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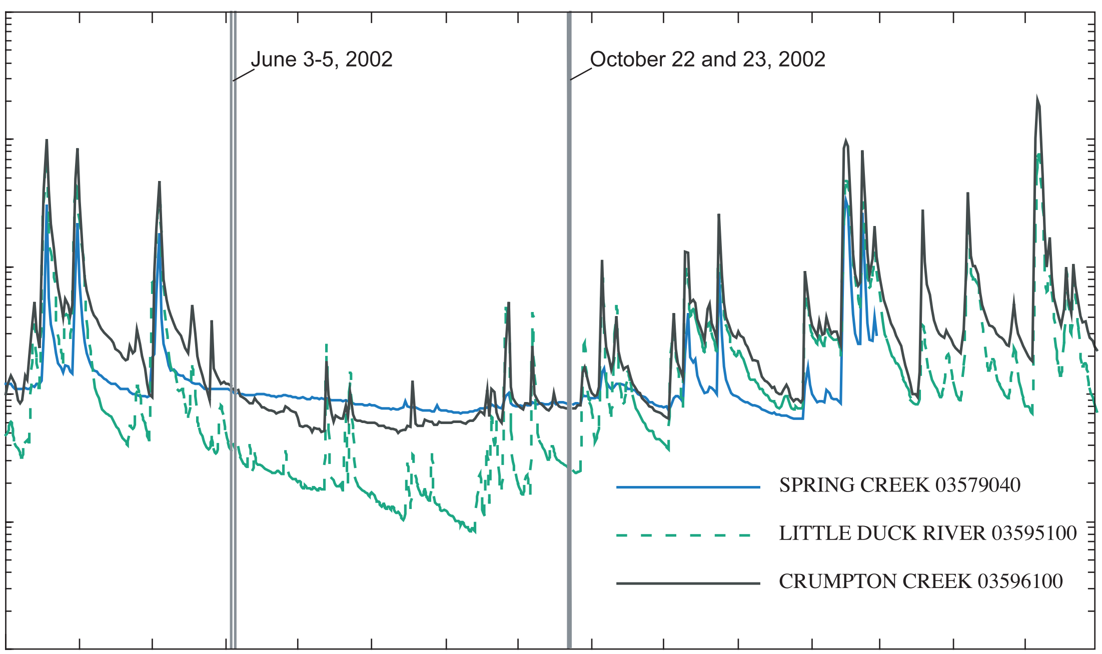
Base-Flow Data in the Arnold Air Force Base Area, Tennessee, June and October 2002



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

By John A. Robinson and Connor J. Haugh

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

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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^2)
acre	0.4047	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [(ft^3/s)/mi^2]	0.01093	cubic meter per second per square kilometer [(m^3/s)/km^2]
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:

$$°F = 1.8° C + 32$$

$$°C = 5/9 (°F – 32)$$

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^3/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^3/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.

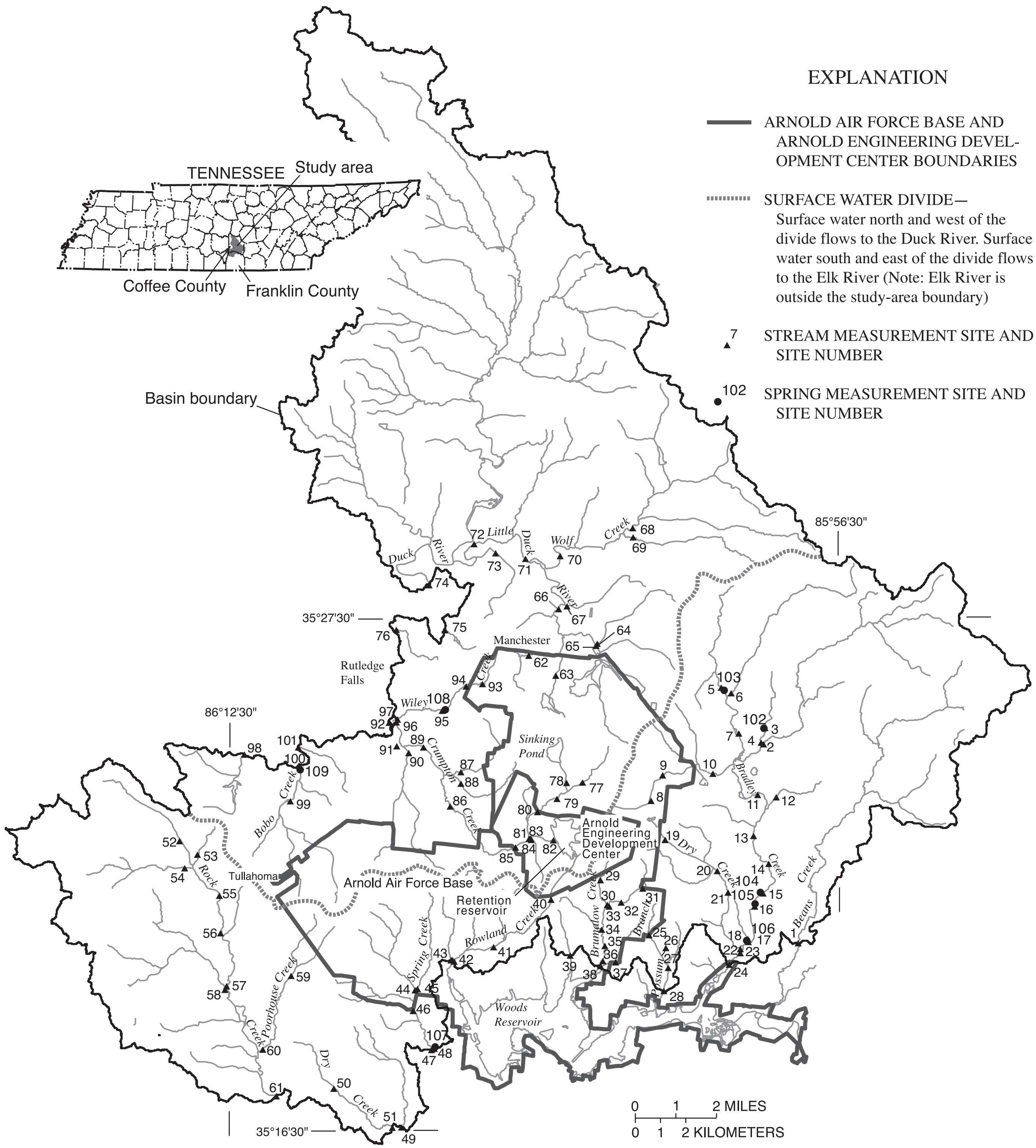
Discharge data were used to categorize stream reaches and sub-basins. Stream reaches were categorized as gaining, losing, wet, dry, or unobserved for each base-flow measurement period. Gaining stream reaches were more common during the high base-flow period than during the low base-flow period. Dry stream 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 $(ft^3/s)/mi^2$ 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



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^3/s for Duck River (site 74), 34.5 ft^3/s for Bradley Creek (site 24), 19 ft^3/s for Rock Creek (site 61), 12.7 ft^3/s for Crumpton Creek (site 97), 10.4 ft^3/s for Spring Creek (site 47), 7.09 ft^3/s for Dry Creek (site 51), 5.88 ft^3/s for Beans Creek (site 1), and 1.36 ft^3/s for Brumalow Creek (site 36). Discharge measurements at sites with flow ranged from an estimated 0.005 ft^3/s (site 84) to 46.4 ft^3/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.

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

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^3/s, cubic foot per second; mi^2, 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, instantaneous (ft^3/s)	Drainage area (mi^2)	Temperature (°C)	Specific conductance (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

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

[ft^3/s, cubic foot per second; mi^2, 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, instantaneous (ft^3/s)	Drainage area (mi^2)	Temperature (°C)	Specific conductance (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^3/s, cubic foot per second; mi^2, 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, instantaneous (ft^3/s)	Drainage area (mi^2)	Temperature (°C)	Specific conductance (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^3/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, instantaneous (ft^3/s)	Temperature (°C)	Specific conductance (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

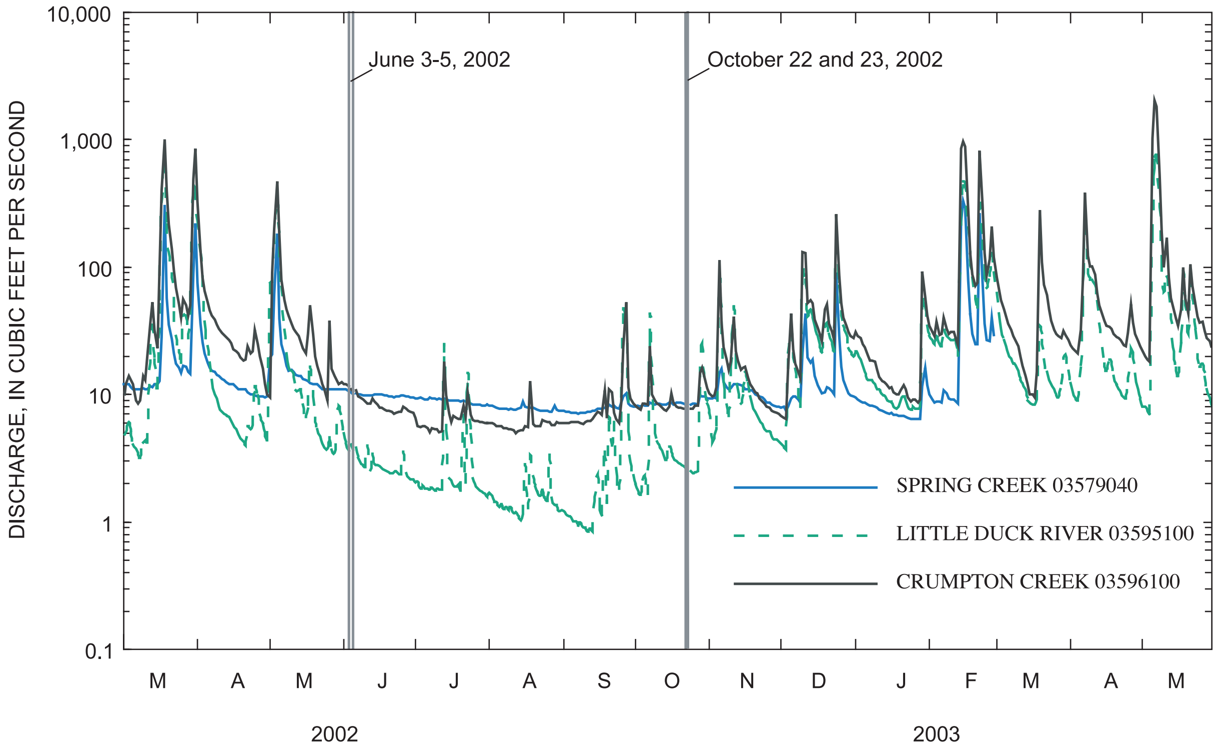


Figure 2. Daily mean discharge on Spring Creek, Little Duck River, and Crumpton Creek.

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^3/s for Duck River (site 74), 13.5 ft^3/s for Rock Creek (site 61), 13 ft^3/s for Bradley Creek (site 24), 8.32 ft^3/s for Spring Creek (site 47), 7.45 ft^3/s for Dry Creek (site 51), 7.62 ft^3/s for Crumpton Creek (site 97), 0.5 ft^3/s for Beans Creek (site 1), and 0.28 ft^3/s for Brumalow Creek (site 36). Discharge measurements at sites with flow ranged from 0.02 ft^3/s (site 29) to 44.6 ft^3/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^3/s (table 2). During the low base-flow period, site 74 on the Duck River had the greatest discharge, 44.6 ft^3/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^3/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).

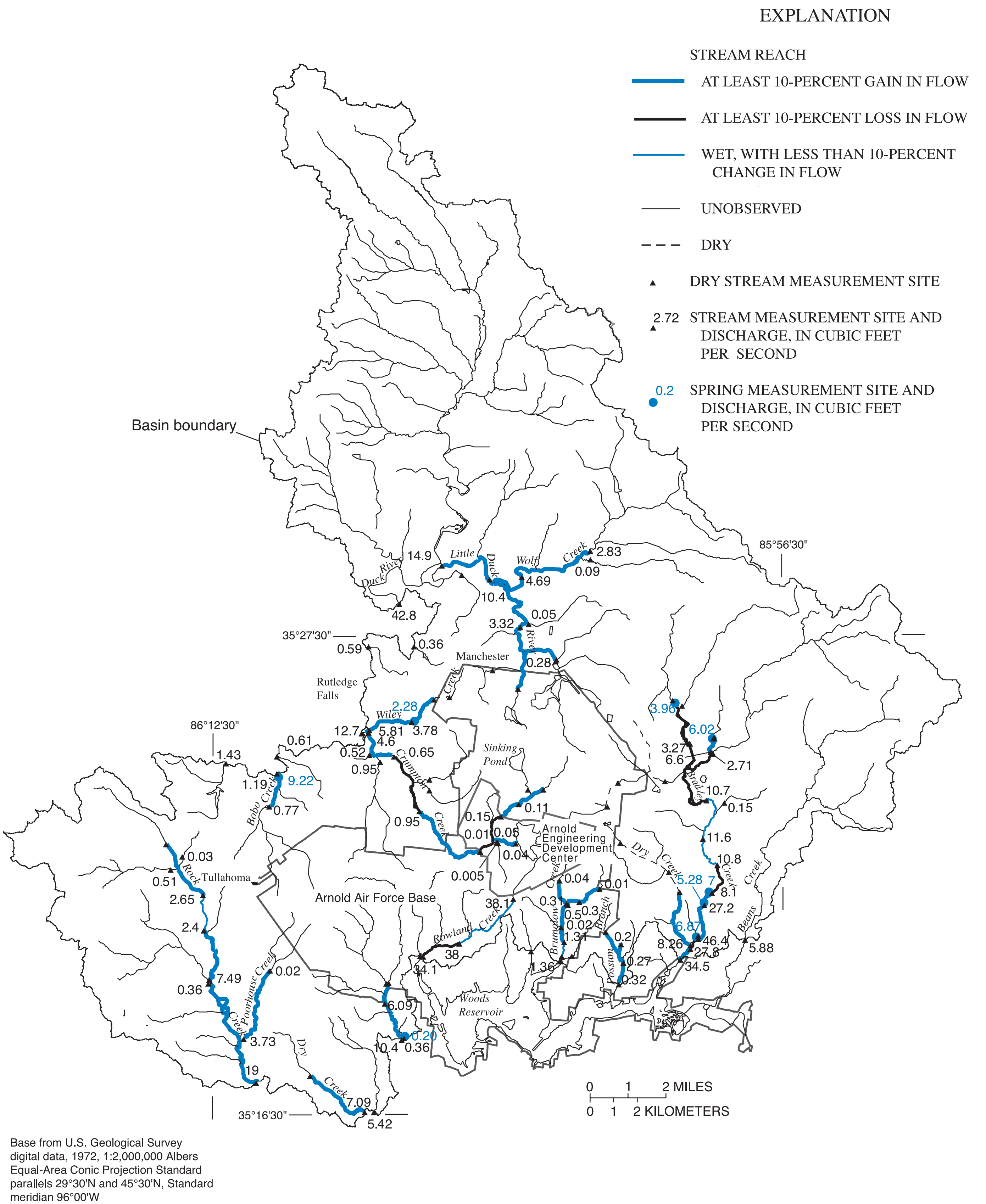
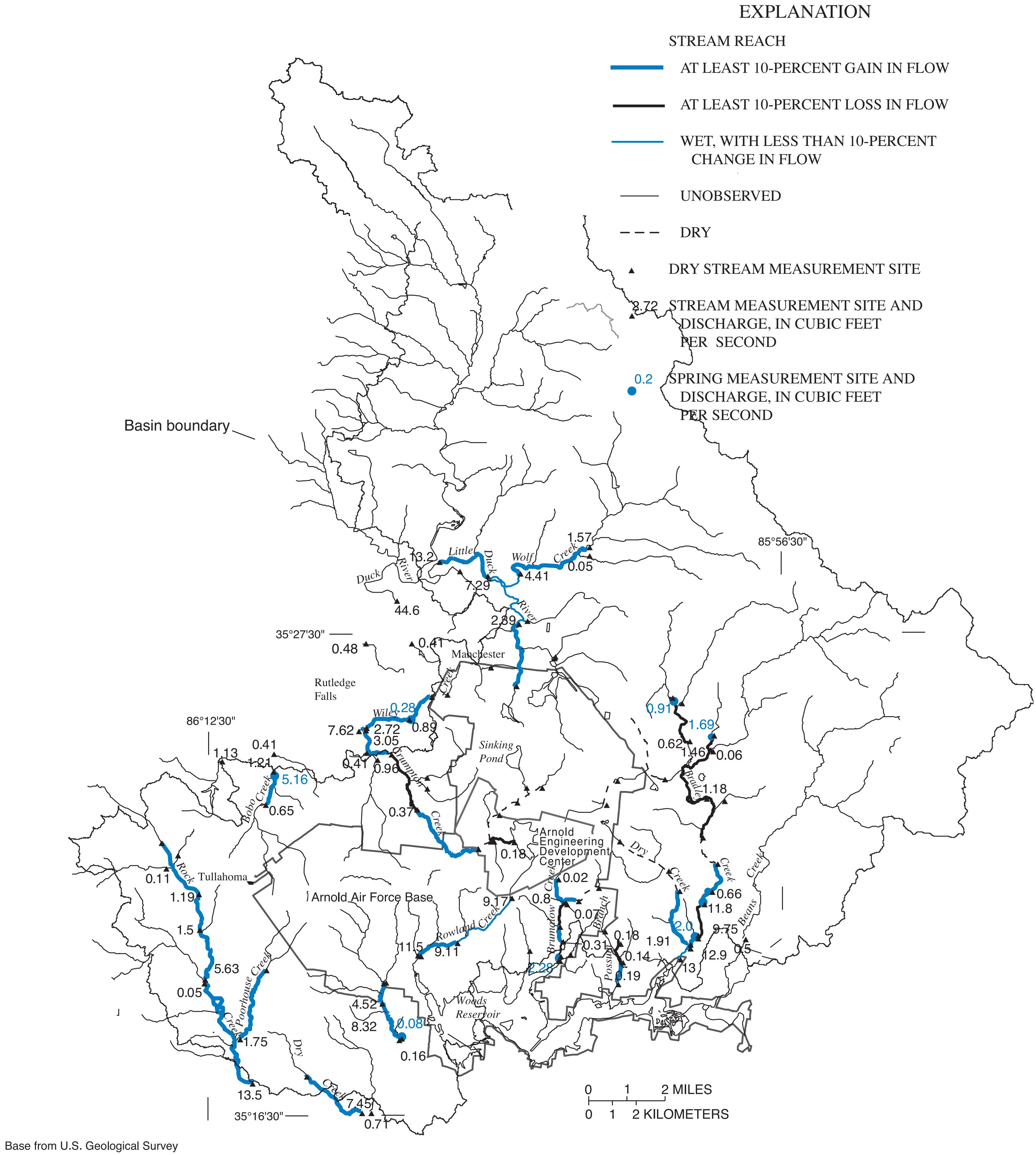


Figure 3. Arnold Air Force Base area showing high base-flow stream and spring measurement sites and discharge measurements, June 3 through 5, 2002.



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^3/s, cubic foot per second; mi^2, 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^3/s)	Drainage area (mi^2)	Temperature (°C)	Specific conductance (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

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

[ft^3/s, cubic foot per second; mi^2, 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^3/s)	Drainage area (mi^2)	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^3/s, cubic foot per second; mi^2, 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^3/s)	Drainage area (mi^2)	Temperature (°C)	Specific conductance (µS/cm at 25 °C)
		Crumpton 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^3/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^3/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 $(ft^3/s)/mi^2$ 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^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, 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^2)	Discharge, entering sub-basin (ft^3/s)	Discharge, leaving sub-basin (ft^3/s)	Change in flow per square mile [$(ft^3/s)/mi^2$]
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

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

[mi^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, 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^2)	Discharge, entering sub-basin (ft^3/s)	Discharge, leaving sub-basin (ft^3/s)	Change in flow per square mile [$(ft^3/s)/mi^2$]
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^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, 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^2)	Discharge, entering sub-basin (ft^3/s)	Discharge, leaving sub-basin (ft^3/s)	Change in flow per square mile [$(ft^3/s)/mi^2$]
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

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

[mi^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, 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 6)	Sub-basin area (mi^2)	Discharge, entering sub-basin (ft^3/s)	Discharge, leaving sub-basin (ft^3/s)	Change in flow per square mile [$(ft^3/s)/mi^2$]
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^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, 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 6)	Sub-basin area (mi^2)	Discharge, entering sub-basin (ft^3/s)	Discharge, leaving sub-basin (ft^3/s)	Change in flow per square mile [$(ft^3/s)/mi^2$]
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

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

[mi^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, 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 6)	Sub-basin area (mi^2)	Discharge, entering sub-basin (ft^3/s)	Discharge, leaving sub-basin (ft^3/s)	Change in flow per square mile [$(ft^3/s)/mi^2$]
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^2, square mile; ft^3/s, cubic foot per second; $(ft^3/s)/mi^2$, cubic foot per second per square mile]

Basin	Site no.	Drainage area (mi^2)	June 2002		October 2002	
			Stream discharge, instantaneous (ft^3/s)	Flow per square mile [$(ft^3/s)/mi^2$]	Stream discharge, instantaneous (ft^3/s)	Flow per square mile [$(ft^3/s)/mi^2$]
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^2, square mile; $(ft^3/s)/mi^2$, cubic foot per second per square mile]

Basin	Site no.	Basin area (mi^2)	Flow per square mile [$(ft^3/s)/mi^2$]	
			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

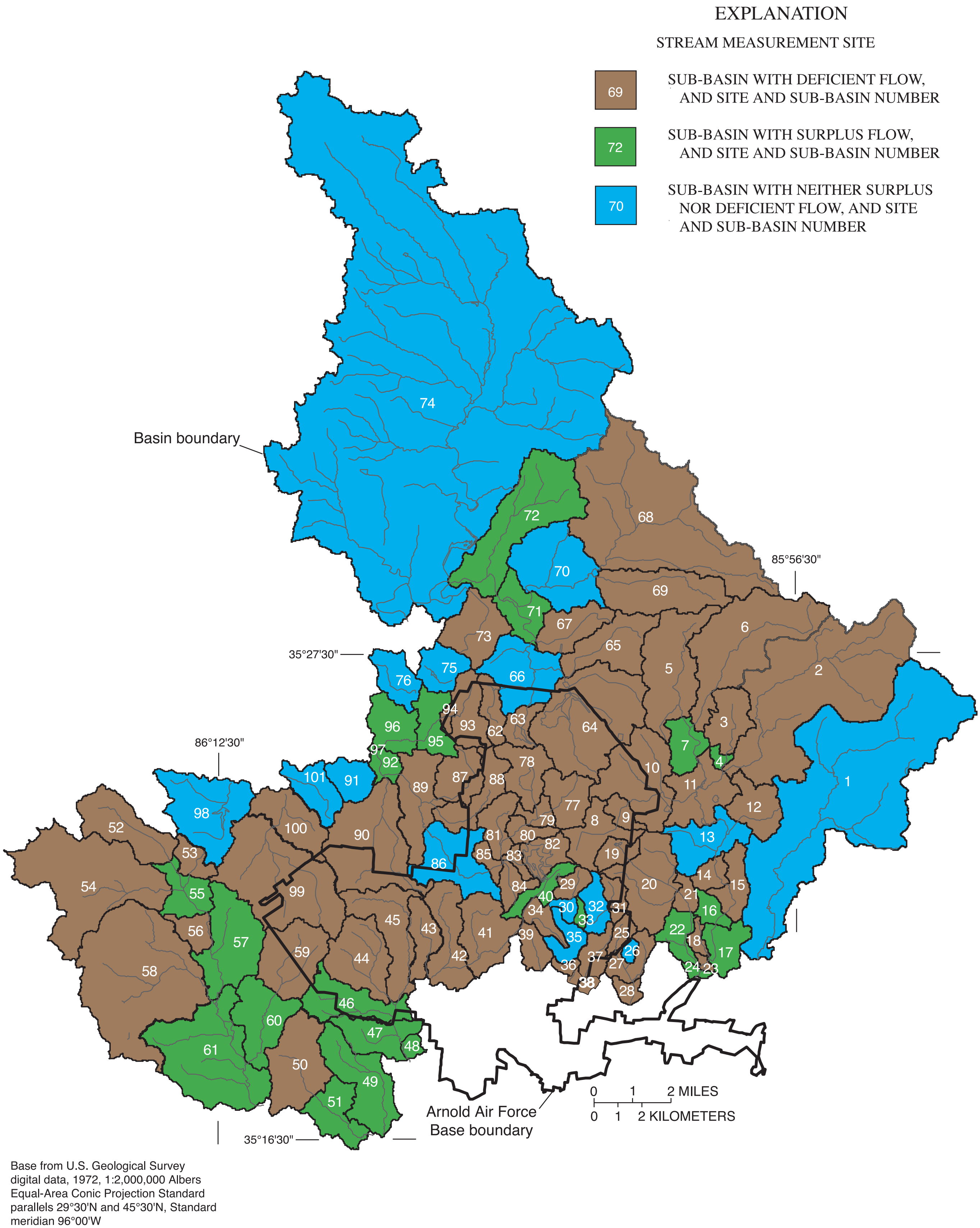
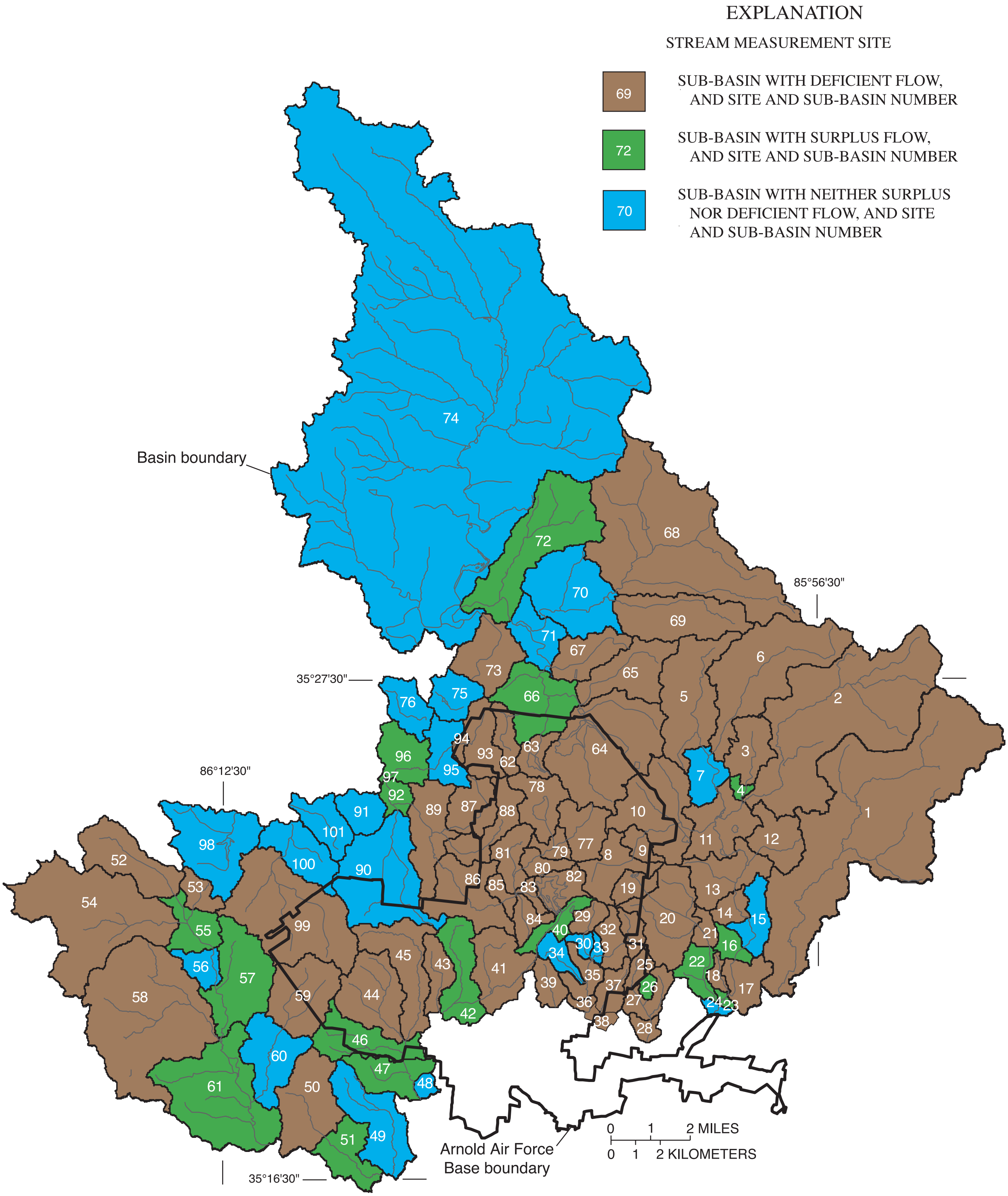


Figure 5. Arnold Air Force Base area showing areas of surplus or deficient flow during high base flow, June 3 through 5, 2002.



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^3/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^3/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 $(ft^3/s)/mi^2$ 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.

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