                  | 03595100    | 2.39   | 13.02                            | 16.9             | 235                                   |
| 67                  | 03595110    | 0  | 1.67                             | --               | --                                    |
| 68                  | 03595150    | 1.57   | 12.12                            | 12.8             | 238                                   |
| 69                  | 03595160    | 0.05   | 3.36                             | 12.9             | 230                                   |
| 70                  | 03595200    | 4.41   | 19.32                            | 19.0             | 200                                   |
| 71                  | 03595300    | 7.29   | 35.58                            | 13.2             | 215                                   |
| 72                  | 03595510    | 13.2   | 40.87                            | 14.7             | 205                                   |
| 73                  | 03595520    | 0  | 2.17                             | --               | --                                    |
| 74                  | 03596000    | 44.6   | 112.20                           | 16.0             | 180                                   |
| Cat Creek           |             |  |                                  |                  |                                       |
| 75                  | 03596023    | 0.41   | 1.24                             | 16.0             | 82                                    |
| Bates Spring Branch |             |  |                                  |                  |                                       |
| 76                  | 03596025    | 0.48   | 1.30                             | 13.5             | 85                                    |

**Table 4.** Low base-flow data for streams in the Arnold Air Force Base area, Tennessee, October 22 and 23, 2002.—Continued

[ft<sup>3</sup>/s, cubic foot per second; mi<sup>2</sup>, square mile; °C, degrees Celsius; μS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; --, not applicable]

| Site no.       | Station no. | Stream discharge,<br>instantaneous (ft <sup>3</sup> /s) | Drainage<br>area (mi <sup>2</sup> ) | Temperature (°C) | Specific conductance<br>(μS/cm at 25 °C) |
|----------------|-------------|---|-------------------------------------|------------------|--|
| Crompton Creek |             |   |                                     |                  |  |
| 77             | 035960745   | 0   | 1.47                                | --               | --                                       |
| 78             | 035960755   | 0   | 1.60                                | --               | --                                       |
| 79             | 035960758   | 0   | 3.58                                | --               | --                                       |
| 80             | 03596076    | 0   | 4.16                                | --               | --                                       |
| 81             | 035960765   | 0   | 5.29                                | --               | --                                       |
| 82             | 03596077    | 0.08  | 1.05                                | 13.8             | 195                                      |
| 83             | 035960772   | 0   | 1.35                                | --               | --                                       |
| 84             | 035960775   | 0   | 0.69                                | --               | --                                       |
| 85             | 03596078    | 0   | 7.74                                | --               | --                                       |
| 86             | 03596079    | 0.37  | 10.45                               | 15.6             | 171                                      |
| 87             | 03596081    | 0   | 1.49                                | --               | --                                       |
| 88             | 03596082    | 0   | 1.62                                | --               | --                                       |
| 89             | 03596086    | 0   | 15.9                                | --               | --                                       |
| 90             | 035960875   | 0.96  | 4.79                                | 13.7             | 187                                      |
| 91             | 03596088    | 0.41  | 1.08                                | 13.1             | 183                                      |
| 92             | 03596090    | 3.05  | 22.36                               | 12.6             | 188                                      |
| 93             | 035960910   | 0   | 1.53                                | --               | --                                       |
| 94             | 03596092    | 0   | 1.74                                | --               | --                                       |
| 95             | 03596096    | 0.89  | 3.08                                | 15.5             | 200                                      |
| 96             | 03596099    | 2.72  | 4.65                                | 12.7             | 195                                      |
| 97             | 03596120    | 7.62  | 27.04                               | 13.9             | 176                                      |
| Ovoca Lake     |             |   |                                     |                  |  |
| 98             | 03596201    | 1.13  | 3.68                                | 16.3             | 126                                      |
| Bobo Creek     |             |   |                                     |                  |  |
| 99             | 03596295    | 0.65  | 6.35                                | 15.5             | 143                                      |
| 100            | 03596298    | 1.21  | 8.32                                | 13.7             | 149                                      |
| Machine Falls  |             |   |                                     |                  |  |
| 101            | 03596304    | 0.41  | 1.43                                | 12.9             | 81                                       |

**Table 5.** Low base-flow data for springs in the Arnold Air Force Base area, Tennessee, October 22 and 23, 2002.[ft<sup>3</sup>/s, cubic foot per second; °C, degrees Celsius; μS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; --, no data]

| Site no. | Station no. | Spring name         | Discharge, instantaneous (ft <sup>3</sup> /s) | Temperature (°C) | Specific conductance (μS/cm at 25 °C) |
|----------|-------------|---------------------|---|------------------|---------------------------------------|
| 102      | 03578400    | Pond Spring         | 1.69  | 19.0             | 400                                   |
| 103      | 03578448    | Blue Spring         | 0.91  | 14.2             | 510                                   |
| 104      | 03578490    | Joe Marlow Spring   | --  | --               | --                                    |
| 105      | 03578495    | Unnamed Spring      | 2.82  | 15.1             | 410                                   |
| 106      | 035785004   | Unnamed Spring      | 2   | --               | --                                    |
| 107      | 03579045    | Spring Creek Spring | 0.08  | 14.8             | 115                                   |
| 108      | 03596094    | Wiley Spring        | 0.28  | 15.0             | 210                                   |
| 109      | 03596300    | Short Spring        | 5.16  | 14.4             | 181                                   |

### Specific Conductance Data

Specific conductance also was measured at most of the sites that had flow. On June 3 through 5, 2002, the specific conductance ranged from 18 to 469 μS/cm at 71 of the 78 sites with flow (tables 2 and 3). On October 22 and 23, 2002, specific conductance ranged from 76 to 510 μS/cm at 61 of the 62 sites with flow (tables 4 and 5).

### Areas of Surplus or Deficient Flow

Areas of surplus or deficient flow can be determined by comparing the change in flow of each sub-basin with the flow of the entire basin. Such a comparison will reveal how much flow each sub-basin is contributing to the total flow of the basin. Areas of surplus or deficient flow were determined for high and low base-flow periods in the following manner:

- The drainage area for each sub-basin was measured from topographic maps.
- The change in flow for each sub-basin was calculated by subtracting the flow entering each sub-basin from the flow leaving each sub-basin. The change in flow was divided by the sub-basin drainage area. The change in flow per square mile for each sub-basin is shown in tables 6 and 7.
- The flow per square mile of surface drainage for the study area was calculated by dividing the sum of the discharge at the farthest downstream sites by the sum of the basin areas of the farthest downstream sites. Flow

and the drainage area for the Rowland Creek basin were not included in the basin totals because a significant part of flow in Rowland Creek is from AEDC discharge water. Values of flow per square mile for the study area of 0.55 and 0.37 (ft<sup>3</sup>/s)/mi<sup>2</sup> were calculated using discharge data collected on June 3 through 5, 2002 and October 22 and 23, 2002, respectively (table 8).

- The change in flow per square mile for each sub-basin was compared to the flow per square mile for the study area. If the change in flow per square mile for a sub-basin was greater than 2 times the flow per square mile for the entire study area, then the sub-basin was defined as an area of surplus flow. If the change in flow per square mile for a sub-basin was less than half of the flow per square mile for the study area, then the sub-basin was defined as an area of deficient flow. Otherwise, the sub-basin was considered neither surplus nor deficient. Areas of surplus or deficient flow are shown in figures 5 and 6.

Many areas of deficient flow occurred throughout the study area under high and low base-flow conditions. Most areas of deficient flow were present in the headwater basins. Fewer areas of surplus flow were present under low base-flow conditions than during the high base-flow conditions. The flow per square mile for each major tributary basin in the study area also was calculated (table 9). The values of flow per square mile for Dry Creek, Spring Creek, and Wiley Creek basins were greatest of all the major tributary basins under both base-flow conditions.

**Table 6.** High base-flow data for drainage areas in the Arnold Air Force Base area, Tennessee, June 3 through 5, 2002.

[mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile; change in flow per square mile, positive numbers reflect gain and negative numbers loss]

| Site and sub-basin no. (figure 5) | Sub-basin area (mi <sup>2</sup> ) | Discharge, entering sub-basin (ft <sup>3</sup> /s) | Discharge, leaving sub-basin (ft <sup>3</sup> /s) | Change in flow per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |
|-----------------------------------|-----------------------------------|--|---|--|
| 1                                 | 17.6                              | 0  | 5.88  | 0.33   |
| 2                                 | 11.80                             | 0  | 2.71  | 0.23   |
| 3                                 | 1.53                              | 0  | 0   | 0  |
| 4                                 | 0.22                              | 0  | 6.60  | 30.0   |
| 5                                 | 3.98                              | 0  | 0   | 0  |
| 6                                 | 5.84                              | 0  | 0   | 0  |
| 7                                 | 1.13                              | 0  | 3.27  | 2.89   |
| 8                                 | 1.62                              | 0  | 0   | 0  |
| 9                                 | 0.54                              | 0  | 0   | 0  |
| 10                                | 3.57                              | 0  | 0   | 0  |
| 11                                | 2.27                              | 12.58  | 10.7  | -0.83  |
| 12                                | 1.61                              | 0  | 0.15  | 0.09   |
| 13                                | 2.06                              | 10.85  | 11.6  | 0.36   |
| 14                                | 0.63                              | 11.6   | 10.8  | -1.27  |
| 15                                | 1.17                              | 10.8   | 8.10  | -2.31  |
| 16                                | 0.56                              | 8.10   | 27.2  | 34.11  |
| 17                                | 1.20                              | 27.2   | 46.4  | 16   |
| 18                                | 0.31                              | 0  | 0   | 0  |
| 19                                | 0.68                              | 0  | 0   | 0  |
| 20                                | 3.00                              | 0  | 0   | 0  |
| 21                                | 0.49                              | 0  | 0   | 0  |
| 22                                | 0.94                              | 0  | 8.26  | 8.79   |
| 23                                | 0.14                              | 54.66  | 27.8  | -191.86  |
| 24                                | 0.20                              | 27.8   | 34.5  | 33.5   |
| 25                                | 0.43                              | 0  | 0   | 0  |
| 26                                | 0.20                              | 0  | 0.20  | 1  |
| 27                                | 0.89                              | 0.20   | 0.27  | 0.08   |
| 28                                | 0.37                              | 0.27   | 0.32  | 0.13   |
| 29                                | 0.55                              | 0  | 0.04  | 0.07   |
| 30                                | 0.29                              | 0.04   | 0.31  | 0.93   |
| 31                                | 0.58                              | 0  | 0.01  | 0.02   |
| 32                                | 0.83                              | 0.01   | 0.30  | 0.35   |
| 33                                | 0.18                              | 0.30   | 0.50  | 1.11   |
| 34                                | 0.67                              | 0  | 0.02  | 0.03   |
| 35                                | 0.82                              | 0.83   | 1.31  | 0.59   |
| 36                                | 0.21                              | 1.31   | 1.36  | 0.24   |
| 37                                | 0.81                              | 0  | 0   | 0  |
| 38                                | 0.20                              | 0  | 0   | 0  |
| 39                                | 0.75                              | 0  | 0   | 0  |
| 40                                | 0.81                              | 0  | 38.1  | 47.04  |

**18 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002**

**Table 6.** High base-flow data for drainage areas in the Arnold Air Force Base area, Tennessee, June 3 through 5, 2002.—Continued

[mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile; change in flow per square mile, positive numbers reflect gain and negative numbers loss]

| Site and sub-basin no. (figure 5) | Sub-basin area (mi <sup>2</sup> ) | Discharge, entering sub-basin (ft <sup>3</sup> /s) | Discharge, leaving sub-basin (ft <sup>3</sup> /s) | Change in flow per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |
|-----------------------------------|-----------------------------------|--|---|--|
| 41                                | 2.30                              | 38.1   | 38.0  | -0.04  |
| 42                                | 2.08                              | 38.0   | 34.1  | -1.87  |
| 43                                | 1.02                              | 0  | 0   | 0  |
| 44                                | 2.75                              | 0  | 0   | 0  |
| 45                                | 2.82                              | 0  | 0   | 0  |
| 46                                | 2.11                              | 0  | 6.09  | 2.89   |
| 47                                | 1.61                              | 6.09   | 10.4  | 2.68   |
| 48                                | 0.28                              | 0  | 0.36  | 1.29   |
| 49                                | 2.92                              | 0  | 5.42  | 1.86   |
| 50                                | 3.05                              | 0  | 0   | 0  |
| 51                                | 1.70                              | 0  | 7.09  | 4.17   |
| 52                                | 2.65                              | 0  | 0   | 0  |
| 53                                | 0.73                              | 0  | 0.03  | 0.04   |
| 54                                | 7.43                              | 0  | 0.51  | 0.07   |
| 55                                | 1.41                              | 0.54   | 2.65  | 1.50   |
| 56                                | 0.80                              | 2.65   | 2.40  | -0.31  |
| 57                                | 3.33                              | 2.40   | 7.49  | 1.53   |
| 58                                | 9.11                              | 0  | 0.36  | 0.04   |
| 59                                | 2.79                              | 0  | 0.02  | 0.01   |
| 60                                | 2.38                              | 0.02   | 3.73  | 1.56   |
| 61                                | 5.87                              | 11.58  | 19.0  | 1.26   |
| 62                                | 0.84                              | 0  | 0   | 0  |
| 63                                | 0.75                              | 0  | 0   | 0  |
| 64                                | 6.16                              | 0  | 0.28  | 0.05   |
| 65                                | 2.46                              | 0  | 0   | 0  |
| 66                                | 2.81                              | 0.28   | 3.32  | 1.08   |
| 67                                | 1.67                              | 0  | 0.05  | 0.03   |
| 68                                | 12.12                             | 0  | 2.83  | 0.23   |
| 69                                | 3.36                              | 0  | 0.09  | 0.03   |
| 70                                | 3.84                              | 2.92   | 4.69  | 0.46   |
| 71                                | 1.57                              | 8.06   | 10.4  | 1.49   |
| 72                                | 5.30                              | 10.4   | 14.9  | 0.85   |
| 73                                | 2.17                              | 0  | 0   | 0  |
| 74                                | 69.2                              | 14.9   | 42.8  | 0.40   |
| 75                                | 1.24                              | 0  | 0.36  | 0.29   |
| 76                                | 1.30                              | 0  | 0.59  | 0.45   |
| 77                                | 1.47                              | 0  | 0   | 0  |
| 78                                | 1.60                              | 0  | 0   | 0  |
| 79                                | 0.51                              | 0  | 0.11  | 0.22   |
| 80                                | 0.59                              | 0.11   | 0.15  | 0.07   |



**Table 6.** High base-flow data for drainage areas in the Arnold Air Force Base area, Tennessee, June 3 through 5, 2002.—Continued

[mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile; change in flow per square mile, positive numbers reflect gain and negative numbers loss]

| Site and sub-basin no. (figure 5) | Sub-basin area (mi <sup>2</sup> ) | Discharge, entering sub-basin (ft <sup>3</sup> /s) | Discharge, leaving sub-basin (ft <sup>3</sup> /s) | Change in flow per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |
|-----------------------------------|-----------------------------------|--|---|--|
| 81                                | 1.12                              | 0.15   | 0   | -0.13  |
| 82                                | 1.05                              | 0  | 0.04  | 0.04   |
| 83                                | 0.30                              | 0.04   | 0.05  | 0.03   |
| 84                                | 0.69                              | 0  | 0.005   | 0.01   |
| 85                                | 0.42                              | 0.06   | 0   | -0.14  |
| 86                                | 2.70                              | 0  | 0.95  | 0.35   |
| 87                                | 1.49                              | 0  | 0   | 0  |
| 88                                | 1.62                              | 0  | 0   | 0  |
| 89                                | 2.34                              | 0.95   | 0.65  | -0.13  |
| 90                                | 4.79                              | 0  | 0.95  | 0.20   |
| 91                                | 1.08                              | 0  | 0.52  | 0.48   |
| 92                                | 0.59                              | 2.12   | 4.60  | 4.20   |
| 93                                | 1.53                              | 0  | 0   | 0  |
| 94                                | 0.20                              | 0  | 0   | 0  |
| 95                                | 1.34                              | 0  | 3.78  | 2.82   |
| 96                                | 1.57                              | 3.78   | 5.81  | 1.29   |
| 97                                | 0.03                              | 10.41  | 12.7  | 76.3   |
| 98                                | 3.68                              | 0  | 1.43  | 0.39   |
| 99                                | 6.35                              | 0  | 0.77  | 0.12   |
| 100                               | 1.97                              | 0.77   | 1.19  | 0.21   |
| 101                               | 1.43                              | 0  | 0.61  | 0.43   |

**20 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002**

**Table 7.** Low base-flow data for drainage areas in the Arnold Air Force Base area, Tennessee, October 22 and 23, 2002.

[mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile; change in flow per square mile, positive numbers reflect gain and negative numbers loss]

| Site and sub-basin no.<br>(figure 6) | Sub-basin area (mi <sup>2</sup> ) | Discharge, entering<br>sub-basin (ft <sup>3</sup> /s) | Discharge, leaving<br>sub-basin (ft <sup>3</sup> /s) | Change in flow per square<br>mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |
|--------------------------------------|-----------------------------------|---|--|---|
| 1                                    | 17.6                              | 0   | 0.50   | 0.03  |
| 2                                    | 11.80                             | 0   | 0.06   | 0.01  |
| 3                                    | 1.53                              | 0   | 0  | 0   |
| 4                                    | 0.22                              | 0   | 1.46   | 6.64  |
| 5                                    | 3.98                              | 0   | 0  | 0   |
| 6                                    | 5.84                              | 0   | 0  | 0   |
| 7                                    | 1.13                              | 0   | 0.62   | 0.55  |
| 8                                    | 1.62                              | 0   | 0  | 0   |
| 9                                    | 0.54                              | 0   | 0  | 0   |
| 10                                   | 3.57                              | 0   | 0  | 0   |
| 11                                   | 2.27                              | 2.14  | 1.18   | -0.42   |
| 12                                   | 1.61                              | 0   | 0  | 0   |
| 13                                   | 2.06                              | 1.18  | 0  | -0.57   |
| 14                                   | 0.63                              | 0   | 0  | 0   |
| 15                                   | 1.17                              | 0   | 0.66   | 0.56  |
| 16                                   | 0.56                              | 0.66  | 11.8   | 19.89   |
| 17                                   | 1.20                              | 11.8  | 9.75   | -1.71   |
| 18                                   | 0.31                              | 0   | 0  | 0   |
| 19                                   | 0.68                              | 0   | 0  | 0   |
| 20                                   | 3.00                              | 0   | 0  | 0   |
| 21                                   | 0.49                              | 0   | 0  | 0   |
| 22                                   | 0.94                              | 0   | 1.91   | 2.03  |
| 23                                   | 0.14                              | 11.66   | 12.9   | 8.86  |
| 24                                   | 0.20                              | 12.9  | 13.0   | 0.50  |
| 25                                   | 0.43                              | 0   | 0  | 0   |
| 26                                   | 0.20                              | 0   | 0.18   | 0.9   |
| 27                                   | 0.89                              | 0.18  | 0.14   | -0.05   |
| 28                                   | 0.37                              | 0.14  | 0.19   | 0.13  |
| 29                                   | 0.55                              | 0   | 0.02   | 0.04  |
| 30                                   | 0.29                              | 0.02  | 0.18   | 0.55  |
| 31                                   | 0.58                              | 0   | 0  | 0   |
| 32                                   | 0.83                              | 0   | 0  | 0   |
| 33                                   | 0.18                              | 0   | 0.07   | 0.39  |
| 34                                   | 0.67                              | 0   | 0  | 0   |
| 35                                   | 0.82                              | 0.25  | 0.31   | 0.07  |
| 36                                   | 0.21                              | 0.31  | 0.28   | -0.14   |
| 37                                   | 0.81                              | 0   | 0  | 0   |
| 38                                   | 0.20                              | 0   | 0  | 0   |
| 39                                   | 0.75                              | 0   | 0  | 0   |
| 40                                   | 0.81                              | 0   | 9.17   | 11.32   |

**Table 7.** Low base-flow data for drainage areas in the Arnold Air Force Base area, Tennessee, October 22 and 23, 2002.—Continued

[mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile; change in flow per square mile, positive numbers reflect gain and negative numbers loss]

| Site and sub-basin no.<br>(figure 6) | Sub-basin area (mi <sup>2</sup> ) | Discharge, entering<br>sub-basin (ft <sup>3</sup> /s) | Discharge, leaving<br>sub-basin (ft <sup>3</sup> /s) | Change in flow per square<br>mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |
|--------------------------------------|-----------------------------------|---|--|---|
| 41                                   | 2.30                              | 9.17  | 9.11   | -0.03   |
| 42                                   | 2.08                              | 9.11  | 11.5   | 1.15  |
| 43                                   | 1.02                              | 0   | 0  | 0   |
| 44                                   | 2.75                              | 0   | 0  | 0   |
| 45                                   | 2.82                              | 0   | 0  | 0   |
| 46                                   | 2.11                              | 0   | 4.52   | 2.14  |
| 47                                   | 1.61                              | 4.52  | 8.32   | 2.36  |
| 48                                   | 0.28                              | 0   | 0.16   | 0.57  |
| 49                                   | 2.92                              | 0   | 0.71   | 0.24  |
| 50                                   | 3.05                              | 0   | 0  | 0   |
| 51                                   | 1.70                              | 0   | 7.45   | 4.38  |
| 52                                   | 2.65                              | 0   | 0  | 0   |
| 53                                   | 0.73                              | 0   | 0  | 0   |
| 54                                   | 7.43                              | 0   | 0.11   | 0.01  |
| 55                                   | 1.41                              | 0.11  | 1.19   | 0.77  |
| 56                                   | 0.80                              | 1.19  | 1.50   | 0.39  |
| 57                                   | 3.33                              | 1.50  | 5.63   | 1.24  |
| 58                                   | 9.11                              | 0   | 0.05   | 0.01  |
| 59                                   | 2.79                              | 0   | 0  | 0   |
| 60                                   | 2.38                              | 0   | 1.75   | 0.73  |
| 61                                   | 5.87                              | 7.43  | 13.5   | 1.03  |
| 62                                   | 0.84                              | 0   | 0  | 0   |
| 63                                   | 0.75                              | 0   | 0  | 0   |
| 64                                   | 6.16                              | 0   | 0  | 0   |
| 65                                   | 2.46                              | 0   | 0  | 0   |
| 66                                   | 2.81                              | 0   | 2.39   | 0.85  |
| 67                                   | 1.67                              | 0   | 0  | 0   |
| 68                                   | 12.12                             | 0   | 1.57   | 0.13  |
| 69                                   | 3.36                              | 0   | 0.05   | 0.01  |
| 70                                   | 3.84                              | 1.62  | 4.41   | 0.73  |
| 71                                   | 1.57                              | 6.80  | 7.29   | 0.31  |
| 72                                   | 5.30                              | 7.29  | 13.2   | 1.12  |
| 73                                   | 2.17                              | 0   | 0  | 0   |
| 74                                   | 69.2                              | 13.2  | 44.6   | 0.45  |
| 75                                   | 1.24                              | 0   | 0.41   | 0.33  |
| 76                                   | 1.30                              | 0   | 0.48   | 0.37  |
| 77                                   | 1.47                              | 0   | 0  | 0   |
| 78                                   | 1.60                              | 0   | 0  | 0   |
| 79                                   | 0.51                              | 0   | 0  | 0   |
| 80                                   | 0.59                              | 0   | 0  | 0   |

**22 Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002**

**Table 7.** Low base-flow data for drainage areas in the Arnold Air Force Base area, Tennessee, October 22 and 23, 2002.—Continued

[mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile; change in flow per square mile, positive numbers reflect gain and negative numbers loss]

| Site and sub-basin no.<br>(figure 6) | Sub-basin area (mi <sup>2</sup> ) | Discharge, entering<br>sub-basin (ft <sup>3</sup> /s) | Discharge, leaving<br>sub-basin (ft <sup>3</sup> /s) | Change in flow per square<br>mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |
|--------------------------------------|-----------------------------------|---|--|---|
| 81                                   | 1.12                              | 0   | 0  | 0   |
| 82                                   | 1.05                              | 0   | 0.08   | 0.08  |
| 83                                   | 0.30                              | 0.08  | 0  | -0.27   |
| 84                                   | 0.69                              | 0   | 0  | 0   |
| 85                                   | 0.42                              | 0   | 0  | 0   |
| 86                                   | 2.70                              | 0   | 0.37   | 0.14  |
| 87                                   | 1.49                              | 0   | 0  | 0   |
| 88                                   | 1.62                              | 0   | 0  | 0   |
| 89                                   | 2.34                              | 0.37  | 0  | -0.16   |
| 90                                   | 4.79                              | 0   | 0.96   | 0.20  |
| 91                                   | 1.08                              | 0   | 0.41   | 0.38  |
| 92                                   | 0.59                              | 1.37  | 3.05   | 2.85  |
| 93                                   | 1.53                              | 0   | 0  | 0   |
| 94                                   | 0.20                              | 0   | 0  | 0   |
| 95                                   | 1.34                              | 0   | 0.89   | 0.66  |
| 96                                   | 1.57                              | 0.89  | 2.72   | 1.17  |
| 97                                   | 0.03                              | 5.77  | 7.62   | 61.67   |
| 98                                   | 3.68                              | 0   | 1.13   | 0.31  |
| 99                                   | 6.35                              | 0   | 0.65   | 0.10  |
| 100                                  | 1.97                              | 0.65  | 1.21   | 0.28  |
| 101                                  | 1.43                              | 0   | 0.41   | 0.29  |

**Table 8.** Downstream sites used to calculate total flow per square mile in study area.

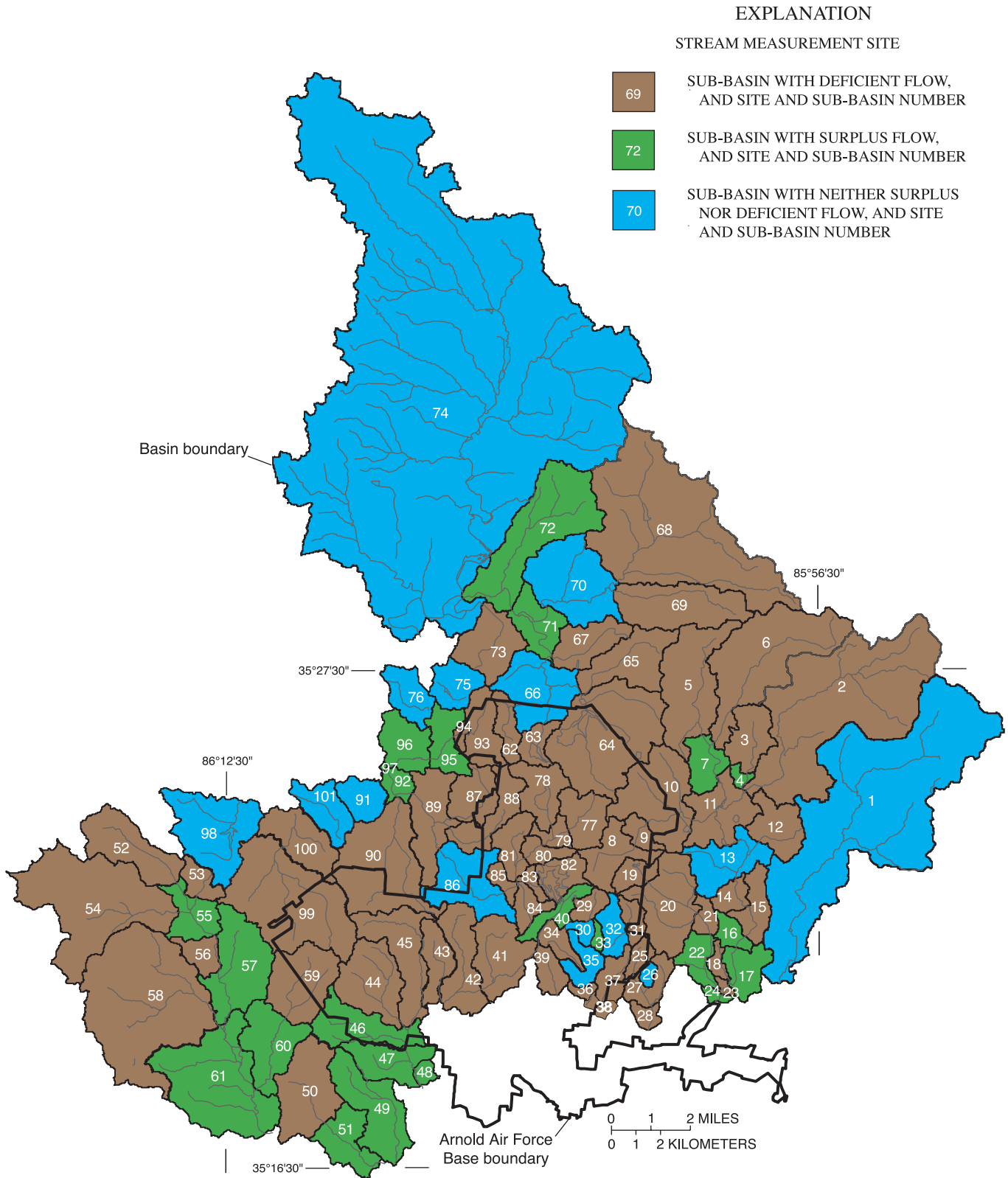
[mi<sup>2</sup>, square mile; ft<sup>3</sup>/s, cubic foot per second; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile]

| Basin                | Site no. | Drainage area (mi <sup>2</sup> ) | June 2002  |  | October 2002   |  |
|----------------------|----------|----------------------------------|--|--|--|--|
|                      |          |                                  | Stream discharge, instantaneous (ft <sup>3</sup> /s) | Flow per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] | Stream discharge, instantaneous (ft <sup>3</sup> /s) | Flow per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |
| Beans Creek          | 1        | 17.6                             | 5.88   | 0.33   | 0.50   | 0.03   |
| Bradley Creek        | 24       | 45.49                            | 34.5   | 0.76   | 13   | 0.29   |
| Possum Branch        | 28       | 1.90                             | 0.32   | 0.17   | 0.19   | 0.10   |
| Brumalow Creek       | 36       | 4.13                             | 1.36   | 0.33   | 0.28   | 0.07   |
| Brumalow Creek       | 38       | 1.06                             | 0  | 0  | 0  | 0  |
| Hardaway Branch      | 39       | 0.75                             | 0  | 0  | 0  | 0  |
| Rowland Creek        | 43       | 1.02                             | 0  | 0  | 0  | 0  |
| Spring Creek         | 47       | 9.29                             | 10.4   | 1.12   | 8.32   | 0.90   |
| Spring Creek         | 48       | 0.28                             | 0.36   | 1.29   | 0.16   | 0.57   |
| Taylor Creek         | 49       | 2.92                             | 5.42   | 1.86   | 0.71   | 0.24   |
| Dry Creek            | 51       | 4.75                             | 7.09   | 1.49   | 7.45   | 1.57   |
| Rock Creek           | 61       | 36.5                             | 19.0   | 0.52   | 13.5   | 0.37   |
| Duck River           | 74       | 112.2                            | 42.8   | 0.38   | 44.6   | 0.40   |
| Cat Creek            | 75       | 1.24                             | 0.36   | 0.29   | 0.41   | 0.33   |
| Bates Spring Branch  | 76       | 1.30                             | 0.59   | 0.45   | 0.48   | 0.37   |
| Crumpton Creek       | 97       | 27.04                            | 12.7   | 0.47   | 7.62   | 0.28   |
| Ovoca Lake           | 98       | 3.68                             | 1.43   | 0.39   | 1.13   | 0.31   |
| Bobo Creek           | 100      | 8.32                             | 1.19   | 0.14   | 1.21   | 0.15   |
| Machine Falls Branch | 101      | 1.43                             | 0.61   | 0.43   | 0.41   | 0.29   |
| Bobo Creek           | 109      | 0                                | 9.22   | 0  | 5.16   | 0.0  |
| Total                |          | 281                              | 153  | 0.55   | 105  | 0.37   |

**Table 9.** Flow per square mile for tributary basins in the Arnold Air Force Base area, Tennessee.

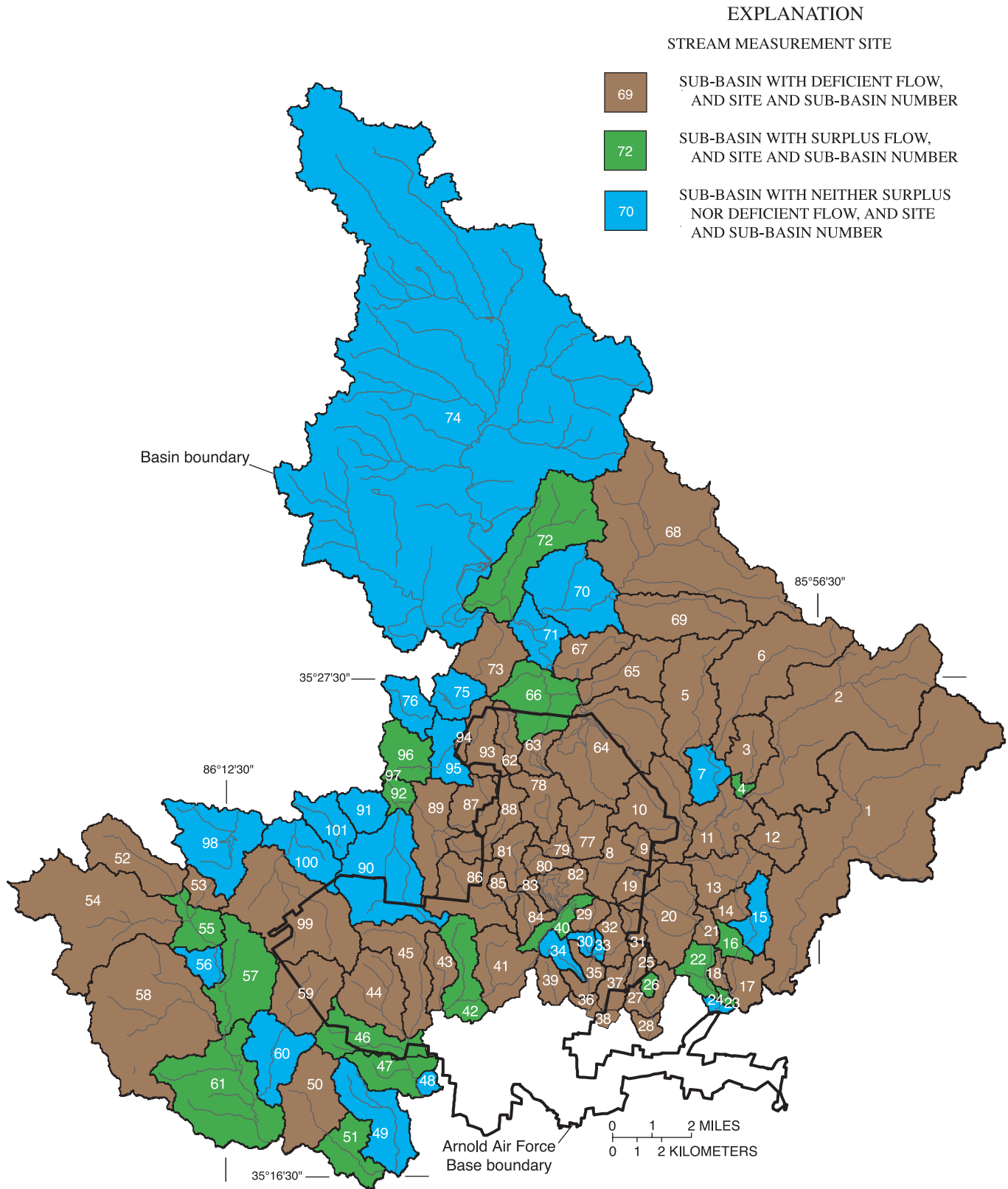
[mi<sup>2</sup>, square mile; (ft<sup>3</sup>/s)/mi<sup>2</sup>, cubic foot per second per square mile]

| Basin  | Site no. | Basin area (mi <sup>2</sup> ) | Flow per square mile [(ft <sup>3</sup> /s)/mi <sup>2</sup> ] |              |
|--|----------|-------------------------------|--|--------------|
|  |          |                               | June 2002  | October 2002 |
| Tributary  |          |                               |  |              |
| Beans Creek  | 1        | 17.6                          | 0.33   | 0.03         |
| Bradley Creek                                      | 24       | 45.49                         | 0.76   | 0.29         |
| Brumalow Creek                                     | 36       | 4.13                          | 0.33   | 0.07         |
| Spring Creek                                       | 47       | 9.29                          | 1.12   | 0.90         |
| Dry Creek (at Estill Springs)                      | 51       | 4.75                          | 1.49   | 1.57         |
| Rock Creek   | 61       | 36.5                          | 0.52   | 0.37         |
| Duck River   | 74       | 112.61                        | 0.38   | 0.40         |
| Crumpton Creek (above confluence with Wiley Creek) | 92       | 22.36                         | 0.21   | 0.14         |
| Wiley Creek (at Rutledge Falls)                    | 96       | 4.65                          | 1.25   | 0.58         |
| Crumpton Creek                                     | 97       | 27.04                         | 0.47   | 0.28         |
| Entire study area (except Rowland Creek)           |          | 281                           | 0.55   | 0.37         |



Base from U.S. Geological Survey digital data, 1972, 1:2,000,000 Albers Equal-Area Conic Projection Standard parallels 29°30'N and 45°30'N, Standard meridian 96°00'W

**Figure 5.** Arnold Air Force Base area showing areas of surplus or deficient flow during high base flow, June 3 through 5, 2002.



Base from U.S. Geological Survey digital data, 1972, 1:2,000,000 Albers Equal-Area Conic Projection Standard parallels 29°30'N and 45°30'N, Standard meridian 96°00'W

**Figure 6.** Arnold Air Force Base area showing areas of surplus or deficient flow during low base flow, October 22 and 23, 2002.

## Summary

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee. The primary mission of AAFB is to support the development of aerospace systems. This mission is accomplished through test facilities at Arnold Engineering Development Center (AEDC), which occupies about 4,000 acres in the center of AAFB. Base-flow data including discharge, temperature, and specific conductance were collected for basins in and near AAFB during high base-flow and low base-flow conditions. Data representing high base-flow conditions from 109 sites were collected on June 3 through 5, 2002, when discharge measurements at sites with flow ranged from 0.005 to 46.4 ft<sup>3</sup>/s. Data representing low base-flow conditions from 109 sites were collected on October 22 and 23, 2002, when discharge measurements at sites with flow ranged from 0.02 to 44.6 ft<sup>3</sup>/s. Discharge from the basin was greater during high base-flow conditions than during low base-flow conditions. In general, major tributaries on the north side and southeastern side of the study area (Duck River and Bradley Creek, respectively) had the highest flows during the study.

Discharge data were used to categorize stream reaches and sub-basins. Stream reaches were categorized as gaining, losing, wet, dry, or unobserved for each base-flow measurement period. More gaining stream reaches were present during the high base-flow period than during the low base-flow period. More dry stream reaches were present during the low base-flow periods than during the high base-flow period. Most losing reaches occur in Bradley and Crumpton Creeks.

Values of flow per square mile for the study area of 0.55 and 0.37 (ft<sup>3</sup>/s)/mi<sup>2</sup> were calculated using discharge data collected on June 3 through 5, 2002, and October 22 and 23, 2002, respectively. Sub-basin areas with surplus or deficient flow were defined within the basin. Drainage areas for each stream measurement site were delineated and measured from topographic maps. Change in flow per square mile for each sub-basin was calculated using data from each base-flow measurement period. The calculated values were used to define the areas of surplus or deficient flow for high and low base-flow conditions. Many areas of deficient flow were present throughout the study area under high and low base-flow conditions. Most areas of deficient flow occurred in the headwater basins. Fewer areas of surplus flow were present during low base-flow conditions than during the high base-flow conditions. The flow per square mile for each major tributary basin in the study area also was

calculated. The values of flow per square mile for the Dry Creek, Spring Creek, and Wiley Creek basins were greatest under both base-flow conditions.

The data for this study were collected in June and October 2002 to help refine the understanding of the regional ground-water-flow system. The comprehensive results of the investigation may aid in the development of corrective measures and long-term monitoring plans for AAFB.

## References Cited

- Buchanan, T.J., and Somers, W.P., 1969, Discharge measurements at gaging stations: Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 3, Chap. A8, p. 65.
- Burchett, C.R., 1977, Water resources of the upper Duck River basin, central Tennessee: Tennessee Division of Water Resources, Water Resources Series no. 12, 103 p.
- Haugh, C.J., and Mahoney, E.N., 1994, Hydrogeology and simulation of ground-water flow at Arnold Air Force Base, Coffee and Franklin Counties, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 93-4207, 69 p.
- Mahoney, E.N., and Robinson, J.A., 1993, Altitude of the potentiometric surface in the Manchester aquifer at Arnold Air Force Base, May 1991, Coffee and Franklin Counties, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 93-4059, one sheet, scale 1:97,000.
- Miller, R.A., 1974, The geologic history of Tennessee: Tennessee Division of Geology Bulletin 74, 63 p.
- Riggs, H.C., 1972, Low-flow investigations: Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 4, Chap. B1, p. 11.
- Wilson, C.W., Jr., 1976, Geologic map and mineral resources summary of the Manchester quadrangle, Tennessee: Tennessee Division of Geology, MRS 86-NE, scale 1:24,000.
- Wolfe, W.J., 1996, Hydrology and tree-distribution patterns of karst wetlands at Arnold Engineering Development Center, Tennessee: U.S. Geological Survey Water-Resources Investigations Report 96-4277, 46 p.
- Wolfe, W.J., and League, D.E., 1996, Water-surface elevations of wetlands and nearby wells at Arnold Air Force Base, near Manchester, Tennessee: U.S. Geological Survey Open-File Report 95-753, 19 p.