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QUALITY OF SURFACE WATER IN BELL COUNTY, KENTUCKY

Robert B. Cook, Jr. [1], and Reese E. Mallette [2]

ABSTRACT

Reconnaissance data for surface waters in Bell County, Kentucky, have been gathered in response to the anticipated need for baseline information related to Federal and State surface-mining regulations. Bell County is particularly well suited for such a study due to past and current coal mining, the widespread distribution of mining and diversity of stratigraphic units affected, the diverse array of both disturbed and undisturbed drainage basins, and the relative ease of access within the county.

Estimated flow rate, temperature, pH, conductivity, and concentration of iron, manganese, and suspended solids were determined for flowing waters collected at 71 scattered sites. Sample localities range from major tributaries of the Cumberland River to first-order streams directly draining both mined and undisturbed areas.

The quality of Bell County streams with respect to criteria of Federal and State surface-mining regulations is good. Streams unaffected by mining have an average pH of 7.4, and conductivity is uniformly less than 500 micromhos/cm. Iron, manganese, and suspended solids contents of these streams are low, averaging 0.7, less than 0.1, and 3.0 milligrams per liter, respectively. Streams draining basins affected by surface coal mining show geochemical and sedimentological characteristics within current statute guidelines, with only three exceptions. These exceptions are the North Fork of Straight Creek and its tributaries in the immediate Crockett vicinity, Back Branch at Pruden, and Little Clear Creek in the vicinity of Clear Creek Springs.

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INTRODUCTION

This report presents reconnaissance water-quality data for streams in Bell County in response to general environmental protection requirements, both specific and implied, in recently enacted Federal and State surface-mining regulations. Although various questions relating to the exact applicability and enforcement of such regulations remain open, specific minimum water-quality standards appear to be established. Of particular significance are Kentucky statutes 405 KAR 1:160 and 405 KAR 1:170 relative to the protection of hydrologic systems, water-quality standards, and surface-water monitoring. Sections I and 2 of 405 KAR 1:160 require that strip-mining and reclamation operations must be planned and conducted in such a manner that disturbance of the prevailing hydrologic balance and water quality and quantity will be minimal. Implied in these requirements is the necessity for baseline data relative to prevailing water quality and hydrology prior to the initiation of mining. In most instances, baseline data are not available. This report, therefore, is an initial attempt to supply such data for drainage areas of current or projected strip mining of coal and to compare these data with the effluent limitations of 405 KAR 1:170 (Table 1).

Table 1. -- Effluent Limitations Set by Kentucky Statute 405 KAR 1:170.

Parameter	Maximum concentration	Daily average for 30 consecutive discharge days
Iron (total)	7.0 mg/1	3.5 mg/1
Manganese (total)	4.0 mg/1	2.0 mg/1
Suspended solids (total)	70.0 mg/1	35.0 mg/1
pH	within range of 6.0 to 9.0	

Bell County was chosen for the preliminary study because of the diversity of minable coals and related strata, the presence of rather restricted drainage basins as yet unaffected by major surface mining, and the relative ease of sampling due to a well developed and maintained road network.

ACKNOWLEDGMENT

Various personnel in the Middlesboro office of the Kentucky Department for Natural Resources and Environmental Protection gave freely of their time during initial orientation and district reconnaissance. Access to private land provided by various coal companies actively mining in Bell County is gratefully acknowledged. The project was encouraged from its inception by the Kentucky Coal Association.

PROCEDURES AND METHODS

Bell County was initially examined to determine the precise location and extent of surface and underground coal mines, and to establish a coherent plan for systematically sampling streams influenced by both active and former mining, as well as a selected number of drainage areas exhibiting no evidence of prior mining. All water samples were collected during the summer of 1978. Toward the end of the sampling program, a day was spent in aerial reconnaissance to check ground observations.

Establishment of 71 sample sites provides an overall picture of Bell County stream quality, as well as specific data for important individual drainage basins. Samples are numbered by date of collection and sequence of collection on that date (Table 2; Plate 1). All samples were collected during periods of low flow, and in no instance within 72 hours of the last previous rain. Although data for only one series of determinations are presented for each station, a significant number were sampled several times to check the acceptability of the sampling procedure and data reproducibility. In addition, blind replicate samples were submitted for suspended-solids analysis.

The Cumberland River proper was eliminated from this study because its geochemical and suspended-solids signature is influenced by an inordinate number of tributaries which do not originate in Bell County.

Flow rate at each sample site was estimated initially, and temperature was determined for calibration of pH and conductivity meters. Approximate flow rates were determined by measured channel cross sections coupled with float times over paced distances. A Hach portable pH meter (Model 17200) was used to measure pH. Conductivity, although not specified as a critical parameter in State and Federal regulations, was determined for estimation of total dissolved ions with a Hach portable conductivity meter (Model 17250). Iron and manganese contents were measured colorimetrically with Hach field kits (Models IR-18B and MN-5, respectively). Detection ranges are 0-10.0 mg/1 for iron and 0-3.0 mg/l for manganese.

Suspended-solids analyses were performed on 1.5-pint samples by Commonwealth Technology, Inc. These determinations were by the glass-fiber technique, method 108-C in "Standard Methods for the Examination of Water and Wastewater" (1975, p. 93). In addition to repetitive field determinations of pH, several replicate samples were submitted to Commonwealth Technology, Inc. for pH determinations as a check against field data.

GENERAL

Various aspects of the geology of Bell and neighboring counties have been published in detail since the late nineteenth century. Notable among early works are those of Ashley and Glen (1906) and Wentworth (1927). More recently, the geology of Bell County has been presented on geologic quadrangle maps produced cooperatively by the United States and Kentucky Geological Surveys. These maps are particularly important with respect to resolving local stratigraphic problems, determining the locations of coal outcrops, and correlating various coal beds.

The majority of rocks exposed in Bell County are Pennsylvanian in age, representing formations of the Breathitt Group and underlying members of the Lee Formation. The county is divided structurally into several parallel, northeast-trending regions. From southeast to northwest there are the Cumberland Mountain monocline, the Middlesboro Basin, and the Pine Mountain overthrust fault. The Middlesboro Basin is essentially a trough formed in the Paleozoic rocks of the Cumberland overthrust block. The northwestern margin of the Middlesboro Basin is marked by southeast-dipping formations overlying the Pine Mountain overthrust fault, the surface trace of which crops out along the northern slope of Pine Mountain. Underlying formations of Devonian and Mississippian ages are exposed on both Pine and Cumberland Mountains.

Although there is natural gas production in Bell County, coal is by far the most significant economic mineral commodity. Yearly coal production exceeds 4.5 million tons from approximately 80 mines, the majority of which are surface operations.

Thickness of the major coal-bearing Pennsylvanian section in Bell County ranges from approximately 2000 to 5000 feet. A number of mineable coals are present in the Breathitt Group, which is extensively exposed in the area. Although some local confusion still exists with respect to correlation of coal beds in the Middlesboro Basin with those northwest of the Pine Mountain overthrust fault, coals of particular significance appear to be the Hazard No. 8, Hazard No. 9, Hazard No. 4, Hance, Mason, Hignite, Fire Clay, Poplar Lick, and Red Springs. The Kellioka coal bed has been successfully used for correlation on either side of the Pine Mountain fault.

DRAINAGE AND HYDROLOGY

Essentially all Bell County drainage is toward the Cumberland River through tributaries entering the river at or near Pineville. The county is divided into several distinct drainage areas by Pine and Cumberland Mountains. Within these areas numerous individual drainage basins exist, many of which are quite restricted in extent. The general drainage pattern for first- and second-order streams is dendritic, although areas underlain by essentially horizontal strata exhibit roughly radial patterns in broadest outline.

Major drainage basins (Plate 1) are those of Straight Creek, Left Fork of Straight Creek, and Stoney Fork, all lying northeast of Pineville and north of Pine Mountain; Greasy Creek west of Pineville and north of Pine Mountain; Clear Creek along the base of Pine Mountain southwest of Pineville; Little Clear Creek southwest of Pineville and Yellow Creek west of Middlesboro; and Yellow Creek, Clear Fork, Hances Creek, Brownies Creek, and Puckett Creek all east of Pineville, northeast of Middlesboro, and north of Cumberland Mountain. A quite small drainage area in the extreme southwestern portion of the county in the vicinity of Fonde and Pruden initially drains to the southwest, entering the Cumberland River near Williamsburg.

Surface waters of Bell County are generally categorized as sulfate. Average annual runoff varies from 22 to 24 inches, and the mean annual precipitation is 48 inches (National Weather Service-NOAA). The Straight Creek, Yellow Creek, and Cumberland River drainages of Bell County are formally classified as flood prone.

In 1978 there were nine hydrological data stations in Bell County (U. S. Geological Survey, 1978). Three stage and discharge monitoring stations are along Yellow Creek between Pineville and Middlesboro. Similar stations are on the Cumberland River at Pineville and on Little Clear Creek and Shillalah Creek. Ground-water levels are monitored in two wells, and analytical data are routinely reported for the deep artesian well of the Middlesboro Tanning Company. Data for 36 wells scattered throughout Bell County were reported by Kilburn and others (1962). These data include depth to water below land surface, type of pump, adequacy, yield, depth of well below land surface, and formation. Additional data presented in this publication and a detailed study of the Middlesboro area water resources (Mull and Pickering, 1968) clearly show prevailing aquifers and their capacity, and general ground-water quality.

RESULTS

Estimated flows at stream sampling sites (Table 2) range from 1 gallon per minute at Saw Mill Branch near Clear Creek Springs to greater than 600 gallons per minute for Yellow Creek near Ponza. Water temperatures vary from 10.0°C for water issuing directly from an abandoned adit at Cary to as high as 31.5°C for Howard Branch at Cary. The rather wide distribution of temperatures (Table 2) generally reflects stream size, flow rate, and, for smaller streams, vegetative cover. Several streams were examined at various periods during a single day, and temperatures were found to fluctuate as much as 8°C between early morning and mid-afternoon. Such fluctuation was recorded for both small and large streams. Water temperatures in Little Clear Creek at Clear Creek Springs were found to vary between 10.0°C for early morning determinations and 24.0°C for mid-afternoon determinations. Water temperatures immediately downstream from sediment basins are generally somewhat higher than those of similar streams in undisturbed areas, apparently due to large surface area exposure.

The pH of Bell County waters was found to vary widely (Table 2), ranging between 3.1 near the headwaters of the North Fork of Straight Creek (8278-10) and 9.8 for Little Clear Creek at Clear Creek Springs (71178-6). Waters exceeding the pH limits of 405 KAR 1:170 were found to be quite uncommon and restricted in extent, representing only 5.6 percent of the sample population. A single sample (71179-6) taken in Little Clear Creek at Clear Creek Springs had an initial pH of 9.8. Re-sampling of this station the following day showed a decrease in pH to 8.2. In all, 13 samples or 18.1 percent of the sample population have a pH greater than 8.0. A total of 63 samples, or 87.5 percent of the population, have a pH greater than 7.0, reflecting the generally basic nature of Bell County streams. Seven samples, or 4.5 percent of the population, have a pH of 7.0 or less. Of these, three exceed the lower limit (pH 6) as established by 405 KAR 1:170. Two of these samples (8278-10 and 82478-2) were collected near each other several miles northeast of Crockett along the North Fork of Straight Creek and its tributary, Little Camp Branch. Both samples were collected in areas of extensive orphaned spoil piles. In addition to low pH, these samples have higher than average iron and manganese contents. The third excessively acidic sample (82578-6, pH 4.2) was collected in Back Branch at Pruden. This sample station is also immediately downstream from extensive orphaned spoils. At each of these stations, there are obvious accumulations of iron hydroxides on pebbles and other stream-bottom materials.

Table 2. -- Quality of Flowing Surface Water in Bell County, Kentucky

Sample Number	Location	Flow (est.) G. P. M.	Temp (°C)	pH	Conductivity (micromhos/cm)	Fe (mg/l)	Mn (mg/l)	Suspended Solids (mg/l)
71078- 1	Howard Branch; Cary	30	24.5	7.2	380	1.1	0.2	--
71078- 2	Howard Branch; Cary	5	31.5	7.3	155	0.9	0.1	--
71078- 3	Adit discharge; Cary	5	14.0	6.5	550	0.4	N. D .	--
71178- 1	Unnamed; Middlesboro	15	20.5	7.6	505	1.2	N. D.	36
71178- 2	Hignite Creek; Olson	150	20.5	7.6	480	1.0	N. D.	--
71178- 3	Campbell Branch; Davisburg	10	20.0	7.2	100	1.3	0.1	--
71178- 4	Caney Creek; Olcott	25	20.5	7.5	160	0.8	0.1	---
71178- 5	Saw Mill Branch; Clear Creek Springs	1	19.0	6.6	500	0.2	0.1	--
71178- 6	Little Clear Creek; Clear Creek Springs	500	24.0	9.8	300	3.9	0.1	78
71178- 7	Smith Branch; Clear Creek Springs	2	22.0	8.5	120	1.9	N.D.	--
71278- 8	Little Clear Creek; Clear Creek Springs	500	19.0	8.2	---	2.5	N. D.	208
71278- 2	Unnamed; Fuson Chapel	3	19.5	7.6	45	1.0	N. D.	--
71278- 3	Little Clear Creek	400	20.0	8.3	480	1.6	N. D.	--
71278- 4	Jack Branch	40	20.0	8.0	175	6.8	N. D.	--
71278- 5	Williams Branch; Ponza	10	29.0	8.4	460	0.8	N. D.	--
71278- 6	Yellow Creek; Ponza	600+	24.5	8.2	680	0.6	N. D.	--
71278- 7	Williams Branch; Ponza	5	26.5	8.2	490	0.7	N. D.	--
71278- 8	Williams Branch; Ponza	2	27.0	8.1	280	0.8	N. D[1]	--
71278- 9	Sam Low Branch; Varilla	200	23.5	8.6	480	1.0	N. D.	--
71278-10	Hances Creek	50	26.5	8.3	670	1.0	N.D.	--
71738- 1	Levi Creek; Fourmile	15	19.5	7.1	320	1.0	N.D.	--
71378- 2	Fourmile Creek	60	21.5	6.7	350	1.0	N. D.	--
71378- 3	Unnamed; Fourmile	15	21.0	7.3	510	0.6	N. D.	--
71378- 4	Unnamed; Fourmile	10	20.5	6.8	550	0.4	N. D.	--
8278- 1	Elliott Branch; Jenson	30	20.5	7.8	670	1.2	N. D.	--
8278- 2	Kettle Branch; Kettle Island	5	23.5	7.7	80	1.0	N. D.	--
8278- 3	Mill Creek	25	21.5	7.6	120	0.9	N. D.	--
8278- 4	Stoney Fork; Stoney Fork	90	26.0	7.7	250	0.6	N. D.	--
8278- 5	Knuckles Branch; Stoney Fork	5	22.5	7.5	36	0.9	N. D.	1
8278- 6	York Branch	15	25.5	6.9	135	0.8	N. D.	1
8278- 7	Red Bird Creek	5	23.0	7.4	280	1.0	N. D.	--
8278- 8	Mud Creek; Red Bird	20	25.5	7.4	390	1.0	N. D.	6
8278- 9	Unnamed; Red Bird	6	26.5	7.0	280	1.2	N. D.	16
8278-10	Straight Creek; Crockett	50	25.0	3.1	2050	10.0+	2.8	59
8378- 1	Shillalah Creek; Hutch	100	22.0	7.4	28	0.2	N. D.	--
8378- 2	Cubbage Creek; Cubbage	80	21.5	8.6!	220	1.1	N. D.	---

[1] N.D., none detected.

Table 2. -- Continued.

Sample Number	Location	Flow (est.) G.P.M.	Temp °C	pH	Conductivity (micromhos/cm)	Fe (mg/l)	M n (mg/l)	Suspended Solids (mg/l)
8378- 3	Cubbage Creek; Cubbage	30	14.5	7.8	34	1.1	N. D[1]	--
81778- 1	Greasy Creek; Ark	60	24.0	6.8	130	1.4	N. D.	1
81778- 2	Center Branch; Ingram	15	23.0	7.5	95	1.4	N. D.	1
81778- 3	Goodin Branch	120	23.5	7.3	240	1.3	N. D.	2
81178- 4	Wilson Branch; Tinsley	150	25.0	7.3	550	0.8	N. D.	--
91778- 5	Unnamed; Hosman	200	25.0	7.3	405	1.0	N. D.	--
81778- 6	Turkey Creek; Fourmile	150	25.0	7.6	120	0.8	N.D.	--
81778- 7	Sugar Run Creek	250	20.0	7.5	29	0.5	N. D.	1
81778- 8	Clear Fork; Hutch	300	23.5	7.8	205	0.9	N.D.	7
81778- 9	Cranes Creek; Colmar	200	26.0	8.6	2650	1.2	N. D.	18
82478- 1	Straight Creek; Jaybee	30	21.5	7.6	740	1.0	N.D.	3
82478- 2	Little Camp Branch; Crockett	25	21.0	5.1	490	2.4	0.1	16
82478- 3	Sims Fork; Rella	40	22.0	7.1	370	1.0	N. D.	10
82478- 4	Sims Fork; Rella	20	22.0	7.6	190	0.6	N. D.	--
82478- 5	Caney Branch; Arjay	15	23.0	7.4	220	1.1	N.D.	9
82478- 6	Wiser Branch; Arjay	9	23.5	7.4	260	0.7	N.D.	50
82478- 7	Bird Branch; East Pineville	35	23.5	7.5	95	0.6	N.D.	3
82479- 8	Watts Creek; Varilla	20	23.0	7.5	68	0.6	N.D.	--
82479- 9	Board Tree Branch; Oaks	20	23.5	7.5	1250	0.7	N. D.	8
82478-10	Brownies Creek; Oaks	150	24.0	7.4	460	0.9	N. D.	3
82478-11	Coal Stone Branch; Cubbage	30	22.5	7.9	890	0.6	N. D.[1]	4
82478-12	Mill Branch; Cubbage	15	22.5	7.7	130	0.5	N.D.	2
82478-13	Black Snake Branch; Cubbage	30	22.5	7.4	570	0.5	N.D.	2
82478-14	Brownies Creek; Cubbage	40	22.5	7.6	120	0.9	N. D.	1
82478-15	Puckett Creek; Tuggleville	80	23.0	7.6	700	0.4	N. D.	1
82478-16	Campbell Branch; Tuggleville	10	22.0	7.5	740	0.5	N. D.	1
85578- 1	Lick Fork; Middlesboro	25	22.5	7.0	180	1.6	N.D.	5
82578- 2	Beans Fork; Middlesboro	20	23.0	7.1	240	0.4	N.D.	0.3
82578- 3	Sowder Branch; Fonde	15	20.5	7.1	590	0.5	N.D.	4
82578- 4	Marsee Branch; Fonde	18	22.0	7.0	545	0.4	N.D.	10
92578- 5	Clear Fork; Fonde	35	22.5	7.8	1650	0.4	N. D.	1
82578- 6	Back Branch; Pruden	10	23.0	4.2	1580	10.0+	1.6	37
82578- 7	Morgan Hollow Branch; Frakes	25	22.5	7.4	250	0.7	N.D.	4
92578- &	Laurel Fork; Frakes	15	22.0	7.4	490	0.3	N. D.	4
82579- 9	Laurel Fork; Frakes	10	22.0	7.2	140	0.5	N. D.	--
82578-10	Bear Creek; Chenoa	10	21.5	7.2	110	0.2	N. D.	--
82578-11	Clear Creek; Chenoa	15	22.5	7.7	240	0.8	N. D.	---

[1] N.D., none detected.

Eight streams draining areas apparently undisturbed by prior mining were found to range in pH from 6.6 (sample 71178-5 at Saw Mill Branch) to 8.0 (sample 71278-4 at Jack Branch). With the exception of the Saw Mill Branch sample, these streams had a slightly basic character, with an average pH of 7.4.

Conductivity (Table 2) was found to vary significantly, ranging from 28 micromhos/cm for waters of Shillalah Creek (8378-1) and Sugar Run Creek (81778-7) to 2650 in Cranes Creek at Colmar (81778-9). Conductivities for streams draining undisturbed areas were in all instances less than 500 micromhos/cm, and averaged 176 micromhos/cm. Conductivity exceeding 1000 micromhos/cm was observed at five sample locations. Streams having high conductivity, while not necessarily characterized by unusual pH, or iron, manganese, and suspended solids contents, in all instances drain basins heavily influenced by orphaned spoils or extensive active mining.

The iron content of Bell County streams (Table 2) is generally low. The average for all samples (values greater than the detection limit of equipment used is arbitrarily taken as 10 mg/l is 1.3 mg/l. Streams draining undisturbed areas contain an average iron content of 0.7 mg/l. Two samples (8278-10 and 82578-6) have an iron content in excess of the maximum allowable limit of 7.0 mg/l. Both samples have been previously described and represent drainage from areas characterized by extensive orphaned spoils. In addition, samples 71178-6 and 71278-4 from Little Clear Creek and Jack Branch, respectively, have iron contents in excess of the maximum daily average allowed for repetitive sampling (3.5 mg/l. These samples are from basins disturbed by current (1978) strip-mining operations.

The manganese content of Bell County streams is quite low. Only eight samples reflect a manganese content greater than 0.1 mg/l. Of these, none exceeds the maximum allowable content of 4.0 mg/l, and only one (North Fork of Straight Creek, 8278-10) contains manganese in excess of the average allowable daily value for 30 consecutive discharge days.

The suspended-solids content of Bell County streams is quite variable (Table 2). Streams apparently unaffected by recent strip mining have low suspended-solids content, averaging only 3 mg/l. The maximum suspended solids content was observed in Little Clear Creek (71178-6 and 71278-1), where sampling on consecutive days returned values of 78 mg/1 and 208mg/l, both of which are above the maximum allowable limit. In addition to these samples, four additional streams have suspended-solids contents greater than the 35 mg/1 daily average allowed for 30 consecutive sampling days. Each of these stations (71178-1, 8278-10, 82478-5, and 82578-6) is in drainage basins affected by either orphaned strip-mine spoils or current surface-mining operations. Of these four, two (71178-1 and 82578-6) barely exceed the allowable limit, having 36 mg/l and 37 mg/l, respectively. The average for all samples analyzed for suspended solids is 17 mg/l.

CONCLUSIONS

The quality of Bell County streams with respect to criteria of recent Federal and State strip-mining regulations is unusually good. This conclusion is particularly significant in view of the wide distribution of both currently operated and abandoned coal mines in Bell County, and the diversity of coal beds and associated strata exposed by those various operations. Several factors, either individually or collectively affecting specific drainage basins, appear responsible f or this generally high water quality. Waters draining portions of Pine and Cumberland Mountains are naturally buffered by exposed carbonate units, principally the Newman Limestone. Shales adjacent to certain coal beds are relatively deficient in iron sulfide minerals. In most areas of extensive, active coal mining, diligent efforts are underway to reclaim lands in compliance with current regulations. Several Bell County coal operations have been recently cited for exemplary reclamation efforts.

Data for eight streams unaffected by old or current mining may be taken as representative of such waters in Bell County for comparative purposes. These streams reflect the slightly basic character of Bell County waters, exhibiting an average pH of 7.4. Conductivity is uniformly less than 500 micromhos/cm for these streams, indicating a generally low dissolved-ions content. Similarly, iron, manganese, and suspended-solids contents of these streams are also quite low, averaging 0.7, less than 0.1, and 3.0 milligrams per liter, respectively.

With only three exceptions, streams draining basins affected by active or orphaned coal mines have geochemical and sedimentological characteristics well within the statute guidelines. These are the North Fork of Straight Creek and its tributaries in the immediate vicinity of Crockett, Back Branch at Pruden, and Little Clear Creek in the vicinity of Clear Creek Springs. Waters in the vicinity of Crockett have abnormally high iron and manganese contents and excessively low pH. A combination of natural recovery and reclamation efforts have upgraded this stream to acceptable standards only a few miles downstream at Jaybee. Similar acidic waters of Back Branch directly drain an extensive area of orphaned spoils and could in all likelihood be upgraded with little effort. Water of Little Clear Creek, which represents drainage from areas of extensive current strip mining in the Log Mountains, appears to offer the most critical problem. Water of this creek has quite variable pH, and iron and suspended-solids contents. Suspended solids are generally excessive. Abnormally high pH apparently reflects neutralization efforts by the addition of chemical agents into sediment basins. Reconnaissance of the headwaters of Little Clear Creek suggests that potential problem areas are strip mines currently under development. Completion of sediment basins currently under construction and adequate monitoring of neutralization attempts may soon correct these problems.

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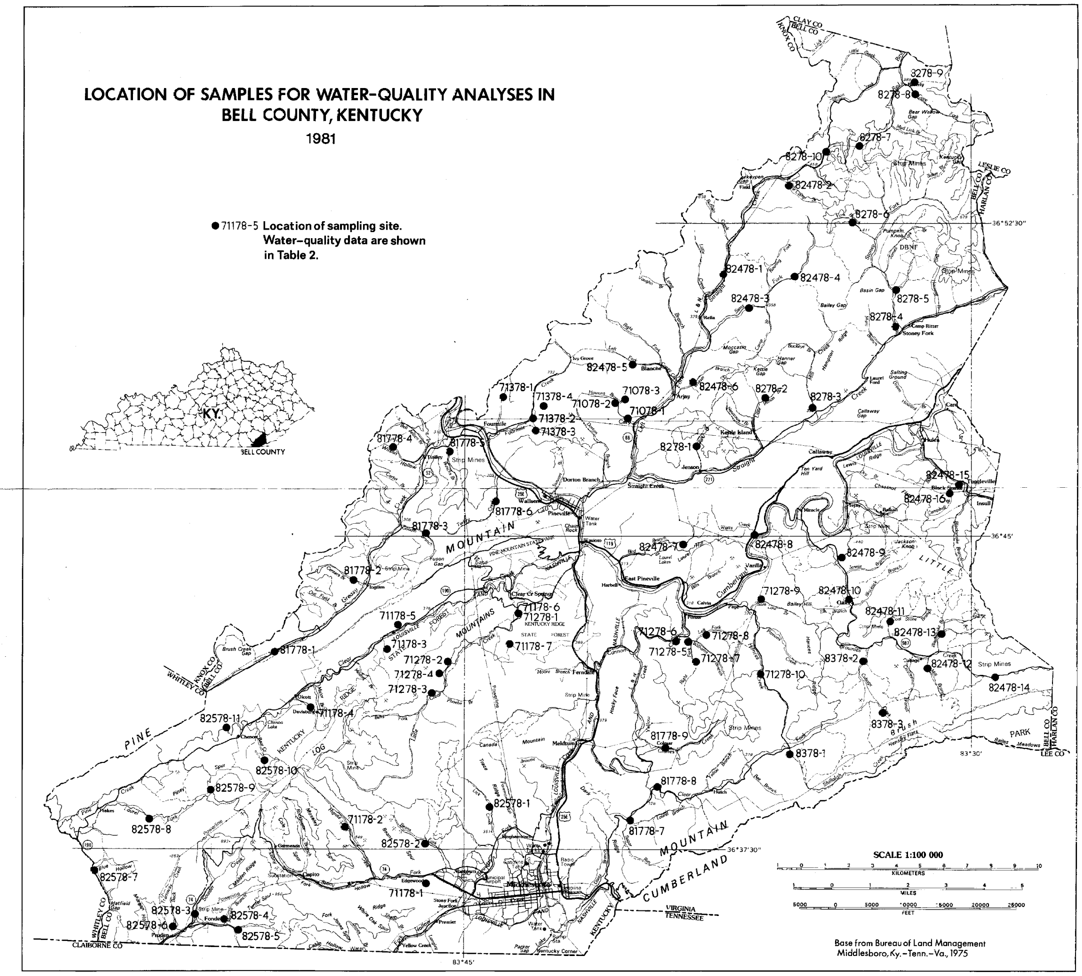
LOCATION OF SAMPLES FOR WATER-QUALITY ANALYSES IN
BELL COUNTY, KENTUCKY
1981
● 71178-5 Location of sampling site.
Water-quality data are shown
in Table 2.
KY.
BELL COUNTY
PINE MOUNTAIN
CUMBERLAND MOUNTAIN
LOG MOUNTAINS
LITTLE
VIRGINIA
TENNESSEE
SCALE 1:100 000
KILOMETERS
MILES
FEET
Base from Bureau of Land Management
Middlesboro, Ky.-Tenn.-Va., 1975