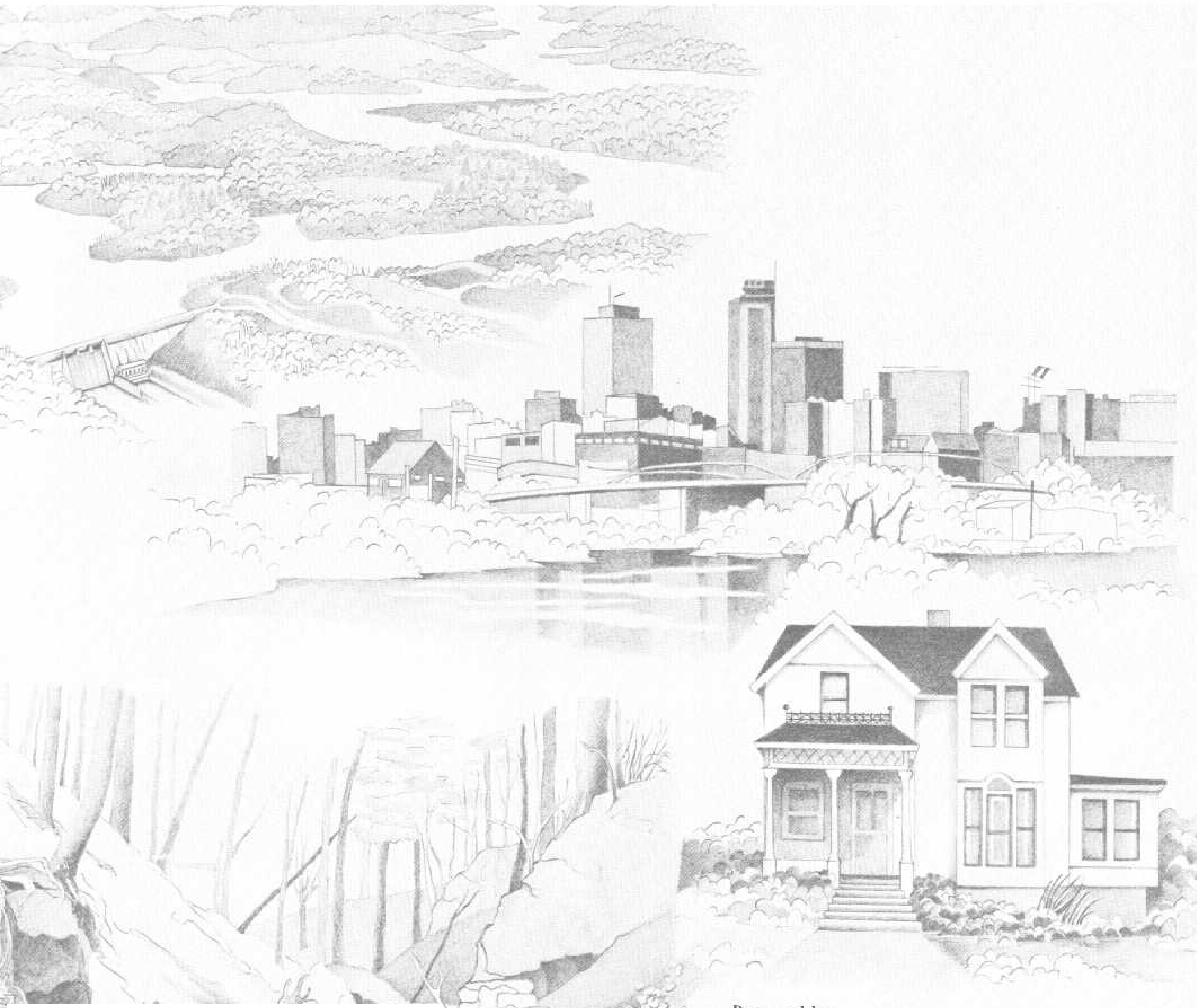
WATER-RESOURCES INVESTIGATIONS REPORT 84-4074

DROUGHT-RELATED IMPACTS ON MUNICIPAL AND MAJOR SELF-SUPPLIED INDUSTRIAL WATER WITHDRAWALS IN TENNESSEE--PART B



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in cooperation with
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TENNESSEE VALLEY AUTHORITY, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Regional

In addition to these reservoirs, several smaller water-supply impoundments including Cove, Davis Branch, Holiday Hills, Meadow Park, and Ollis Creek Lakes plus Brushy Mountain Prison's reservoir are also located in this basin. Further information regarding the estimated storage capacity of these reservoirs is found in table 1 of appendix I.

Ground Water

The Clinch River and its tributaries drain parts of the Cumberland Plateau and Valley and Ridge physiographic provinces. Water occurs in limited fractures in the sandstone underlying the Cumberland Plateau and in solutionally enlarged openings in the carbonate rocks of the Valley and Ridge province. The average yields and water quality of wells and springs in these areas are quite different. Most of the Clinch River basin lies in the Valley and Ridge province. This area is characterized by northeast-trending parallel valleys and ridges. The ridges are capped by resistant sandstones, silty shales, and silt stones, while the valleys are primarily underlain by more soluble calcareous rocks such as limestone, dolomite, and limy shale rocks. The rocks in the Valley and Ridge province contain little or no primary porosity; however, secondary porosity in the form of solution cavities in the calcareous has been developed by circulating ground water. On the ridges, domestic supplies are obtained from dug wells, drilled wells, and springs. Well yields are generally low, normally ranging from a few gallons per minute to 15 gal/min from depths of 200 feet or less. Ground water in the valleys is generally easier to obtain than on the ridges. Domestic supplies are available from drilled and dug wells as well as springs. Yields of wells normally average 25 gal/min or less from depths of 300 feet or less; however, as the fractures in the calcareous rocks have been enlarged to varying degrees by the dissolving action of circulating ground water, yields of 100 gal/min or more are common. Moderately large (50-100 gal/min) to large (>100 gal/min) springs are numerous in the Valley and Ridge part of the Clinch River basin, with the exception of Hancock and Campbell Counties. A number of municipalities use springs for public water supplies. Water quality is generally good, with the most objectionable property of water from calcareous rocks being hardness which, in most cases, is 100 mg/L.

Ground water in the Cumberland Plateau areas of the Clinch River basin occurs in fractures in tightly cemented sandstones. As these siliceous rocks have not been structurally disturbed to the extent of those in the Valley and Ridge province (with the exception of the eastern escarpment of the Plateau), fractures are not as numerous. Also, fractures in the plateau rocks are resistant to enlargement by the solvent action of ground water. Consequently, ground water is more difficult to obtain in significant quantities. Yields to drilled wells are generally low; however, in areas of more severe fracturing, near surface streams, well yields of 100 gal/min or more have been recorded. Well depths are usually 200 feet or less. However, some unpublished well logs are reported to indicate that the Sewanee Conglomerate can yield good-quality water from depths of at least 500 feet in Cumberland County and other local areas of the Cumberland Plateau. With the exception of water produced from the Sewanee Conglomerate, ground water from plateau wells of less than 150 feet in depth is usually rather high in iron. In most cases, the water is acidic due to dissolved carbon dioxide. Water encountered at or near coal seams or carbonaceous shale is usually high in sulfates and sometimes very acidic due to the decomposition of pyrite to sulfuric acid. Springs on the plateau generally have low yields and often go dry in times of low rainfall.

Ground water in the Clinch River basin is generally confined to fractures and solution cavities in the rocks. In areas where fractures are numerous and particularly where they have been enlarged by solution, relatively large-yield wells are possible. Most of the wells listed in the existing ground-water data base were drilled for domestic use and were not located as the result of local geologic investigation. Therefore, the true ground-water potential of the Clinch River basin cannot be accurately assessed at present.

Demography

Historical (1970) and recent (1980) population (U.S. Department of Commerce, 1982a), total wage and salary employment (Tennessee Valley Authority, 1982) including both full- and part-time workers, and per capita personal income (Tennessee Valley Authority, 1982) data for the county boundary approximation of the Clinch River basin are presented in table 4. Counties included in this approximation are Anderson, Campbell, Claiborne, Cumberland, Hancock, Morgan, and Union. Note, both Anderson and Union Counties are also part of the Knoxville Standard Metropolitan Statistical Area (SMSA) which encompasses Anderson, Blount, Knox, and Union Counties with the majority of its population being located in the Upper Tennessee River basin. Urban or metropolitan areas in the Tennessee part of the basin and their 1980 census population include Clinton (5,245), Crossville (6,394), Harriman (8,303), Kingston (4,441), La Follette (8,198), Oak Ridge (27,662), and Oliver Springs (3,659).

Public and Self-Supplied Commercial and Industrial Water Users

Presently, there is a total of 30 public, community water-supply facilities and three large, self-supplied commercial and industrial water users whose use exceeds 0.1 million gallons per day (Mgal/d) in the Clinch River basin part of the State of Tennessee. Tabular inventories containing pertinent information and data relative to each community or self-supplied user's source of water, average daily water use, source capacity, population served, treatment plant and storage capacities, and water-supply quantity-related problems are found in tables 1 and 2 of appendix I, respectively. Total water withdrawals for public and large, self-supplied commercial and industrial purposes in the Clinch River basin currently amounts to about 29.8 Mgal/d. The location and water-supply source of all public and large, self-supplied commercial and industrial water users inventoried in the Clinch River basin are shown in figures 3 and 4, respectively.

Currently, public water systems serve approximately 188,000 or 98 percent of the basin's 1980 population. Average daily water use for public purposes equals about 16.3 Mgal/d of which about 11.6 Mgal/d or 71 percent is withdrawn

Table 4.--County population, employment, and per capita personal income data, Clinch River basin

[Per capita income based on 1970 income converted to 1980 dollars]

County	Population		Employment		Per capita personal income 1980 dollars	
	1970	1980	1970	1980	1970	1980
Anderson	60,300	67,346	25,983	36,393	$7,678	$9,464
Campbell	26,045	34,923	5,964	8,842	4,408	5,700
Claiborne	19,420	24,595	3,810	5,890	4,051	5,497
Cumberland	20,733	28,676	5,494	7,883	4,228	5,427
Hancock	6,719	6,887	951	768	3,947	4,108
Morgan	13,619	16,604	2,320	3,418	3,614	4,436
Union	9,072	11,707	867	1,342	4,011	4,983
Total	155,908	190,738	45,389	64,536	-	-

from surface-water sources and 4.7 Mgal/d or 29 percent from ground-water sources. Major public water-supply facilities whose average daily use exceeds 1.0 Mgal/d include the following:

Facility name	Average water use (Mgal/d)
Clinton Utilities Board	1.261
La Follette WD	1.200
North Anderson County UD	1.029
Crossville WS	2.100
Hallsdale-Powell UD	3.171
Harriman UD	2.030

Together these systems account for about 66 percent of the basin's total water use for public purposes.

Large, self-supplied commercial and industrial users use or withdraw about 13.5 Mgal/d from surface-water sources in the basin. Available survey information indicates that no large, self-supplied water users are currently utilizing any ground-water sources. Approximately 77 percent of the total water withdrawn for commercial and industrial purposes is withdrawn by the U.S. Department of Energy's Oak Ridge Gaseous Diffusion Plant (10.4 Mgal/d) in Oak Ridge. Consumptive water use by large, self-supplied users equals about 0.5 Mgal/d.

Summarized below is a list of the specific water-supply problems now being experienced by individual communities and self-supplied commercial and industrial water users in the Clinch River basin. The number in parentheses following each identified problem indicates the number of communities and self-supplied water users who are now or have experienced this problem in the past. Note, these are not listed in order of frequency of occurrence or overall severity.

- Occasional turbidity problems following heavy rainfall and flooding. (5)
- Limited storage for treated water and inadequate booster pump capacity. (2)
- Periodic water-supply shortages during drought periods. (1)
- Excessive water losses due to leaks in the water mains and distribution lines. (3)
- Occasional periods of discoloration. (1)

Water-Supply Adequacy Analysis

Approximately 2,612 mi^2 or 1,672,000 acres of land and water area are drained by the Clinch River basin in Tennessee. In general, this basin's water resources are of good quality and replenished by ample rainfall whose long-term (1941-70) average above Norris Dam is 46.81 inches. As one moves southwestward through the basin, average annual runoff varies from about 19 to 30 inches. Normally, the 3-month period from September through November is the driest time of the year with July and March being the wettest months. It is not unusual for this basin's small, unregulated streams to go dry during drought periods in the late summer and fall months, particularly in Cumberland

Figure 3--Explanation

Site No.	Facility name
1	Anderson County Utility Board
2	First UD of Anderson County
3	North Anderson County UD
4	Oliver Springs WS
5	Clinton Utilities Board
6	Norris WS
7	Oak Ridge WS
8	La Follette WD
9	Caryville-Jacksboro UD
10	Arthur-Shawnee UD
11	Claiborne County UD
12	Lincoln Memorial University WS
13	Crossville WS
14	Sneedville UD
15	Hallsdale-Powell UD
16	Brushy Mountain Prison WS
17	Plateau (Wartburg) UD
18	Cumberland UD
19	Harriman UD
20	Maynardville WS

and Morgan Counties along the rim of the basin. Streamflows in these counties are generally intermittent because of their limited drainage area while ground-water supplies under water table conditions are often unreliable because of their limited recharge area and the type of aquifer (U.S. Water Resources Council, 1978, p. 16).

Average daily water use or withdrawal for public and large, self-supplied commercial and industrial water users in the Clinch River basin equals about 29.8 Mgal/d. Of this amount, water use for public purposes equals about 16.3 Mgal/d, of which about 11.6 Mgal/d or 71 percent is from surface-water sources and 4.7 Mgal/d or 29 percent from ground-water sources. Self-supplied commercial and industrial water use amounts to 13.5 Mgal/d, all of which is withdrawn from surface-water sources. Consumptive water use by known large, self-supplied water users equals 0.5 Mgal/d.

Based on available data and information only the Lincoln Memorial University WS is experiencing periodic water-supply shortages. However, analysis of the basin's known water-supply facilities for whom recent data are available indicates that a number of communities, as shown below, are utilizing surface- and ground-water sources whose source capacity is less than or nearly equal to the facility's average daily use as indicated by the percentage figure following each facility's supply source(s).

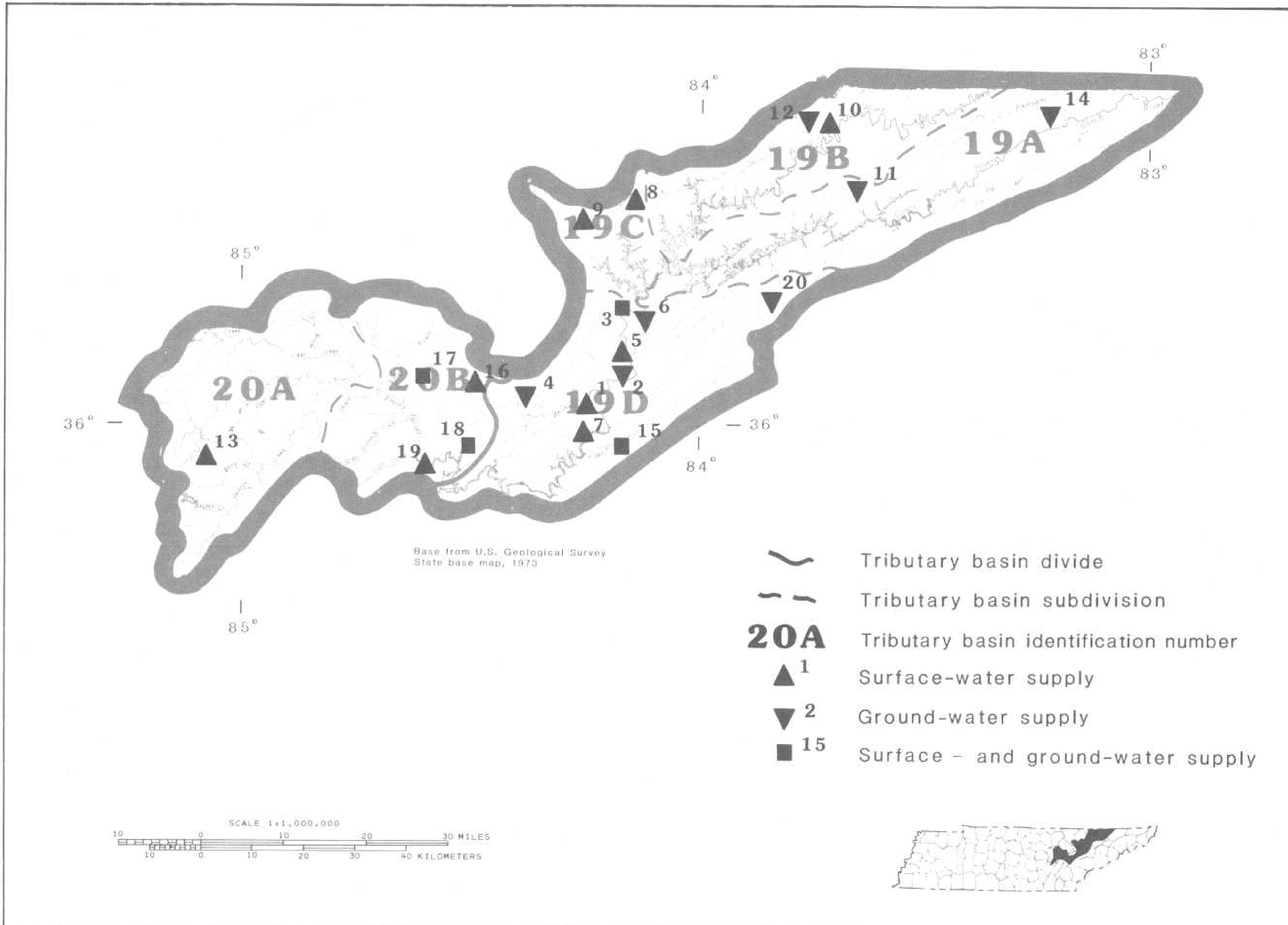

Figure 3.--Public water-supply facilities, Clinch River basin.

Figure 4--Explanation

Site No.	Facility name
1	U.S. Department of Energy, Y-12 Plant (Oak Ridge)
2	Harriman Paperboard Corp. (Harriman)
3	U.S. Department of Energy, Gaseous Diffusion Plant (Oak Ridge)

Facility name and county	Water source (percent)	Source capacity (Mgal/d)	Average daily use (Mgal/d)
Cumberland UD (Roane)	Little Emory River (60) Springs (40)	0.000 0.200	0.300 0.200
First UD of Anderson County	Springs (53)	0.288	0.224
Hallsdale - Powell UD (Knox)	Springs (56)	1.161	1.776
Harriman UD (Roane)	Emory River (100)	0.060	2.030
Lincoln Memorial University WS (Claiborne)	Spring (100)	0.144	0.142
Maynardville WS (Union)	Spring (100)	0.110	0.110
Norris WS (Anderson)	Spring (100)	0.346	0.320
North Anderson County UD	Spring (28)	0.288	0.288
Oliver Springs WS (Anderson)	Spring (94)	0.281	0.788
Plateau (Wartburg) UD (Morgan)	Crooked Fork Creek (50) Wells (50)	0.000 0.216	0.175 0.175
Sneedville UD (Hancock)	Spring (100)	0.140	0.188

While several of these systems also withdraw a part of their daily requirement from surface-water sources (Hallsdale - Powell UD and North Anderson County UD) whose source capacity appears adequate to provide additional water or purchase water from neighboring systems (First UD of Anderson County, North Anderson County, and Oliver Springs WS); it is entirely possible that some or all of

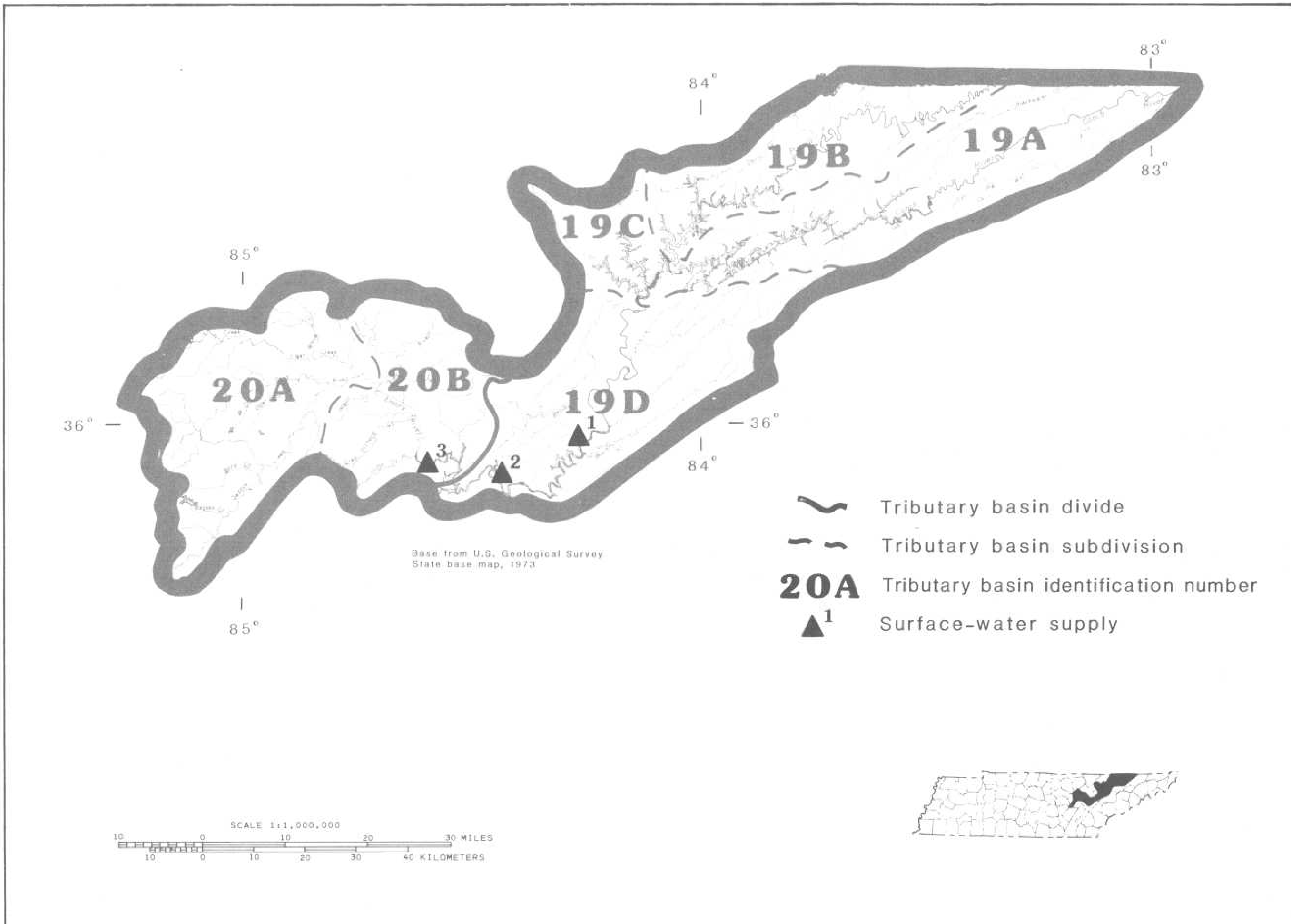

Figure 4.--Self-supplied commercial and industrial water users, Clinch River basin.

these systems could expect to face water shortages because of extended drought or increased water use due to industrial expansion and (or) an increase in population.

At present, only one large, self-supplied water user (Harriman Paperboard Corporation) is utilizing a water-supply source (Emory River) whose source capacity (0.060 Mgal/d) is considerably less than the industry's average daily water withdrawal (1.000 Mgal/d). However, to date, the industry has reported no water-supply shortage problems. Recognizing that the industry's intake is located within Watts Bar Lake at normal maximum pool (elevation 741) and just outside the lake at normal minimum pool (elevation 735), no serious water-supply shortages are anticipated.

Water systems which are currently utilizing surface- and (or) ground-water resources which are inadequate or of unknown capacity should consider exploring the availability of alternative, cost-effective water-supply sources to augment or meet their future water needs if necessary. While the basin's water resources are subject to contamination from a variety of sources; existing and pending Federal, State, and local statutes relative to water-quality protection and maintenance or improvement should ensure that current water quality will be maintained with little, if any, future degradation of the basin's water resources. Potential sources of contamination include (1) leachate from municipal and industrial water disposal facilities and septic tank systems; (2) agricultural pollution from fertilizers, pesticides and herbicides, and livestock wastes; and (3) runoff from surface mine lands and quarries.

Although there are periods of extended drought which cause seasonal water table declines and periodic local problems with adequate ground-water supplies, observation-well data indicate there are no long-term, regional water table declines. Periodic local problems associated with a decline in an area's water table are caused by excessive withdrawals. To alleviate this problem, optimum ground-water withdrawal rates should be determined during the initial test pumping of the source.

LOWER CUMBERLAND RIVER BASIN

Basin Description

The Tennessee part of the Lower Cumberland River basin (including that part of the Green River basin in Tennessee) covers 5,599 mi^2 of land and water area and consists of all or parts of the following tributary basins as delineated by the Geological Survey and the Tennessee Department of Water Management in 1982.

Tributary basin No. (fig. 5)	Basin description	Tennessee drainage area (square miles)
6A	Cumberland River south-side minor tributaries between Caney Fork and Stones River.	442
6B	Cumberland River north-side minor tributaries between Caney Fork and Stones River.	618
7A	East and West Forks Stones River	569
7B	Stones River below East and West Fork	367
8	Cumberland River and minor tributaries between Stones River and Harpeth River.	574
9A	Harpeth River above Bellevue, including Little Harpeth River.	408
9B	Harpeth River below Bellevue	458
10A	Upper Red River and Sulphur Fork	509
10B	Lower Red River below Sulphur Fork	258
11	Cumberland River and minor tributaries below Harpeth River to Tennessee-Kentucky State line, but excluding Red River.	984
12	Barren River basin, Kentucky-Tennessee	412

The Lower Cumberland River basin (including that part of the Green River basin in Tennessee) includes all or major parts of Cheatham, Davidson, Dickson, Macon, Montgomery, Robertson, Rutherford, Stewart, Sumner, Trousdale, Williamson, and Wilson Counties and minor parts of Cannon, Hickman, Houston, Jackson, and Smith Counties. A map of middle Tennessee which delineates the area drained by the Lower Cumberland River basin is shown in figure 5.

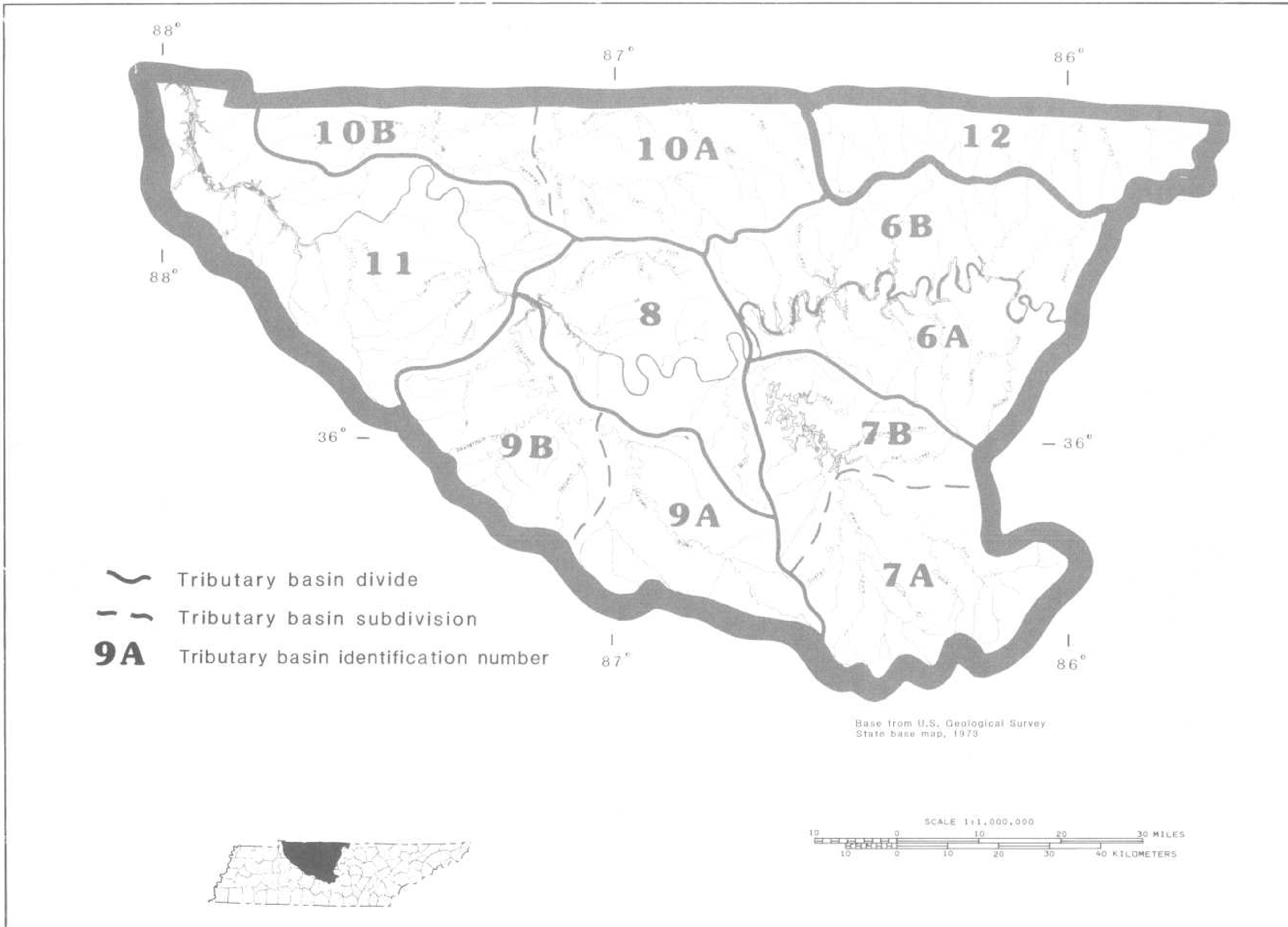

Figure 5.--Lower Cumberland River basin.

Topography

From the Caney Fork, the Cumberland River flows westward to Davidson County and then turns in a northwesterly direction to the Tennessee-Kentucky State line. This part of the Cumberland River Basin is in the Central Basin and the Western Highland Rim physiographic sections. The Central Basin is characterized by gently rolling to hilly terrain, with some nearly level areas, and by meandering, low-gradient streams. The Western Highland Rim is characterized by dissected, rolling terrain that is crossed by numerous streams (Miller, 1974, p. 5). Water-surface elevations of the Cumberland River in the study area are controlled by three reservoirs, Barkley, Cheatham, and Old Hickory. The normal pool elevations of Barkley Reservoir are 359.0 feet and 354.0 feet during the summer season and winter season, respectively. These elevations affect that part of the river between mile 30.6 and mile 148.7. Cheatham Reservoir has a normal pool elevation of 385 feet, which would affect that part of the river between mile 148.7 and mile 216.2. The normal pool elevation of Old Hickory Reservoir is 445.0 feet, which affects that part of the river between mile 216.2 and mile 313.5. Major streams and tributaries draining this basin include:

Harpeth River. Jones Creek, South Harpeth River, Turnbull Creek, and West Harpeth River.

Stones River. East Fork Stones River, Fall Creek, Hurricane Creek, Stewart Creek, Suggs Creek, and West Fork Stones River.

Cumberland River Minor Tributaries. Barton, Bear, Big Elk, Cedar, Drake, Goose, Johnson, Long, Mill, Peyton, Round Lick, Saline, Sams, Spencer, Spring, Station Camp, Sycamore, and Yellow Creeks.

The elevation in this basin generally ranges from 350 to over 2,000 feet above sea level. The maximum elevation is 2,092 feet atop Short Mountain, which is an erosional remnant of the Cumberland Plateau, in Cannon County.

Approximately 18 percent of the Green River basin is located in Tennessee. The headwaters of several creeks are in this part of the basin. All flow is to the north through hilly terrain into Kentucky. Elevations of the basin range from about 1,060 feet at the basin divide to 610 feet above sea level at the Kentucky-Tennessee State line. Streams draining this basin include West Fork Drakes Creek, Salt Lick Creek, and its tributary, Long Fork.

Hydrology

Surface Water

Surface- and ground-water resources in this basin are replenished by ample rainfall whose long-term (1941-70) average downstream from Carthage equals 48.51 inches. From 1970-79, average annual precipitation below Carthage equaled 55.20 inches with a low of 45.02 inches in 1971 and a high of 69.86 inches in 1979. Average precipitation data for watershed subdivisions of the Lower Cumberland basin during the 1970-79 time period are summarized in table 5 (Corps of Engineers, Nashville, District, unpublished data). Annual (1979)

Table 5.--Precipitation data by watershed subdivision for the period 1970-79, Lower Cumberland River basin

Watershed description	Precipitation (inches)				
	High	Year	Low	Year	10-year average
Cumberland River from Carthage to Hunters Point.	73.21	1979	46.45	1976	58.78
Cumberland River from Hunters Point to Old Hickory Dam.	67.97	1979	46.11	1976	56.59
Stones River upstream from J. Percy Priest Dam.	69.79	1973	46.65	1976	57.26
Cumberland River from Old Hickory Dam to Nashville.	69.24	1979	39.22	1971	54.32
Cumberland River from Nashville to Cheatham Dam.	71.25	1979	42.76	1971	55.98
Harpeth River upstream from Kingston Springs.	74.14	1979	44.38	1971	57.58
Cumberland River from Cheatham Dam to Clarksville.	67.79	1979	41.68	1976	52.43
Cumberland River from Clarksville to Dover.	67.64	1979	45.09	1978	53.50
Red River upstream from Port Royal	73.34	1979	41.60	1971	53.83
Cumberland River from Dover to Barkley Dam.	66.46	1979	40.90	1971	51.77

and long-term (1941-70) precipitation data for selected rainfall stations in the basin are shown in table 6 (Department of Commerce, 1977 and 1979; and Water Information Center, 1974).

Generally, the months of August, September, and October are the driest months in the Lower Cumberland River basin. During these months, average rainfall varies from 2.50 to 3.59 inches. Throughout the rest of the year, rainfall varies from 3.62 to 5.28 inches with March having the highest rainfall. Analysis of long-term precipitation records for the 1941-70 time period for selected rainfall stations (Clarksville, Dover, and Nashville) indicate that, in general, the months of August, September, and October are the driest with rainfall ranging from 2.16 to 3.49 inches. During the remaining months, rainfall varies from 3.38 to 5.35 inches with the most rain falling in March.

Average annual runoff in this basin usually ranges from 18 to 28 inches. Average discharge data for selected hydrologic data stations in the Lower Cumberland River basin is shown in table 7. Most of this runoff occurs during the winter and spring months.

Major Reservoirs

Major reservoirs located in the basin and their total storage in acre-feet at normal minimum pool are Old Hickory (356,600), J. Percy Priest (268,000), Cheatham Lake (84,100), and Lake Barkley (339,200). Detailed information describing the reservoirs' location and operation pattern follows:

Cheatham Reservoir

Location and drainage area.--Cheatham Reservoir is formed by Cheatham Dam which is located on the Cumberland River at river mile 148.7. Cheatham Dam controls 14,159 mi^2 of drainage area.

Reference period.--1959-82.

Reservoir discharge (minimum daily average discharge).--During the reference period, the minimum daily average discharge ranged from a low of 600 ft^3/s in 1960 to a high of 4,530 ft^3/s in 1961.

Average number of days of zero flow.--None.

Existing agreements regarding reservoir releases.--None.

J. Percy Priest Reservoir

Location and drainage area.--J. Percy Priest Reservoir is formed by J. Percy Priest Dam which is located on the Stones River at river mile 6.8 in Davidson County.

Reference period.--1970-82.

Reservoir discharge (minimum daily average flow).--During the reference period, minimum daily average discharge from J. Percy Priest Dam was zero for each year.

Table 6.--Precipitation data for 1979 and for the period 1941-70 for selected rainfall stations, Lower Cumberland River basin

Station location	Station owner	Elevation above sea level (feet)	Period of record (years)	1979 Precipitation (inches)	Long-term annual precipitation (inches)
Clarksville	NWS	382	120	[a] 68.44	47.50
Dover	NWS	475	87	[a] 78.76	49.56
Springfield	NWS	745	47	[a] 74.68	46.98
Kingston Springs	NWS	448	37	72.05	48.78
Dickson	NWS	780	87	75.55	50.11
Lafayette	NWS	975	24	72.27	[b] 54.21
Nashville	NWS	580	42	70.12	46.00
Portland sewage plant	NWS	794	10	78.14	[c] 56.71
Franklin	NWS	655	100	78.16	49.59
Murfreesboro	NWS	550	98	[a] 67.51	49.59

[a]Estimated.

[b]Period of record only (1956-79).

[c]Period of record only (1962-63 and 1972-79).

Table 7.--Average discharge data for selected hydrologic data stations operated by the U.S. Geological Survey, Lower Cumberland River basin

Station name and location (county)	River mile	Drainage area (square miles)	Period of record (years)	Average discharge: Cubic feet per second	Average discharge: Inches per year	Average discharge: Cubic feet per second per square mile
Cumberland River at Carthage (Smith).	308.2	10,690	58	17,690	22.46	1.65
Cumberland River downstream from Old Hickory (Davidson).	212.1	11,735	44	19,270	---	1.64
East Fork Stones River at Woodbury (Cannon).	45.6	39.1	18	71.2	24.73	1.82
East Fork Stones River near Lascassas (Rutherford).	15.4	262	25	472	24.46	1.80
West Fork Stones River at Manson Pike, at Murfreesboro (Rutherford).	16.1	165	7	304	25.02	1.84
West Fork Stones River at Murfreesboro (Rutherford).	10.7	177	8	361	27.70	2.04
West Fork Stones River near Smyrna (Rutherford).	6.4	237	15	461	26.42	1.95
Richland Creek at Charlotte Avenue, at Nashville (Davidson).	3.6	24.3	16	36.6	20.45	1.51
Sycamore Creek near Ashland City (Cheatham).	8.6	97.2	19	146	20.40	1.50
Harpeth River at Franklin (Williamson).	88.1	191	6	368	26.16	1.93

Table 7.--Average discharge data for selected hydrologic data stations operated by the U.S. Geological Survey, Lower Cumberland River basin--Continued

Station name and location (county)	River mile	Drainage area (square miles)	Period of record (years)	Average discharge: Cubic feet per second	Average discharge: Inches per year	Average discharge: Cubic feet per second per square mile
Harpeth River at Bellevue (Davidson).	62.1	408	60	584	19.44	1.43
Harpeth River near Kingston Springs (Cheatham).	32.4	681	56	990	19.75	1.45
Cumberland River downstream from Cheatham Dam (Cheatham).	148.4	14,163	26	24,080	---	1.70
Sulphur Fork Red River near Adams (Robertson).	10.2	186	42	251	18.33	1.35
Red River at Port Royal (Montgomery).	25.5	935	19	1,353	19.65	1.45
Yellow Creek near Shiloh (Montgomery).	9.0	124	23	190	20.81	1.53

Average number of days of zero flow.--From 1970-82, J. Percy Priest Dam has averaged about 138 days of zero discharge per year ranging from a low of 72 days in 1975 to a high of 202 days in 1980. Zero discharge days were most common during the months of June, July, August, and September. During the reference period there were 1,797 days of zero discharge and 126 instances of zero discharge for 3 or more consecutive days from J. Percy Priest Dam. The maximum number of consecutive days per year ranged from a low of 11 days in 1975 to a high of 71 days in 1981.

Existing agreements regarding reservoir releases.--None.

Old Hickory Reservoir

Location and drainage area.--Old Hickory Reservoir is formed by Old Hickory Dam which is located on the Cumberland River at river mile 216.2 in Sumner County. Old Hickory Dam controls 11,673 mi^2 of drainage area.

Reference period.--1957-82.

Reservoir discharge (minimum daily average flow).--During the reference period, minimum daily average discharge from Old Hickory Dam ranged from zero flow in 1957 to a high of about 4,300 ft^3/s in 1960. The average 1-day minimum discharge for the reference period was about 2,020 ft^3/s.

Average number of days of zero flow.--From 1957-82, only 1 day of zero discharge has occurred at Old Hickory Dam. This was on November 11, 1957.

Existing agreements regarding reservoir releases.--Although no formal agreement exists regarding reservoir releases, the Corps of Engineers maintains a minimum daily average flow of 1,000 ft^3/s past Nashville for water-quality control.

Ground Water

The Lower Cumberland River basin lies within two physiographic sections, each with characteristic rocks and ground-water resources. The southeastern half of the basin is within the Central Basin physiographic section where ground water occurs in solution-widened joints and bedding plane openings in the limestone bedrock. The clay-rich regolith is only about 6 feet thick and stores little, if any, water for recharging openings in the underlying bedrock.

In the Central Basin, domestic supplies of 5 to 10 gal/min are obtained from wells drilled less than 200 feet into the bedrock. Most of the shallow, water-bearing openings extend only a few hundred to a few thousand feet laterally and are no more than a fraction of an inch to a few inches high. Locally they may not exist and, consequently, a significant number of holes are dry or fail to obtain an adequate supply. In these situations and in the southern half of the Central Basin in the Lower Cumberland River basin, domestic supplies of potable, but highly mineralized water may be obtained from the Knox Dolomite at depths between 350 and 1,500 feet. Supplies greater than 100 gal/min and as much as 900 gal/min are available locally from the bedrock at depths less than 200 feet, but are difficult to locate. These large supplies appear to be associated with gaining reaches of streams, with fracture zones whose presence is revealed by alinement of sinkholes, and with unusually coarse-grained or fossil-fragmental limestone bedrock. In addition, supplies of 200 to 300 gal/min are available from sand and gravel locally occurring near the base of the alluvium that fills the flood plain of the Cumberland River and its major tributaries (Rima and Mull, 1980).

Although the ground water is hard to very hard, it is suitable for drinking water use with only chlorination needed at a few locations. Locally, concentrations of iron and manganese, which can cause staining of laundry and plumbing fixtures, occur in the water from the alluvium.

The northwestern half of the Lower Cumberland River basin is within the Highland Rim physiographic section where ground water occurs in the thick, clay-rich regolith as well as in solution openings in the underlying limestone, dolomite, and silicified-carbonate bedrock. Supplies of 5 to 10 gal/min for domestic use often are obtained by drilled wells either from rock rubble at the base of the regolith at about 80-foot depths or from a solution opening within the upper 100 feet of the bedrock. Dry holes are rare. Supplies of 50 gal/min may be obtained from depths less than 200 feet from partly clay-filled solution openings in the Fort Payne Formation in those locations that are within a few miles of the Highland Rim escarpment where the Fort Payne is the shallowest bedrock capping the Rim (C. R. Burchett, written commun., 1982). In some places, supplies of 200 to 400 gal/min may be obtained from depths less than 200 feet from solution openings in interbedded coarse-grained and fine-grained carbonate rock underlying thick regolith on uplands northwest of the outcrop of the Fort Payne Formation (M. W. Bradley, written commun., 1982). In addition, supplies of 300 to 500 gal/min are available from sand and gravel near the base of the alluvium that fills the flood plains of the Cumberland River and its major tributaries (Rima and Mull, 1980).

The ground water in the bedrock in the Highland Rim section of the Lower Cumberland River basin is hard to very hard but is suitable for drinking-water use without treatment unless the water is obtained from openings below gypsum horizons in the Fort Payne Formation. Water from these openings may contain greater than 1,000 mg/L of dissolved solids, mostly calcium and sulfate, as well as objectionable concentrations of iron and manganese (Burchett and others, 1982). Excessive iron and manganese may also occur in water from the alluvium.

Demography

Historical (1970) and recent (1980) population and employment and per capita personal income (1980) data for the county boundary approximation of the basin are summarized in table 8. Counties included are Cannon, Cheatham, Davidson, Dickson, Macon, Montgomery, Robertson, Rutherford, Smith, Stewart, Sumner, Trousdale, Williamson, and Wilson. Urban and metropolitan centers in the basin and their 1980 census populations are Clarksville (54,777), Franklin (12,407), Gallatin (17,191), Lafayette (3,808), Lebanon (11,872), Murfreesboro (32,845), Nashville (344,273), Portland (4,030), and Red Boiling Springs (1,173).

Table 8.--County population, employment, and per capita personal income data, Lower Cumberland River basin

[Per capita income based on 1970 income converted to 1980 dollars]

County	Population		Employment		Per capita personal income 1980 dollars	
	1970	1980	1970	1980	1970	1980
Cannon	8,467	10,234	1,666	2,412	$4,524	$6,273
Cheatham	13,199	21,616	2,665	4,281	5,872	6,322
Davidson	447,877	477,811	229,217	292,849	8,176	10,018
Dickson	21,977	30,037	5,717	7,283	5,950	6,698
Macon	12,315	15,700	3,638	3,677	5,197	6,572
Montgomery	62,721	83,342	15,443	21,857	7,225	6,963
Robertson	29,102	37,021	6,271	9,123	6,065	7,275
Rutherford	59,428	84,058	18,237	26,388	6,014	7,159
Smith	12,509	14,935	3,023	5,237	5,089	6,363
Stewart	7,319	8,665	4,044	2,814	5,632	6,080
Sumner	56,266	85,790	11,794	19,493	6,642	7,115
Trousdale	5,155	6,137	2,323	8,674	5,572	7,066
Williamson	34,423	58,108	8,634	15,210	7,671	8,385
Wilson	36,999	56,064	10,012	14,630	6,563	7,292
Total	807,757	989,518	322,684	433,928	-	-

Public and Self-Supplied Commercial and Industrial Water Users

Presently, there is a total of 60 public, community water-supply facilities and three large, self-supplied commercial and industrial water users whose use exceeds 0.1 Mgal/d in the Lower Cumberland River basin. Detailed inventories containing pertinent information and data relative to each community or self-supplied user's source of water, average daily water use, source capacity, population served, treatment plant and storage capacities, and water supply quantity related problems are found in tables 3 and 4 of appendix I, respectively. Total water use or withdrawal for public and large, self-supplied commercial and industrial users in the basin equals about 160.1 Mgal/d. The general location and water-supply source of all public and large, self-supplied commercial and industrial water users inventoried in the Lower Cumberland River basin are shown in figures 6 and 7, respectively.

Figure 6--Explanation

Site No.	Facility name	Site No.	Facility name
1	Woodbury WS	21	Springfield WS
2	Ashland City WD	22	White House UD
3	Pleasant View UD	23	Eagleville WD
4	South Cheatham UD	24	Murfreesboro WD
5	River Road UD	25	Smyrna WD
6	Cumberland UD	26	Dover WD
7	Harpeth Valley UD	27	Gallatin WD
8	Nashville	28	Hendersonville UD
9	Madison Suburban UD	29	Portland WS
10	Old Hickory UD	30	Hartsville WD
11	Harpeth UD	31	College Grove UD
12	Turnbull UD	32	Franklin WD
13	Van Leer WS	33	Nolensville UD
14	Erin WD	34	Lebanon WD
15	Tennessee Ridge WS	35	Watertown WS
16	Clarksville WD	36	West Wilson UD
17	Adams-Cedar Hill UD	37	Red Boiling Springs WS
18	Greenbrier WS	38	Lafayette
19	Mill Creek Heights UD		
20	Orlinda WS		

Public water systems currently serve about 815,000 or about 82 percent of the basin's 1980 population. Total water use or withdrawal for public purposes averages about 119.6 Mgal/d of which 115.8 Mgal/d or 97 percent is withdrawn from surface-water sources and 3.8 Mgal/d or 3 percent from

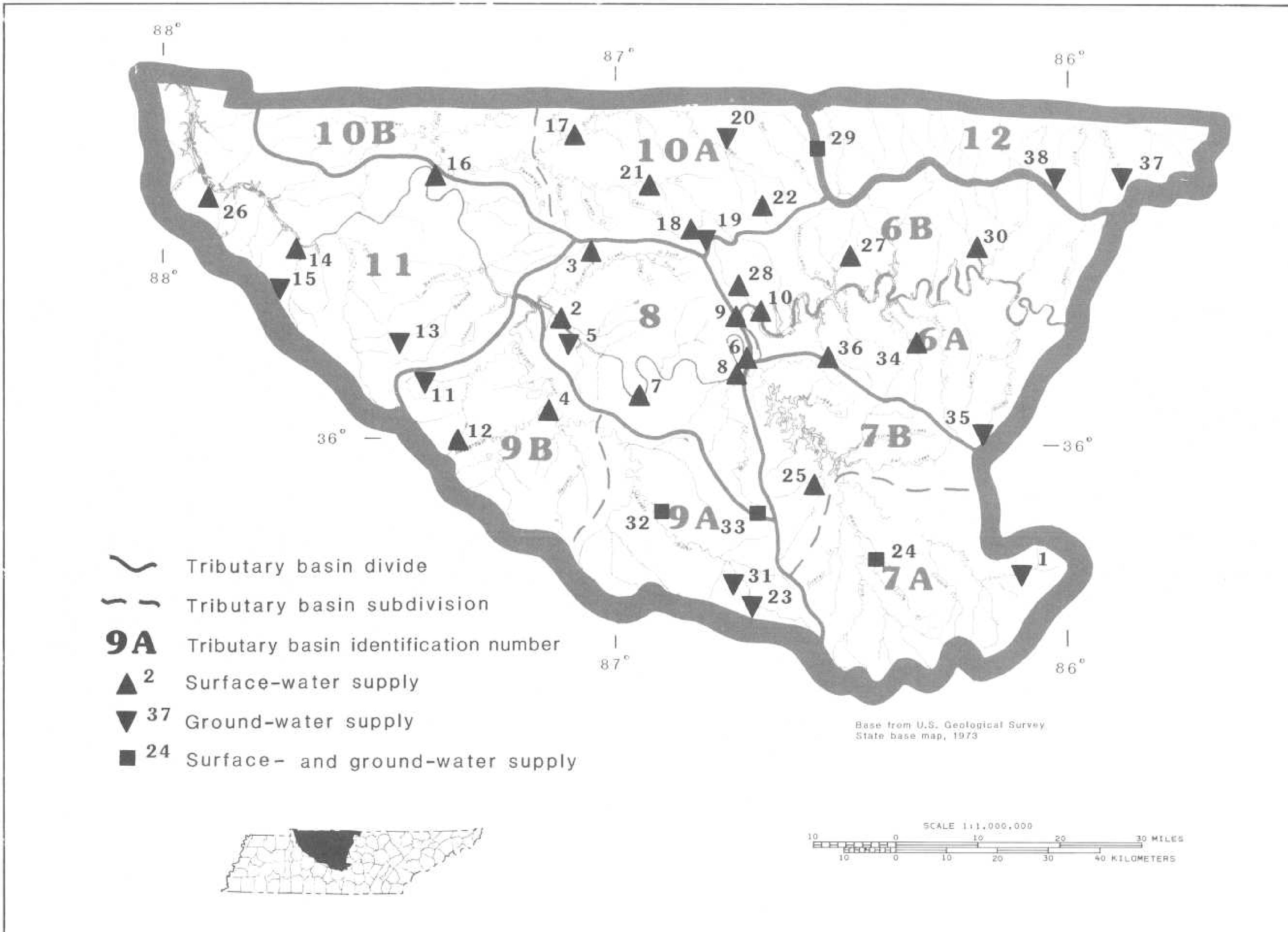

Figure 6.--Public water-supply facilities, Lower Cumberland River basin.

Figure 7--Explanation

Site No.	Facility name
1	E. I. DuPont De Nemours and Co., Inc.
2	Ford Motor Co., Inc.
3	Jersey Miniere Zinc Co.

ground-water sources. Major public water-supply facilities whose average daily use exceeds 1.0 Mgal/d include the following:

Facility name	Average water use (Mgal/d)
Cumberland UD	1.510
Harpeth Valley UD	3.500
Nashville WD	65.000
Madison Suburban UD	7.500
Turnbull UD	1.250
Clarksville WD	10.000
Springfield WS	1.840
White House UD	2.863
Murfreesboro WD	5.500
Smyrna WD	1.533
Gallatin WD	3.646
Hendersonville UD	3.000
Franklin WD	2.378
Lebanon WD	3.470
West Wilson UD	1.300

Together, these systems account for about 96 percent of the total water use for public purposes.

Self-supplied commercial and industrial users currently use or withdraw about 40.5 Mgal/d, all of which is obtained from surface-water sources. The only major self-supplied users are E. I. DuPont De Nemours and Company (26.736 Mgal/d) and Ford Motor Co. (13.000 Mgal/d) in Davidson County and Jersey Miniere Zinc Co. (0.800 Mgal/d) in Montgomery County. The total consumptive use of these three companies is about 3.776 Mgal/d.

Summarized below is a list of the specific water-supply problems experienced in the basin during the period surveyed. The number in parentheses following each identified problem indicates the number of communities or self-supplied water users who are now or have experienced this problem in the past. Note, these are not listed in order of frequency of occurrence or overall severity.

- Inadequate treatment capacity. (1)
- Occasional turbidity problems following heavy rainfall or during periods of flooding. (5)
- Periodic water-supply shortage during extended drought. (3)
- Clogging of water-supply intake facilities during fall of year. (1)
- Occasional taste or odor problems. (2)

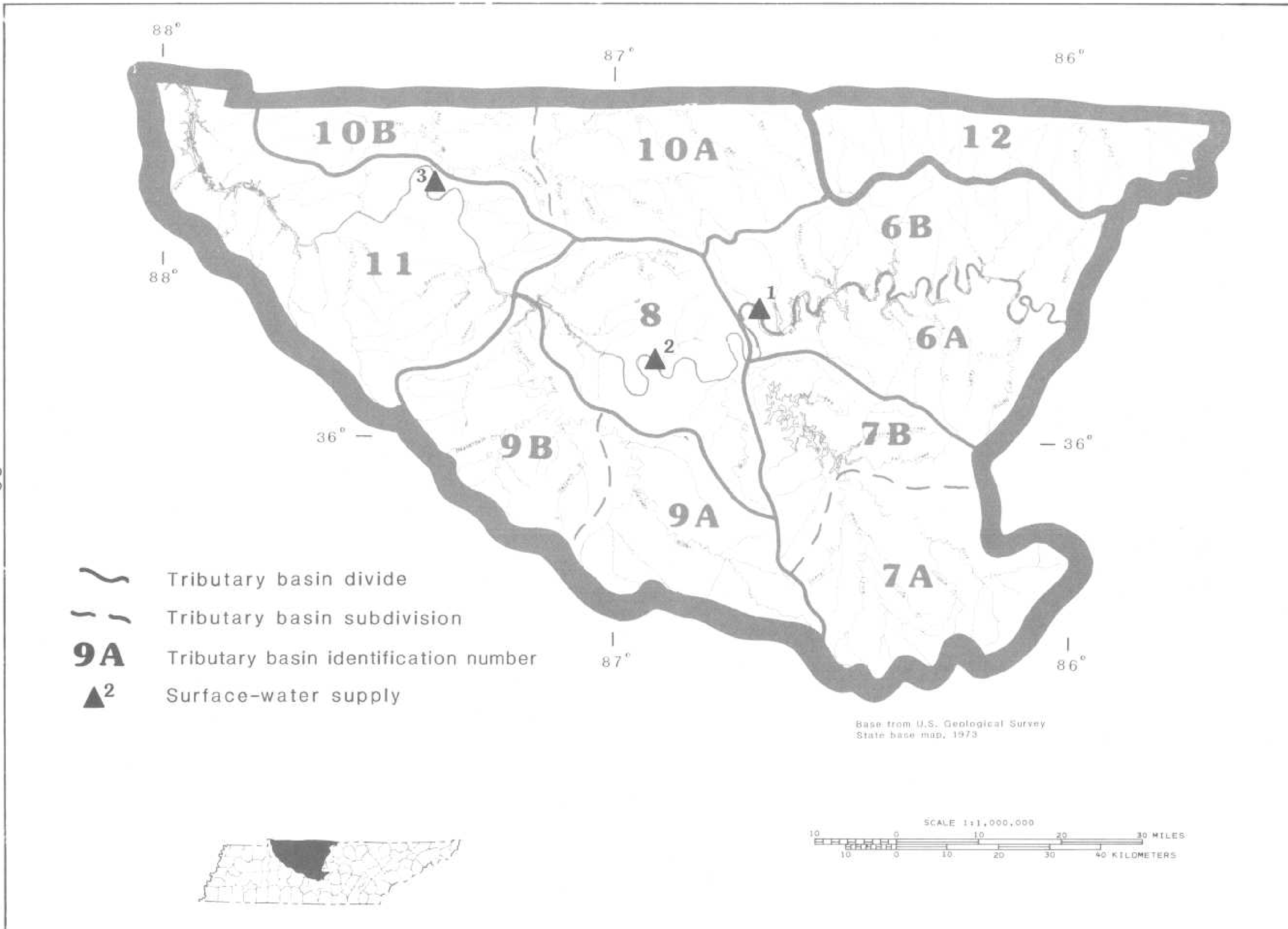

Figure 7.--Self-supplied commercial and industrial water users, Lower Cumberland River basin.

Water-Supply Adequacy Analysis

The Lower Cumberland River basin covers 5,599 mi^2 (3,320,000 acres) of land and water area. This basin's surface- and ground-water resources are replenished by substantial rainfall whose long-term (1941-70) average below Carthage equals 48.51 inches. Average annual runoff generally ranges from 18 to 28 inches with the heaviest runoff occurring in the vicinity of Murfreesboro. The driest months of the year are usually August, September, and October with March being the wettest month.

Total present water use or withdrawal for public and large self-supplied commercial and industrial purposes in the Lower Cumberland River basin amounts to approximately 160.1 Mgal/d. Of this amount, public water systems use about 119.6 Mgal/d, of which about 115.8 Mgal/d or 97 percent is withdrawn from surface-water sources and 3.8 Mgal/d or 3 percent from ground-water sources. Self-supplied commercial and industrial users use about 40.5 Mgal/d, all of which is obtained from surface-water sources.

Generally, the basin's public water-supply systems, particularly those served by surface-water sources, are found to be adequate in quantity to meet the basin's present needs. However, three systems (Harpeth, Red Boiling Springs, and Van Leer) that use springs as their primary water source have experienced shortages during dry periods. Several communities or systems (including College Grove, Eagleville, Franklin, Lafayette, Mill Creek Heights, Nolensville, Orlinda, River Road, Tennessee Ridge, Watertown, and Woodbury) are presently using ground-water sources of unknown capacity. Three systems (Franklin, Murfreesboro, and Portland) obtain their supplies from surface-water sources which are inadequate to meet the total demands of the systems at times. However, these systems have other sources of supply.

Water systems which are currently utilizing surface- and (or) ground-water resources which are inadequte or of unknown capacity should consider exploring the availability of alternative, cost-effective water-supply sources to augment or meet their future water needs if necessary. While the basin's water resources are subject to contamination from a variety of sources; existing and pending Federal, State, and local statutes relative to water-quality protection and maintenance or improvement should ensure that current water quality will be maintained with little, if any, future degradation of the basin's water resources. Potential sources of contamination include (1) leachate from municipal and industrial water disposal facilities and septic tank systems; (2) agricultural pollution from fertilizers, pesticides and herbicides, and livestock wastes; and (3) runoff from surface mine lands and quarries.

Although there are periods of extended drought which cause seasonal water table declines and periodic local problems with adequate ground-water supplies, observation-well data indicate there are no long-term, regional water table declines. Periodic local problems associated with a decline in an area's water table are caused by excessive withdrawals. To alleviate this problem, optimum ground-water withdrawal rates should be determined during the initial test pumping of the source.