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Task II Report: Part 1: Evaluation of Water Supplies in the North, South, and Middle Fork Kentucky River Watersheds

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ASSESSMENT STUDY

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Prepared for:
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EXECUTIVE SUMMARY

This study was part of a larger study of water supplies throughout the Kentucky River basin conducted by the University of Kentucky Water Resources Research Institute for the Kentucky River Authority. This report examines municipal and private water supplies in the North, South, and Middle Fork watersheds of the Kentucky River. Municipal supplies which depend on the mainstem Kentucky River, and municipal and private water supplies in the Red River, Dix River, and mainstem watersheds of the Kentucky River basin are examined in a separate reports.

Municipal water systems in Letcher, Knott, Leslie, and Breathitt counties in the North Fork Kentucky River basin, Leslie county in the Middle Fork Kentucky River basin, and Owsley and Clay counties in the South Fork Kentucky River basin were examined for current and projected water supply adequacy and water system needs. Eight municipal water suppliers - Fleming-Neon Water Company, Whitesburg Municipal Water, Hindman Municipal Water Works, Hazard Water Department, Jackson Municipal Water Works, Booneville Water & Sewer, and Manchester Water Works - and three purchasing districts: Vicco Water System, Hima-Sibert Water District, and North Manchester Water District - were included in the study.

Population projections from the Kentucky State Data Center were combined with service area expansion projections from Long Range Water Supply Plans to produce estimates of water use for the years 2000, 2010, and 2020. Moderate and high growth population projections from the Kentucky State Data Center were used to produce estimates of water use for the years 2000, 2010, and 2020. Moderate growth assumes only minor gains from migration, high growth reflects recent trends in migration (1990-94). Moderate growth assumptions project a 6 percent drop in population and high growth assumptions predict a 13 percent gain in population for the seven-county study area for the 1994-2020 period.

County	1994 Population	2020 Population Moderate Growth	2020 Population High Growth	Change Moderate / High Growth
Breathitt	15,400	15,333	15,911	0% / 3%
Perry	31,140	28,233	33,998	-9% / 9%
Knott	18,340	18,713	22,974	2% / 25%
Letcher	27,000	24,278	30,929	-10% / 15%
Leslie	13,810	13,472	16,795	-2% / 22%
Owsley	5,410	4,258	5,958	-21% / 10%
Clay	22,776	22,051	24,770	-3% / 9%
Region	**133,876**	**126,338**	**151,335**	**-6% / 13%**

A 50 to 60 percent growth in the number of customers is anticipated by the year 2020.

County	Water Supplier	1994	Moderate Growth 2020	High Growth 2020	Change Moderate /High
Breathitt	Jackson Municipal Water Works	1,910[1]	2,610	2,640	37% / 38%
Perry	Hazard Water Department (Vicco Water System)	5,580	8,230	8,830	47% / 58%
Knott	Hindman Municipal Water Works	340[2]	580	660	71% / 94%
Letcher	Whitesburg Municipal Water, Fleming-Neon Water Company	1,620	3,430	3,670	112% / 127%
Leslie	Hyden-Leslie County Water District	1,730	2,770	2,990	60% / 73%
Owsley	Booneville Water & Sewer	1,190	1,430	1,600	20% / 34%
Clay	Manchester Water Works (Hima-Sibert Water District, North Manchester Water Works)	3,380	4,550	4,710	35% / 39%
Region		**15,750**	**23,600**	**25,100**	**50% / 59%**

[1] 1992, [2] 1990

The projected average and peak water needs were compared with estimates of available water supplies during droughts. The water supply adequacy of each system through the year 2020 was evaluated using drought susceptibility classes developed by the Kentucky Division of Water. The classes are defined:

A - Systems unlikely to experience water shortage during drought conditions.

B - Systems that should be examined for susceptibility to water shortage during drought. Plans need to be made for response to possible shortage.

C - Systems that are likely to have water shortage during drought conditions. Plans for response to shortage are necessary.

Water Supplier	Drought Susceptibility Class
Whitesburg Municipal Water	B
Fleming-Neon Water Company	A-B
Hindman Municipal Water Works	A
Hazard Water Department	C
Jackson Municipal Water Works	A
Hyden-Leslie Water District	C
Manchester Water Works	B
Booneville Water & Sewer System	B-C

Water supplies for 5 of the 8 water suppliers were found to be inadequate. Long Range Water Supply Plans indicated that flooded deep mines near the Whitesburg, Hyden-Leslie, and Hazard systems would be the most feasible sources for their needed additional water. A new intake in Kentucky River Pool 14 was considered the most feasible source of reliable water for Booneville Water & Sewer. Manchester Water Works had not begun an evaluation of additional supplies.

Water supplies for the Fleming-Neon Water Company were considered adequate for current needs, but by the year 2010 might not be able to meet average water demands during a drought. Water supplies for Jackson Municipal Water Works and Hindman Municipal Water Works were considered adequate for current and future needs.

An estimated investment of at least $16,000,000 is needed in the region: $6,000,000 to develop water supplies, renovate water plants, and repair system leaks, and $10,000,000 to extend water service areas. An estimated investment of $200,000,000 would be required to provide full public water service to the region.

The developmental progress of the upper forks region depends on the provision of safe drinking water to its residents. Private water supplies in the region are vulnerable to contamination from household and industrial wastes and to disruption from extractive industries. Over half the wells tested for bacteria in the region have been found to be contaminated. The extent of chemical contamination of private drinking water supplies by mining and oil and gas recovery operations has not been fully documented because private supplies are seldom tested for chemicals and toxic metals. More extensive and consistent data on the quality and availability of groundwater in the region is needed. Contaminated drinking water can cause a variety of health problems, and there is also a need for more comprehensive data on the incidence of health problems linked with contaminated drinking water. In contrast to public water supplies, private drinking water supplies are not directly protected by current federal or state water quality regulations.

EVALUATION OF WATER SUPPLIES IN THE UPPER FORKS OF THE KENTUCKY RIVER BASIN

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EVALUATION OF WATER SUPPLIES IN THE UPPER FORKS OF THE KENTUCKY RIVER BASIN

Introduction

This study was part of a larger study of water supplies throughout the Kentucky River basin conducted by the University of Kentucky Water Resources Research Institute for the Kentucky River Authority. This report examines municipal and private water supplies in the upper forks of the Kentucky River. The basins of the North, Middle, and South Forks of the Kentucky River, with a combined area of over 2,600 square miles (USGS, 1981), form the upper forks region of the Kentucky River (Figure 1). The area covered lies entirely within the Eastern Coal Field physiographic region. The area includes the counties of Breathitt, Leslie, Owsley, Perry, nearly all of Clay county, over 80 percent of Letcher county, 70 percent of Knott county, and small parts of Bell, Harlan, and Knox counties. Only those municipal systems that derived their water from within the basin were evaluated. Municipal water systems in Letcher, Knott, Leslie, and Breathitt counties in the North Fork Kentucky River basin, Leslie county in the Middle Fork Kentucky River basin, and Owsley and Clay counties in the South Fork Kentucky River basin were examined for current and projected water supply adequacy and water system needs. Eight municipal water suppliers - Fleming-Neon Water Company, Whitesburg Municipal Water, Hindman Municipal Water Works, Hazard Water Department, Jackson Municipal Water Works, Booneville Water & Sewer, and Manchester Water Works - and three purchasing districts: Vicco Water System, Hima-Sibert Water District, and North Manchester Water District - were included in the study.

Population projections from the Kentucky State Data Center were combined with service area expansion projections from Long Range Water Supply Plans to produce estimates of water use for the years 2000, 2010, and 2020. The projected average and peak water needs were compared with estimates of available water supplies during droughts. Evaluation procedures recommended by the Kentucky Division of Water were used to determine the drought susceptibility of each municipal water supplier.

Municipal water supplies currently provide water to about 39,000 residents in the upper forks, or 29 percent of the basin's 134,000 residents. 94,570 people (71 percent) in the region are not served by municipal water systems. Based on private water supply data from the 1990 census, it is estimated that, of these, 28,290 households rely on drilled wells, 4,400 households on dug wells, and 3,315 households depend on small water systems, cisterns, hauled water, and other sources.

The developmental progress of the upper forks region depends on the provision of safe drinking water to its residents. Private water supplies in the region are vulnerable to contamination from household and industrial wastes and to disruption from extractive industries. Over half the wells tested for bacteria in the region have been found to be contaminated. The extent of chemical contamination of private drinking water supplies by mining and oil and gas recovery operations has not been fully documented because private supplies are seldom tested for chemicals and toxic metals. More extensive and consistent data on the quality and availability of groundwater in the region is needed. Contaminated drinking water can cause a variety of health problems, and there is also a need for more comprehensive data on the incidence of health problems linked with contaminated drinking water. In contrast to public water supplies, private drinking water supplies are not directly protected by current federal or state water quality regulations.

Demographics

In Kentucky, population growth is increasingly more dependent on migration. *Natural increase* is declining as birth levels remain stable or decline, and deaths increase with the aging of the population. Migration, however, is more difficult to understand and forecast. Kentucky's migration history includes patterns of persistence (outmigration of young adults) and change (the influx of workers and families or the settlement of retirees).

1995 population projections were taken from the Kentucky State Data Center. The 1995 edition of **How Many Kentuckians** includes a *high growth* series and the previously released *moderate growth* series. Produced by demographic cohort-component methods, both series are presented through the year 2020.

The *high growth* series is new, incorporating the latest postcensal population estimates from the U.S. Bureau of the Census. It uses 1994 estimates as a base or starting point, projects migration using 1990-94 trends, and assumes that longevity increases in the future. This series represents and *optimum* forecast. Since 1990, Kentucky has been gaining more migrants than have left, a reversal of the net outmigration of the 1980s. The *high growth* series assumes net inmigration for the state, as a whole, based on recent county trends.

The *moderate growth* series assumes that migration flows result in only minor gains statewide. Less migration lowers *natural increase* because there are fewer women of childbearing age. The *moderate series* uses the 1990 census as a base. Its migration assumptions were developed by reducing outmigration flows while maintaining inmigration flows of the 1980s.

The latest population projections from the U.S. Census Bureau of the Census show a growth trajectory for Kentucky six percent below that of the *high growth* series. From 1990 through 2020, Kentucky is expected to grow 844,000 persons, or 23 percent, in the *high growth* series; 626,000 persons, or 17 percent, according to the Census Bureau's *Preferred Series*; and 240,000 persons, or seven percent, in the *moderate growth* series.

The historical and projected population for the seven counties in the Upper Forks region is shown in Table 1.

Year	Moderate Growth	High Growth
1980	139,679	139,679
1990	131,316	131,316
1995	131,116	135,047
2000	130,423	140,834
2010	129,228	148,212
2020	126,538	151,335

Table 1. Projected population, Upper Forks Kentucky River Basin

The Moderate Growth assumptions result in a projected 3.6 percent drop in population from 1990-2020. The High Growth assumptions result in a projected 15.2 percent growth in the region's population from 1990-2020. The population dynamics are not uniform over the basin, however. As shown in Table 2, Breathitt county's population is projected to remain relatively stable under either assumption, Knott county's population is expected to grow, perhaps significantly, under either assumption, and the projections for Owsley county differ markedly.

County	Percent Change 1990-2020 Moderate Growth	Percent Change 1990-2020 High Growth
Breathitt	-2.4	1.3
Perry	-6.8	12.3
Knott	4.5	28.3
Letcher	-9.3	14.6
Hyden	-1.2	23.1
Owsley	-16	18
Clay	-1	14

Table 2. Projected percent population change by county.

Municipal Water Systems

Ten municipal water suppliers provided water for about 39,310 people in the region, either directly or through purchasing water districts, as shown in Table 3.

Water Supplier	People Served
Whitesburg Municipal Water	1,700
Fleming-Neon Water Company	1,900
Jenkins Water Supply[1]	2,500
Hindman Municipal Water Works	920
Caney Creek Water District[1]	230
Hazard Water Department	10,740
Vicco Water System	1,910
Jackson Municipal Water Works	4,200
Hyden-Leslie Water District	2,660
Manchester Water Works	6,110
Hima-Sibert Water District	1,300
North Manchester Water District	2,380
Booneville Water & Sewer System	2,760
TOTAL	39,310

[1] Water supply from outside the basin.

Table 3. Number of residential customers by system.

The projected growth in residential service as a percentage of 1994 service is shown in Table 4.

	Percentage Growth in Residential Customer Service[1] Year moderate/high		
SYSTEM	**2000**	**2010**	**2020**
Jackson Municipal Water Works	0.6/0.6	0.6/1.8	0.6/2
Hazard Water System	7/12	17/25	17/26
Vicco Water Works	60/67	70/81	70/83
Hindman Municipal Water Works	15/22	40/53	40/59
Whitesburg Municipal Water	99/105	152/164	154/168
Fleming-Neon Water Company	45/52	70/82	70/84
Hyden-Leslie Water District	39/43	61/71	61/73
Booneville Water & Sewer	7/20	20/32	20/35
Manchester Water Works	2	4/7	4/7
Hima-Sibert Water District	56	57/62	57/62
North Manchester Water District	29	30/35	30/35
Regional Growth	31/35	44/52	44/53

[1] As a percentage of 1994 service.

Table 4. Projected growth in residential water service.

Projected growth in residential water service varies widely among systems, ranging from very limited growth of Jackson Municipal Water Works, to the more than doubling of Whitesburg Municipal Water's service.

The existing water service area is shown in Figure 2.

Water Resources

Forty-six inches of precipitation (2.1 trillion gallons) fall on the basin every year, on the average (Ref. 49). Twenty-eight inches of rainfall returns to the atmosphere through evaporation or transpiration by plants. The remaining eighteen inches of rainfall (831 billion gallons of water) is transported by the Kentucky River out of the region (Ref. 41).

The water yield from the basin is about 1.36 cubic feet per second per square mile, or 880,000 gallons per day per square mile (Ref. 41). This water yield corresponds to about 8,800 gallons per day for every person living in the basin.

Clearly, an abundance of water falls on, and runs out of, the basin. Runoff tends to be higher in the winter and lower in the summer and fall, and can approach zero even on perennial streams during droughts. Water withdrawal permitting program criteria allow up to 10 percent of available water under normal conditions to be withdrawn. "Available" water under normal conditions is defined as 10 percent of the average flow during the month of lowest average monthly flow, typically September or October.

Water withdrawal regulations, and most withdrawal permits, also state that withdrawals must be reduced when flows approach the 7-day, 10-year (7Q10) low flow level. The 7Q10 flow is the lowest 7-day flow that occurs on the average once every ten years. When 7Q10 flows are experienced for four consecutive days, withdrawals must cease. This minimum stream flow requirement can be waived by the regulatory authority in the case of a governor's declaration of a "water emergency" as occurred in 1988.

Water Quality

Streams in the North and Middle Fork basins continue to have problems caused by siltation and pathogens (Figure 3). Non-support of swimming and aquatic life in streams used for drinking water supplies increases water treatment costs. Mining, agriculture, septic systems and petroleum activities were the sources of stream pollution. Other potential sources of pollution in the region were identified - including effluent discharge sites, hazardous waste handling sites, water treatment plants, and solid waste landfills - and are presented in detail under the discussion for each county. Locations of potential sources of pollution in the region are shown in Figure 4.

Water Supply Adequacy

The Water Resources Branch of the Kentucky Natural Resources and Environmental Protection Cabinet, Division of Water developed a program to evaluate water systems. Water systems are grouped into three classes of susceptibility to water shortages during drought

NORTH FORK KENTUCKY RIVER BASIN

The North Fork basin is the largest of the three forks (Figure 5) and has the greatest population. The North Fork basin lies within the Kentucky River Area Development District (KRADD). Long-Range Water Supply Plan (LRWSP) documents (Ref. 5,6,7,9,11,12,13,14) for each county in the KRADD were completed in 1994, and provided much of the information below.

An estimated 91,880 people lived in the region in 1994. 24,100 people received their water from municipal supplies, 52,200 from drilled wells, 8,800 from dug wells, and 6,800 from small systems, cisterns, hauled water, and other sources.

Population projections with moderate and high growth assumptions for the region are shown in Table 12 (Ref. 1).

Year	Moderate Growth	High Growth
1980	99,394	99,394
1990	90,892	90,892
1995	90,749	92,682
2000	90,191	96,404
2010	89,022	101,575
2020	86,757	103,812

Table 12. Projected population growth, North Fork basin.

Moderate growth, in fact, projects a 4.5 percent decline in regional population from 1990 to the year 2020. High growth assumptions project a 14.2 percent increase in population over the same period. The population dynamics are not uniform over the basin, however. As shown in Table 13, Breathitt county's population is projected to remain relatively stable under either assumption.

County	Percent Change 1990-2020 Moderate Growth	Percent Change 1990-2020 High Growth
Breathitt	-2.4	1.3
Perry	-6.8	12.3
Knott	4.5	28.3
Letcher	-9.3	14.6

Table 13. Projected population, relative change by county.

The projected growth in the number of residential customers served, both through line extensions to new areas and population growth, as a percentage of 1994 service, is shown in Table 14. Anticipated increases in residential service range from no significant increase for

Jackson Municipal Water Works to more than doubling residential service by Whitesburg Municipal Water.

	Percent growth in residential customer service[1] Year moderate/high		
SYSTEM	2000	2010	2020
Jackson Municipal Water Works	0.6/0.6	0.6/1.8	0.6/2
Hazard Water System	7/12	17/25	17/26
Vicco Water Works	60/67	70/81	70/83
Hindman Municipal Water Works	15/22	40/53	40/59
Whitesburg Municipal Water	99/105	152/164	154/168
Fleming-Neon Water Company	45/52	70/82	70/84
REGION TOTAL	23/27	38/45	38/47

[1] As a percentage of 1994 service level.

Table 14. Projected percent change in residential service by water system.

Water supplies for Jackson Municipal Water Works and Hindman Municipal Water Works were considered adequate for current and future needs. Water supplies for the Fleming-Neon Water System were considered adequate for current needs. The system may not be able to meet peak demands during a drought by the year 2000, however, and by the year 2010 may not meet average demands during a drought.

Water supplies for the Hazard Water Department and Whitesburg Municipal Water were considered inadequate for current and future needs. Both systems were looking to flooded deep mines in the area for additional water.

Unaccounted-for water losses (difference between water withdrawn and water sold) were highest for those systems most susceptible to drought (Table 15).

Water Supplier	Percent Unaccounted-for Water
Whitesburg Municipal Water	26
Fleming-Neon Water Company	23
Hindman Municipal Water Works	7.6
Hazard Water Department	37
Vicco Water System	45
Jackson Municipal Water Works	12

Table 15. Percent unaccounted-for water.

A detailed evaluation of each system is given below.

BREATHITT COUNTY

The estimated population of Breathitt County in 1994 was 15,400. 4,200 residents (27%) were provided water by the Jackson Municipal Water Works, and 11,200 depended on small systems or private supplies for their water.

The historical and projected population of Breathitt County (Ref. 1) is:

Year	Moderate Growth Rate	High Growth Rate
1980	17,004	17,004
1990	15,703	15,703
1995	15,776	15,438
2000	15,756	15,654
2010	15,638	15,926
2020	15,333	15,911

The moderate growth projection indicates a decline in population of 2.4 percent from 1990-2020, while the high growth projection indicates an 1.3 percent increase over the same period.

Jackson Municipal Water Works

Area Served

The Jackson Municipal Water Works serves the City of Jackson and several areas outside of the city. The existing service area is shown in Figure 6. Jackson withdraws water from the North Fork Kentucky River at mile point 305.45, about 49.4 miles upstream of Beattyville's water intake. Figure 7 shows permitted municipal water withdrawal points throughout the Kentucky River basin.

Available Water During Normal Conditions

Water withdrawal permitting program criteria allow up to 10 percent of available water under normal conditions to be withdrawn. "Available" water under normal conditions is defined as 10 percent of the average flow during the month of lowest average monthly flow, typically September or October.

The average flow of the North Fork of the Kentucky River during the month of lowest flow at USGS Gage 03280000, located at the Jackson intake, is 131 million gallons per day (mgd), in October. Ten percent of this value is 13.1 mgd.

Available Water During Low-Flow Conditions

A zero flow condition occurred at the intake point for one day during the drought of 1930. Normal releases of water at Carr Fork Reservoir should eliminate the possibility of a recurrence of that situation.

Water withdrawal regulations, and most withdrawal permits, state that withdrawals must be reduced when flows approach the 7-day, 10-year (7Q10) low flow level to protect aquatic life. When 7Q10 flows are experienced for four consecutive days, withdrawals must cease. This minimum stream flow requirement can be waived by the regulatory authority in the case of a governor's declaration of a "water emergency" as occurred in 1988.

Low stream flows at the Jackson gage (and intake) have been estimated to be:

- 7Q10 5.1 mgd
- 7Q20 4.1 mgd

These estimates have been adjusted to include the effects of the minimum discharge from Carr Fork Reservoir of 3.2 mgd.

Flow Duration

Flow duration data for the USGS station at Jackson is summarized in Table 16 (Ref. 7).

Duration[2] (%)	Discharge, mgd[1]	
	Unregulated[3] 1926-31, 1939-75	Regulated[4] 1977-90
100.0	0.00	16.8
99.5	1.84	26.0
99.0	3.78	30.2
98.0	6.79	37.0

[1] From USGS unpublished data.
[2] The percentage of time during the period of record that flow equalled or exceeded the listed value.
[3] Before Carr Fork Reservoir constructed.
[4] After Carr Fork Reservoir constructed.

Table 16. Flow duration data, North Fork of the Kentucky River at Jackson

It should be noted that the most significant droughts occurred in 1930 and 1953 and that the significance of Carr Fork during such droughts is not known.

<u>Historical Water Use</u>

Average daily usage for 1985-89 was 618,000 gallons, with a modestly increasing rate over the period. The Jackson system withdrew an average of 627,900 gpd of water from the North Fork of the Kentucky River in 1990. 1990-92 water use for the Jackson system is shown in Table 17.

<u>Projected Water Use</u>

Residential Water Use Forecast

The City of Jackson had a line extension project that would serve 454 customers along KY 15, KY 205, KY 30, and KY 52. Other possible line extensions were to the Haginsville and South Fork areas. Those extensions would be along KY 30 and RT 1098 and would pick up approximately 150 customers.

	Gallons Per Day[1]		Customers [1]	
Type of User	1990	1992	1990	1992
Residential	406,950	338,300	1,533	1,651
Commercial	120,500	100,000	220	242
Institutional	21,800	18,300	20	20
Industrial	0	200	0	1
Public	650	500	1	1
Subtotal[2]	549,900	457,300		
Unaccounted	78,000	64,700		
Total[3]	627,900	522,000	1,773	1,914

[1] From Jackson Municipal Water Works, data prior to 1990 was unobtainable.
[2] Water sold.
[3] Water withdrawn.

Table 17. Historical water use, Jackson Municipal Water Works

If the population declines or grows only slightly, future increases in water use will primarily come from expansion of the service area to serve more existing homes in rural areas of the county. The residential service forecast is shown in Table 18.

	Projected Number of Residential Customers[1] Year moderate/high		
	2000	2010	2020
Existing Service Area	1,650/1,650	1,650/1,670	1,650/1,670
KY15, KY205, KY30, KY52	430	454	454
Haginsville and South Fork Areas	0	150	150
Total Residential Customers	2,080/2,080	2,254/2,274	2,254/2,274
Projected Residential Service[2]	5320/5320	5,770/5,820	5,770/5,820

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period
[2] Based on the number of customers and on 2.56 persons per household in Breathitt County from the 1990 census.

Table 18. Residential service forecast, Jackson Municipal Water Works

Commercial Water Use Forecast

Changes in commercial activity are generally expected to be in direct proportion to population change. Since the population of Breathitt County is not expected to change during the planning period, commercial activity and water use in the county are not expected to increase. Because almost all of the current commercial activity is now served by the Jackson Municipal Water Works, the commercial water use is not expected to change during the planning period.

Institutional Water Use Forecast

The institutional water use is expected to remain constant during the planning period (1990 - 2010) for the same reasons that the commercial use is expected to do so.

Industrial Water Use Forecast

Breathitt County currently has one industry, Appalachian Regional Manufacturing, that has 10 employees and used 210 gpd of water in 1992. The plant is expecting to expand to 200 employees. The water use is projected to increase to 4,200 gpd.

It is expected that relatively light industry, requiring only moderate amounts of process water, would locate in Breathitt County. This type of activity might include fabrication, metal processing, painting, and assembly. Typical water use for this type of industry is 1,000 to 1,500 gallons per acre per day. An allowance of about 10 percent of other projected year 2010 water uses (74,500 gpd) was made to allow for industrial expansion, representing the development and occupancy of a 50-acre industrial park during the planning period.

Combined Water Use Forecast

The combined water use forecast is shown in Table 19. The annual average water withdrawal of Jackson Municipal Water Works is projected to increase from 627,900 gpd in 1990 to 935,600 - 942,600 gpd in 2020 primarily due to extension of water lines.

The actual peak average monthly withdrawal for the Jackson system has been about 1.3 times the average annual withdrawal. A peak daily withdrawal of 1.5 times annual average withdrawal was used for estimating peak demands during drought conditions.

The peak daily water withdrawal was estimated to increase from .942 mgd in 1990 to about 1.41 mgd in 2020.

<u>Competing Uses</u>

Only about 10 to 15 acres of cropland are irrigated in Breathitt County. At a typical irrigation rate of 120,000 gallons per acre per month, irrigation use is about 0.06 mgd. Therefore agriculture is not a significant competing use.

Consolidation Coal Company of Kentucky withdraws water from two wells along Spring Fork of Quicksand Creek in the extreme eastern part of the county.

There are no other known competing uses that could impact water availability.

	Average Water Use gpd	Projected Water Use, gpd Year moderate/high		
	1990	2000	2010	2020
Residential[1]	406,950	551,700/551,700	598,300/603,500	598,300/603,500
Commercial	120,500	120,500	120,500	120,500
Institutional	21,800	21,800	21,800	21,800
Industrial	0			
Existing		4,200	4,200	4,200
Allowance for future		74,500	74,500	74,500
Public[2]	650	890	960	1,000
Subtotal - Water Sold	549,900	773,600/773,600	820,300/825,500	820,300/825,500
Unaccounted[3]	78,000	109,700/109,700	116,400/117,100	116,400/117,100
Total - Water Withdrawn	627,900	883,300/883,300	936,700/942,600	936,700/942,600
Peak Daily Demand[4], gpd	941,800	1,325,000/1,325,000	1,405,000/1,414,000	1,405,000/1,414,000

[1] Based on the 1990 per capita water use of about 104 gallons per person per day and the population projections in Table 18.
[2] Fire protection and other public water use is estimated to increase in proportion to the number of customers.
[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1990.
[4]Peak daily demand equals 1.5 times average annual demand.

Table 19. Combined water use forecast, Jackson Municipal Water Works

Infrastructure Assessment

Existing Treatment and Total Distribution System Capacity

The Jackson water treatment plant, constructed in 1981, has a design capacity of 1,500,000 gpd. The operator reports that it is capable of producing 1,500,000 gpd of "good" finished water.

The Jackson water distribution system has an estimated capacity of 600,000 gpd. This estimate is based on the existing storage tank capacity (excluding clearwell storage) of 600,000 gallons and a criteria of one-day minimum allowable storage. It is believed that this is a good indication of the design capacity of the overall distribution system.

Intake Limitations

The existing intake is located on the North Fork of the Kentucky River at Jackson (river mile 305). The intake is in a deep pool of the river. This configuration does not present any limitations.

System Losses

The total unaccounted water is 12 percent of water withdrawn (Ref. 5,14). This rate of loss is not excessive.

Water Quality

The water quality was reported by water plant staff to be generally good although occasional high turbidity or extremely clear water is difficult to treat. Division of Water data shows no significant violations for the Jackson Municipal Water Works for the period 1/90-10/95.

Potential sources of contamination are listed in Tables 20-22 (Ref. 22) and shown in Figure 7. There are no permitted solid waste landfills in the county. These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

NAME	PERMIT
MT CARMEL HIGH SCHOOL	2325
ROUSSEAU ELEMENTARY SCHOOL	1713
CONSOLIDATED COAL/SKYLINE PLANT	504
ASHLAND BRANDED MARKETING 026-000	634
HIGHLAND TURNER ELEMENTARY SCHOOL	2488
ROBERTS MARIE ELEMENTARY SCHOOL	1272
JACKSON STP	1679

Table 20. Potential sources of pollution, effluent discharge sites, Breathitt County.

NAME	PERMIT
KOSMOS CEMENT CO	2293
PRESTOLITE WIRE DIVISION	623
ORION LIFT SERVICES	2059
D & H WOODWORKING	2390
ASHLAND BRANDED MARKETING 349-010	2723
MONTGOMERY REALTY	2016
US DOE/SRC 1 DEMO PLANT	3436
ASHLAND BRANDED MARKETING 579-006	2724
CARBIDE PRODUCTS	2281
TURNER ELMER DBA BREATHITT COUNTY	633
HARROD CLEANERS	3348
AAMCO TRANSMISSION	1500

Table 21. Potential sources of pollution, hazardous waste handlers, Breathitt County.

NAME	PERMIT
CONSOLIDATION COAL COMPANY	896
JACKSON MUNICIPAL WATER WORKS	163

Table 22. Potential sources of pollution, permitted water withdrawers, Breathitt County

Water Supply Adequacy

Based on the 7Q10, 7Q20, and historical flow duration information, it is concluded that the quantity of water available at the Jackson supply is adequate for projected needs and that

7Q10 flows will not be significantly impacted. The nearest public water user intake downstream of Jackson is Beattyville Water Works which has a relatively large quantity supply. The Jackson water system withdrawal is not expected to have any significant downstream impacts due to the small percentage of the flow being withdrawn.

Recommendations

Estimated Costs

Proposed project costs are shown in Table 23 (Ref. 16).

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
South Fork	Water line extensions along KY 1111 and KY 1098. Project area includes the communities of Portsmith, Press, and Wilstacy	$1,070,000/ 110	$10,000	2
Quicksand Creek	Water line extension along KY 30 and Quicksand Creek, includes the community of Noctor	$500,000/ 56	$9,000	1
Total Project Cost Estimates		$1,570,000		

Table 23. Project cost estimates, Jackson Municipal Water Works

Cost of Full Service

About 11,200 people are currently not served by public water in Breathitt County. Cost estimates for providing full public water service in the county were developed. It was assumed that water service would be provided along every road in the county (as shown on Kentucky Department of Transportation county highway maps). A line extension cost of $10 per foot was used. This unit cost included auxiliary costs: storage tanks, pump stations, land and rights-of-way, etc. It was assumed that 95 percent of the currently unserved population would be served by the new lines, and that usage would be 100 gpd per person. The costs for additional treatment facilities were calculated as $2.50 per gpd for the total new usage. Legal, administrative, engineering, and contingency costs were estimated at 25 percent of construction costs. Costs per customer were based on 2.56 people per household (Ref. 1).

The total estimated cost for providing full public water service to the county is about $31,000,000. An additional 10,600 people, or 4,000 households, in the county would be provided with 1.06 mgd of public water by 420 miles of new water lines. The average cost per household for the region would be about $7,700. Within the county, however, some areas will be more cheaply served than others. A prioritization of line extensions based on serving low-cost areas first was beyond the scope of this project. The addition of 1.06 mgd water usage from the North Fork of the Kentucky River at Jackson would move the system into drought susceptibility class B, and a supplemental source would need to be developed.

Private Water Supplies

Population Served

About 73 percent of the county, or 4,375 households, were served by small systems or private supplies in 1994.

Types of Private Supplies

Based on private water supply usage in 1990 (Ref. 1), it is estimated that about 3,100 (71 percent) of the private supplies were drilled wells, 1,000 (23 percent) were dug wells, and 275 households (6 percent) were served by cisterns, hauled water, and other sources.

Well Contamination

62 percent of the wells tested during 1991-92 were contaminated by fecal coliform. Of those tested during 1994-95, 72 percent were contaminated (Ref. 23).

Ground Water Quality and Quantity

The majority of ground water in eastern Kentucky is obtained from shallow bedrock wells (less than 100 feet deep) and from shallow dug wells in alluvium. Most of the ground water obtained from bedrock wells is from sandstone aquifers, but in many cases water is contributed from various bedrock types including coal seams. The clays and shales that underlie coal are relatively impermeable and inhibit the vertical movement of water. Therefore, the ground water flows horizontally through the coal seams and other highly conductive layers. Maximum ground water yields are usually derived from wells located in valley bottoms.

The Breathitt and Lee formations provide ground water to wells near Jackson.

In the Breathitt formation, most wells drilled in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gallons per day [gpd]). Nearly all wells drilled in valleys and more than three-quarters of the wells drilled on hillsides are adequate for a minimum domestic supply (more than 100 gpd). Wells drilled on hilltops and ridges yield smaller quantities of water. Most wells dug in valleys and about half of the wells dug on hills are adequate for a minimum domestic supply. A few wells dug in valleys and on hills are adequate for a modern domestic supply. Within a 4 mile radius of Jackson, three dug wells have been reported with depths ranging from 9 to 31 feet below the ground surface. One of the dug wells produced 6 gallons per minute (8,640 gpd). Ground water obtained from most drilled wells in this area is extremely hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms.

In the Lee formation, most wells drilled in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gpd). Nearly all wells drilled in valley bottoms and on hillsides are adequate for a minimum domestic supply (more than 100 gpd). Fewer than three-quarters of the wells drilled on hilltops and ridges are adequate for a minimum domestic supply. About a third of the wells on hilltops and ridges are adequate for a modern domestic supply. Deep wells penetrating the entire thickness of the Lee formation where it exceeds 500 feet in thickness may yield enough water for small municipal or industrial supplies. Within a 4 mile radius of Jackson, six drilled wells have been reported with depths ranging from 39 to 114 feet below the ground surface. One of the drilled wells produced 20 gallons per minute (28,800 gpd). Ground water obtained from most wells in this area is moderately hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms. Nearly all wells tapping the Lee formation yield salty water where the Lee lies beneath the Breathitt formation and below the principal drainage.

Ground water may be obtained in the alluvium of the North Fork. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. A few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

Overall, wells in Breathitt County do not have the potential to provide significant municipal supplies.

PERRY COUNTY

The estimated population of Perry County in 1994 was 31,140. About 10,740 residents were provided water by the Hazard Water Department and 1,910 residents by the Vicco Water System. The remaining 18,490 residents (59%) depended on small systems or private supplies for their water.

The historical and projected population of Perry County (Ref. 1) is:

Year	Moderate Growth Rate	High Growth Rate
1980	33,763	33,763
1990	30,283	30,283
1995	30,123	31,359
2000	29,796	32,414
2010	29,170	33,623
2020	28,233	33,998

The moderate growth projection indicates a decline in population of 6.8 percent from 1990-2020, while the high growth projection indicates a 12.3 percent increase over the same period.

Hazard Water Department - Vicco Water Works

Hazard withdraws for the North Fork at milepoint 361.23, 56 miles upstream from Jackson's intake (Figure 7). The existing service area is shown in Figure 8. Hazard is the only city upstream of Richmond with water withdrawals exceeding 1 mgd (Ref. 18).

<u>Available Water During Normal Conditions</u>

Water withdrawal permitting program criteria allow up to 10 percent of available water under normal conditions to be withdrawn. "Available" water under normal conditions is defined as 10 percent of the average flow during the month of lowest average monthly flow, September.

A USGS stream gage is located on the North Fork of the Kentucky River at the Hazard water treatment plant (Gage #0327750). The discharge of the North Fork of the Kentucky River at Hazard, under normal September conditions, has been estimated by the US Geological Survey (USGS) to be 58 mgd. Ten percent of this value is 5.8 mgd.

<u>Available Water During Low-Flow Conditions</u>

Water withdrawal regulations (and most withdrawal permits) state that withdrawals must be reduced when flows approach the 7-day, 10-year (7Q10) low flow level to protect aquatic life. When 7Q10 flows are experienced for four consecutive days, withdrawals must cease. This minimum stream flow requirement can be waived by the regulatory authority in the case of a governor's declaration of a "water emergency" as occurred in 1988.

Low stream flows at the Hazard gage and intake have been estimated to be:

- 7Q10 4.4 mgd
- 7Q20 4.0 mgd

The Hazard intake is downstream of Carr Fork Reservoir, so the stream flow is regulated by the minimum discharge of 3.2 mgd from this impoundment. The DOW permit has a maximum withdrawal limit of 2.75 mgd, and if the North Fork flow falls to 5 mgd or less, Hazard water withdrawals would have to be reduced or even halted.

Flow Duration

Flow duration data for the USGS station at Hazard is summarized in Table 24.

USGS historical flow duration information for the Hazard gage indicates that the flow has exceeded 6.46 mgd 100 percent of the time during the period of regulation by Carr Fork Reservoir (1977 - 1990).

	Discharge, mgd[1]	
Duration[2] **(%)**	**Regulated**[3] **1977 - 1990**	**Historical**[4] **1941 - 1990**
100.0	6.46	0.65
99.5	10.8	1.94
99.0	12.6	2.97
98.0	15.8	4.65

[1] From USGS unpublished data.
[2] The percentage of time during the period of record that flow equalled or exceeded the listed value.
[3] After Carr Fork Reservoir constructed.
[4] Entire period of record.

Table 24. Flow duration data, North Fork of the Kentucky River at Hazard

Historical Water Use

Average daily withdrawals for 1985-89 were 1.82 million gallons, with no clear trend of increase or decrease (Ref. 18).

The Hazard Water System withdrew about 2.045 mgd from the North Fork of the Kentucky River in 1990. Vicco purchased about 195,600 gpd from Hazard in 1990.

1990-94 water use for the Vicco system is shown in Table 25.

	Gallons Per Day			Customers		
Type of User	1990	1992	1994[4]	1990	1992	1994[5]
Residential	72,400	69,600	76,100	651	702	725
Commercial	10,200	11,700	10,500	53	45	47
Institutional	3,900	4,400	4,500	3	3	3
Industrial	0	0	0	0	0	0
Public[1]	24,500	26,400	27,300	--	--	--
Subtotal[2]	111,000	112,100	118,400			
Unaccounted	84,600	105,400	106,600			
Total [3]	195,600	217,500	225,000	707	750	775

[1] Fire Protecton
[2] Water sold
[3] Water withdrawn.
[4] Estimated values except for Total.
[5] Estimated values except for Residential.

Table 25. Historical water use, Vicco Water Works.

Hazard Water System

1986-94 water use for the Hazard system is shown in Table 26.

	Gallons Per Day[1]			Customers		
Type of User	1986	1990	1994[5]	1986	1990	1994[6]
Residential	977,100	1,002,500	1,396,100	2,987	3,617	4,112
Commercial	177,400	184,000	189,100	531	644	662
Institutional	9,600	11,500	11,500	20	25	25
Industrial	0	0	0	0	0	0
Public[2]	1,400	1,700	1,700	7	9	9
Wholesale	185,000	195,600	225,000	1	1	1
Subtotal[3]	1,350,000	1,395,300	1,823,400			
Unaccounted	584,000	649,700	1,066,600			
Total [4]	1,934,500	2,045,000	2,890,000	3,546	4,296	4,800

[1] From City of Hazard
[2] Fire Protecton
[3] Water sold
[4] Water withdrawn, as reported to the Kentucky Division of Water
[5] Estimated values except for Total.
[6] Estimated .

Table 26. Historical water use, Hazard Water System.

Projected Water Use

Residential Water Use Forecast

If the population declines, future increases in water use will primarily come from expansion of the service area to serve more existing homes in rural areas of the county. With the projected high growth rate, future increases in water use would occur through system expansion and through population growth.

Vicco Water System

The Vicco Water System has several water line extension projects in various stages of planning and construction. Extensions in the Viper, Kodak, and Sassafras (Knott County) areas would potentially serve 450 homes. Potential extensions included 50 homes in the Newsite Station and Cornettsville communities, and about 10 potential customers in the Fourseam area.

The residential service forecast is shown in Table 27.

	Projected Number of Residential Customers[1] Year moderate/high		
	2000	2010	2020
Existing Service Area	722/770	722/800	722/810
Viper, Kodak, Sassafras Areas	390	450	450/455
Newsite Station and Cornettsville	40	50	50
Fourseam Area	10	10	10
Total Residential Customers	1,162/1,210	1,232/1,310	1,232/1,325
Projected Residential Service[2]	3,040/3,170	3,230/3,430	3,230/3,470

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period

[2] Based on the number of customers and on 2.62 persons per household in Perry County from the 1990 census.

Table 27. Residential service forecast, Vicco Water Works

Hazard Water System

Hazard Water System has several water line extension projects in various stages of planning and construction. An extension project serving the Chavies/Airport area in northern Perry County will ultimately serve 500 customers along the route. Extensions would serve 704 customers in the Town Mountain/Big Creek area west of Hazard. An extension to 470 potential customers in the Lotts Creek area east of Hazard is planned. This project would serve 200 customers in Knott County. Extension of service to about 100 potential customers in the Second Creek area east of Hazard is being considered. Lines along KY 451 from Busy to Chavies were deleted from the Chavies/Airport project, but may be included in a later project. This extension could serve 350 potential customers. An extension project to 145 homes, Buckhorn Childrens Center, and Buckhorn State Park is in the early planning stages.

The residential service forecast is in Table 28.

	Projected Number of Residential Customers[1] Year moderate/high		
	2000	2010	2020
Existing Service Area	3,617/3,870	3,617/4,010	3,617/4,050
Chavies/Airport	460	500	505
Town Mountain/Big Creek	660	704	710
Second Creek	85	100	100
KY451 (Busy to Chavies)	0	350	355
Buckhorn Lake	125	145	145
Lotts Creek	435	470	475
Total Residential Customers	5,382/5,635	5,886/6,279	5,907/6,340
Projected Residential Service[2]	14,100/14,760	15,420/16,450	15,480/16,610

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period

[2] Based on the number of customers and on 2.62 persons per household in Perry County from the 1990 census.

Table 28. Residential service forecast, Hazard Water System.

Commercial Water Use Forecast

Changes in commercial activity are generally expected to be in direct proportion to population change.

Institutional Water Use Forecast

With the exception of the potential connection of Buckhorn Childrens Center to the Hazard Water System, the institutional water use of the Vicco and Hazard systems is expected to grow in proportion to population. The Buckhorn Childrens Center is expected to use about 7,000 gpd.

Industrial Water Use Forecast

Perry County does not have any industry at this time. However, an allowance of about 7 percent of other projected year 2010 water uses (150,000 gpd) was made for the Hazard System to accomodate industrial development. It is generally expected that such development would be relatively light industry, requiring only moderate amounts of process water. This type of activity might include fabrication, metal processing, painting, and assembly. Typical design values for estimating water use from this type of industry are 1,000 to 1,500 gallons per acre per day. At a water use of 1,500 gallons per acre per day this industrial allowance represents the development and occupancy of a 100 acre industrial park during the planning period.

The primary potential for industrial development in Perry County is expected to be in Hazard. No industrial allowance was made for Vicco.

Combined Water Use Forecast

The combined water use forecast for the Vicco Water and Hazard Water Systems are shown in Tables 29 and 30.

The actual peak average monthly withdrawal for the Hazard and Vicco systems has been about 1.1 times the average annual withdrawal. A peak daily withdrawal of 1.4 times annual average withdrawal was used for estimating peak demands during drought conditions.

The peak daily water withdrawal for the Hazard system is estimated to increase from 4.1 mgd in 1990 to 5.2 - 5.6 mgd in 2020.

	Average Water Use gpd	Projected Water Use, gpd Year moderate/high		
	1994	2000	2010	2020
Residential[1]	72,400	130,700/136,300	138,900/147,500	138,900/149,200
Commercial	10,200	10,200/10,600	10,200/11,000	10,200/11,100
Institutional	3,900	3,900/4,100	3,900/4,200	3,900/4,200
Industrial	0	0	0	0
Public[2]	24,500	43,700/45,600	46,300/49,200	46,300/49,800
Subtotal - Water Sold	111,000	188,500/196,600	199,300/211,900	199,300/214,300
Unaccounted[3]	84,600	143,700/149,800	151,900/161,500	151,900/163,300
Total - Water Withdrawn	195,600	332,000/346,000	351,000/373,000	351,000/378,000
Peak Daily Demand[4], gpd	273,800	465,000/484,000	491,000/522,000	491,000/529,000

[1] Based on the 1990 per capita water use of about 43 gallons per person per day and the population projections in Table 27.
[2] Fire protection and other public water use is estimated to increase in proportion to the number of customers.
[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1990.
[4]Peak daily demand equals 1.4 times average annual demand.

Table 29. Combined water use forecast, Vicco Water Works.

<u>Competing Uses</u>

Agricultural use in Perry County was estimated to be negligible. Therefore, agriculture is not a significant competing use.

There are 16 permitted stream withdrawals at coal mining operations in Perry County, 11 in the watershed of the Hazard intake. These are listed in Table 31 (Ref. 18), with geographic location shown in Figure 9. The combined permitted water withdrawal of the 11 facilities upstream is 2.82 mgd. Coal mining could be a significant competing use for the Hazard intake.

	Average Water Use gpd	Projected Water Use, gpd Year moderate/high		
	1994	2000	2010	2020
Residential[1]	1,396,100	1,495,000/1,565,000	1,635,000/1,744,000	1,641,000/1,761,000
Commercial	.189,100	190,000/202,000	190,000/225,000	190,000/227,000
Institutional	11,500	19,000/20,000	19,000/22,000	19,000/23,000
Industrial	0	75,000	150,000	150,000
Public[2]	1,700	2,000/2,100	3,000/3,200	3,000/3,200
Sales for Resale	225,000	332,000/346,000	351,000/373,000	351,000/378,000
Subtotal - Water Sold	1,823,400	2,113,000/2,210,000	2,345,000/2,517,000	2,354,000/2,542,000
Unaccounted[3]	1,066,600	1,236,000/1,293,000	1,372,000/1,472,000	1,377,000/1,487,000
Total - Water Withdrawn	2,890,000	3,349,000/3,503,000	3,717,000/3,989,000	3,731,000/4,029,000
Peak Daily Demand[4], gpd	4,046,000	4,689,000/4,904,000	5,204,000/5,585,000	5,223,000/5,641,000

[1] Based on the 1990 per capita water use of about 106 gallons per person per day and the population projections in Table 28.
[2] Fire protection and other public water use is estimated to increase in proportion to the number of customers.
[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1990.
[4]Peak daily demand equals 1.4 times average annual demand.

Table 30. Combined water use forecast, Hazard Water System.

Infrastructure

Existing Treatment and Total Distribution System Capacity

Vicco Water System

The Vicco water distribution system has an estimated capacity of 450,000 gpd. This estimate is based on the existing storage tank capacity of 450,000 gallons and a criteria of one-day minimum allowable storage. It is believed that this is a good indication of the design capacity of the overall distribution system.

Hazard Water System

The Hazard water treatment plant, constructed in 1968 and expanded in 1990, has a design capacity of 4,000,000 gpd, but the continuous duty of pumps and other treatment units can only supply an average of about 2,500,000 gpd of "good" finished water. Recent plant improvements are expected to allow the plant to produce 4,000,000 gpd of finished water.

The Hazard water distribution system has an estimated capacity of 6,035,000 gpd. This estimate is based on the existing storage tank capacity of 6,035,000 gallons and a criteria of one-day minimum allowable storage. It is believed that this is a good indication of the design capacity of the overall distribution system.

NAME	SOURCE	PERMITTED WITHDRAWAL mgd	AVERAGE WITHDRAWAL mgd	PERMIT
BENCO MINING INC.	POND ADJACENT TO TRIB. OF FIRST CREEK	0.16	0.00	1318
BLUE DIAMOND COAL COMPANY[1]	MINE WORKS NEAR CLOVER FORK MILE 2.5R	0.19	0.01	262
BLUE DIAMOND COAL COMPANY[1]	UNDERGROUND MINE	0.19	0.02	799
BLUE DIAMOND COAL COMPANY[1]	RM 6.7 LEATHERWOOD CR	0.30	0.10	1056
BLUE DIAMOND COAL COMPANY[1]	DEEP MINE NEAR TRIB OF BLAIR FK	0.23	0.01	1072
BLUE DIAMOND COAL COMPANY[1]	IMPOUNDMENT OF BEAR BR OF N FORK KENTUCKY	0.06	0.006	1111
BUCKHORN PROCESSING COMPANY	IMPOUNDMENT OF HARRIS BRANCH OF LOST CREEK	0.42	0.14	898
COCKRELL'S FORK MINING COMPANY	RM 3.05 OF FIRST CREEK	0.03	0.00	1097
LEECO INC.[1]	POND #993 AT RM 0.035 OF BUCKEYE CREEK	0.14	0.08	999
LEECO INC.[1]	IMPOUNDMENT AT RM 0.7 OF BUCKEYE CREEK	0.29	0.26	1089
LEECO INC.[1]	RM 0.2 OF CARR FORK OF N FORK KENTUCKY RIVER	0.06	0.00	1334
WHITAKER COAL COMPANY[1]	IMPOUNDMENT, RM 2.3 OF BUFFALO CREEK	0.93	0.74	1227
WHITAKER COAL COMPANY[1]	IMPOUNDMENT #8, BETWEEN DAVIDSON BR AND BUFFALO CREEK	0.26	0.71	1091
WHITAKER COAL COMPANY[1]	IMPOUNDMENT #1, HW OF TRIB OF MESSER BRANCH	0.16	0.32	1133

[1] In the Hazard watershed

Table 31. Non-municipal water withdrawers, Perry County

Intake Limitations

The existing Hazard intake is located on the North Fork of the Kentucky River at Hazard. The intake is located just upstream of a small water retention structure and near the bottom of the river. This configuration allows withdrawal from the river over a wide range of river flow and does not present any limitations.

System Losses

The total unaccounted water for the Hazard system is about 37 percent of water withdrawn (Ref 6,11). Leak losses are probably about 22 percent to 27 percent. This rate of leak loss is rather high compared to an acceptable value of 15 percent. The total unaccounted water for the Vicco system is about 45 percent of the total water received from Hazard. This rate of loss is extremely high compared to an acceptable value of 15 percent.

Water Quality

The Hazard source water quality was reported by water plant staff to be good. Occasional high turbidity due to increased flows during periods of wet weather requires the increased addition of chemicals to treat the water. The most difficult treatment conditions occur following periods of high water or during extremely muddy water conditions. Even though Carr Fork is not operated for water supply, the low-flow releases in drought periods seems to result in river flows at Hazard that are greater than they would otherwise be.

System violations for the Hazard Water Department and Vicco Water Supply, as reported by the Kentucky Division of Water for the period 1990-October, 1995, are shown in Tables 32 and 33 (Ref. 20). M/R are monitoring and reporting (administrative) violations.

Violation Date	Violation Type	Contaminant
September, 1990	Regular Sampling	Bacteria
January, 1991	SWTR Turbidity	Turbidity
February, 1991	SWTR Turbidity	Turbidity
July, 1992	Initial Pb/Cu Tap M/R	Pb/Cu
October, 1992	Minor M/R	Bacteria
January, 1993	Initial Pb/Cu Tap M/R	Pb/Cu
January, 1994	SWTR Turbidity	Turbidity
April, 1994	Regular Sampling	Nitrates
October, 1995	Minor M/R	Bacteria

Table 32. Public water systems violations, Hazard Water Department.

Violation Date	Violation Type	Contaminant
November, 1991	Regular Sampling	Bacteria
October, 1992	Minor M/R	Bacteria
May, 1993	Minor M/R	Bacteria
July, 1993	Minor M/R	Bacteria
July, 1993	Initial Pb/Cu Tap M/R	Pb/Cu
January, 1994	Initial Pb/Cu Tap M/R	Pb/Cu
November, 1994	Minor M/R	Bacteria
May, 1995	Minor M/R	Bacteria
August, 1995	Minor M/R	Bacteria
September, 1995	Minor M/R	Bacteria
October, 1995	Minor M/R	Bacteria

Table 33. Public water systems violations, Vicco Water Supply.

Potential sources of contamination in the county are given in Tables 34-37, with geographic locations shown in Figures 10, 11A, and 11B. These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

NAME	PERMIT
BUCKHORN PROCESSING	898
BENCO MINING	1318
COCKRELL'S FORK MINING	1097
BUCKHORN LAKE STATE PARK	276
HAZARD WATER DEPARTMENT	26
LEECO	1089
WHITAKER COAL	1133
WHITAKER COAL	1091
LEECO	999
LEECO	1334
WHITAKER COAL	1227
BLUE DIAMOND COAL	1111
BLUE DIAMOND COAL	1056
BLUE DIAMOND COAL	262
BLUE DIAMOND COAL	1072
BLUE DIAMOND COAL	799

Table 34. Potential sources of pollution, permitted water withdrawers, Perry County.

NAME	PERMIT
PERRY COUNTY RECYCLING	277
PERRY COUNTY LANDFILL	276

Table 35. Potential sources of pollution, solid waste landfills, Perry County.

NAME	PERMIT
GOODYEAR AUTO SERVICE CENTER	2149
VISTA PERFORMANCE POLYMERS	1613
CONVENIENT FOOD MART #202	1918
AAMCO TRANSMISSIONS	1610
NATIONAL WOOD PROD	2286
HAZARD STATE VO-TECH SCHOOL	1034
SHERWIN WILLIAMS CO	955
MUNICIPAL EQUIPMENT INC	2911
MODERN LAUNDRY COMPANY	1752
UNION WIRE ROPE	1826
AUDUBON GULF SERV CTR	3094
KENTUCKY POWER CO/HAZARD DIV	853
CUMMINS CUMBERLAND INC	793
CHEVRON USA INC HAZARD PLANT	43
A&T MANUFACTURING CO INC	2
WOODBRIDGE INOAC INC	2068

Table 36. Potential sources of pollution, hazardous waste handlers, Perry County.

NAME	PERMIT
KEM COAL CO	509
ROBINSON ELEM SCH	969
CHAVIES ELEM SCH	1121
RONS MHP	1120
PERRY COUNTY LANDFILL	2769
LOST CREEK ELEM SCH	1168
COMBS TRAILER PARK	2333
CHAVIES CTR APPALACHIA SRV PRO	1122
BAR WAT PARK	2602
PINE BRANCH COAL SALES	203
BUCKHORN ELEM & HIGH SCH	1049
DWARF CHURCH OF GOD	1177
LOST MOUNTAIN MINING INC	464
BUCKHORN PROCESSING/#4 PREP PLANT	276
BUCKHORN PROCESSING/#4 PREP PLANT	277
KAT-A-PULT INC	2534
GRAPEVINE PLACE APTS	2356
NEACE RESIDENCE	1028
AAA MINE SERVICE INC	488
FUGATES WATER PK	1030
BENCO MINING INC	942
ASHLAND BULK PLT 296	1305
BUCKHORN CHILDREN CTR	1048
MONGIARDO RESIDENCE	1911
BUCKHORN PROCESSING/JAKES FORK TIPPLE	378
KY DOP BUCKHORN LAKE ST PK	2109
KY DOP BUCKHORN LK ST PK	2081
MIDDLE RIDGE SUBD	1029
FELTNERS TRAILER COURT	1638
CAMPBELL DAIRY BAR	2491
HAZARD STP	84
ACECO INC	508
MOUNTAIN ENTERPRISES	597
WILLARD ELEM SCH	2461
COUCH APARTMENTS	1135
P & C RADIATOR	2546
CSX TRANSPORTATION HAZARD	1306
HAZARD WTP	1304
WHITAKER COAL/PREP PLANT #1	262
BIG CREEK ELEM SCH	983
LEECO INC	580
B B S & D DEVELOPMENT CORP	1370
KY/WEST VIRGINIA GAS/JEFF	1368
KY/WEST VIRGINIA GAS/JEFF	1367
VICCO STP	1821
GOLDEN OAK MINING/KODAK UNIT TRAIN FAC	24
ADAMS APTS	1371
DILCE COMBS HIGH SCH	1369
COMBS R W ELEM SCH	1276
VIPER ELEM SCH	1823
LEATHERWOOD BLACKEY HEALTH CTR	2323
BLUE DIAMOND COAL/BEECH FORK PLANT	557
LEATHERWOOD ELEM SCH	1750

Table 37. Potential sources of pollution, permitted effluent discharge sites, Perry County.

Water Supply Adequacy

The quantity of water available at the Hazard supply is not adequate for current or projected needs (drought classification C). It is also concluded that stream withdrawals at coal mining operations in the watershed could be significant competing uses and may result in conflicts with water use by the Hazard Water System.

The Hazard water system and competing withdrawals are not expected to impact downstream use at Jackson on the North Fork. However, the Division of Water generally considers it necessary to protect stream flows below the 7Q10 flow rate in order to protect water quality, and 7Q10 flows will be significantly impacted at Hazard.

Recommendations

Additional Water Source

A preliminary feasibility study conducted by engineers for the Kentucky River Area Development District recommended a series of wells constructed in flooded deep mine works as an additional source of water. According to local officials with the City and the Department of Abandoned Mines, the area around Hazard has been extensively mined. Two abandoned mines in the area have reportedly yielded 2 - 5 mgd. The estimated costs are given below.

Water Losses

The water loss analysis was taken from the LRWSP (Ref. 6,11).

The estimated total length of water line for the Hazard System was approximately 48 miles. The estimated leak survey cost for this system was $10,800. The estimated unaccounted-for water loss due to leaks was approximately 552,200 gpd. Based on this water loss, it was estimated that a leak survey could detect 46 possible leaks. The estimated leak repair cost was $36,800. The estimated cost of repair for distribution systems that have an excessive amount of water loss is divided into two separate estimates, the leak survey cost and the corrective repair cost.

The leak survey cost estimate was based on the estimated total length of water line for the given system and an estimated leak survey cost of $225.00 per mile of water line. In some instances, the cost was factored up due to the limited amount of water line for the given system and the mobilization cost to perform the leak survey.

The corrective repair cost estimate was based on data from Georgia and Mississippi leak detection surveys and an estimated $800 to repair each leak. The Georgia and Mississippi leak detection surveys indicated that the average water loss per leak located is approximately 6,000 gpd and that most leaks are small spot repairs. Also, it was assumed that system leak losses can be reduced by 50 percent by conducting a leak survey with follow-up repairs. This assumption was based on experience of the Georgia survey that reported a 53 percent reduction in unaccounted-for water by conducting leak survey with follow-up repairs. The Mississippi survey reported a 68 percent reduction in unaccounted-for water loss.

The estimated total length of water line for the Vicco System was approximately 21 miles. The estimated leak survey cost for this system was $7,050. The estimated unaccounted-for water loss due to leaks was approximately 72,900 gpd. Based on this water loss, it was estimated that a leak survey could detect six possible leaks. The estimated leak repair cost was $4,800.

The total estimated cost of repair, including the leak survey, for the Vicco System was $11,850. The total estimated cost of repair including the leak survey for the Hazard System was $47,600.

Estimated Costs

Estimated costs of proposed projects for Hazard are given in Table 38 (Ref 16).

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
Water Supply	Abandoned deep mines in the surrounding area	$2,270,000/ N/A	N/A	1
Leak Survey/ Repair	Systemwide	$20,000/ N/A	N/A	1
Lotts Creek	KY 1088 and Lotts Creek	$330,000/ 200	$2,000	2
Second Creek	KY 1440 and Second Creek	$230,000/ 100	$2,500	3
Buckhorn	Chavies to Buckhorn State Park and KY 1833	$480,000/ 145	$3,000	5
KY 451	From Busy to Chavies along KY 451	$870,000/ 350	$2,500	4
Total Project Cost Estimates		$4,200,000		

Table 38. Project cost estimates, Hazard Water Department.

Estimated costs of proposed projects for Vicco are given in Table 39 (Ref. 16).

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
Leak Survey/ Repair	Systemwide	$15,000/ N/A	N/A	1
Fourseam	Along Buffalo Creek and Ky 1096	$60,000/ 10	$6,000	2
Newsite Station/ Cornettsville	KY 7 beginning at Fusonia and ending at the Letcher county line plus tie to Viper	$620,000/ 50	$12,000	3
Total Project Cost Estimates		$695,000		

Table 39. Project cost estimates, Vicco Water Works.

Total water system costs for Perry County are given in Table 45.

Water System	Total System Project Cost Estimate
Vicco Water System	$695,000
Hazard Water System	$4,200,000
Total Perry County Estimated Project Costs	$4,895,000

Table 40. Total estimated water project costs, Perry County.

Cost of Full Service

About 18,500 people are currently not served by public water in Perry County. Cost estimates for providing full public water service in the county were developed. It was assumed that water service would be provided along every road in the county (as shown on Kentucky Department of Transportation county highway maps). A line extension cost of $10 per foot was used. This unit cost included auxiliary costs: storage tanks, pump stations, land and rights-of-way, etc. It was assumed that 95 percent of the currently unserved population would be served by the new lines, and that usage would be 100 gpd per person. The costs for additional treatment facilities were calculated as $2.50 per gpd for the total new usage. Legal, administrative, engineering, and contingency costs were estimated at 25 percent of construction costs. Costs per customer were based on 2.62 people per household (Ref. 1).

The total estimated cost for providing full public water service to the county is about $27,400,000. An additional 17,600 people, or 6,700 households, in the county would be provided with 1.76 mgd of public water by 330 miles of new water lines. The average cost per household for the region would be about $4,100. Within the county, however, some areas will be more cheaply served than others. A prioritization of line extensions based on serving low-cost areas first was beyond the scope of this project. Additional sources of water are currently being sought by the Hazard Water System, and it is recommended that the additional full-service 1.76 mgd water usage be considered in the water supply planning.

Private Water Supplies

Population Served

About 59 percent of the county, or 7,060 households, were served by small systems or private supplies.

Types of Private Supplies

Based on private water supply usage in 1990 (Ref. 1), it is estimated that about 5,150 (73 percent) of the private supplies were drilled wells, 710 (10 percent) were dug wells, and 1,200 households (17 percent) were served by cisterns, hauled water, and other sources.

Well Contamination

54 percent of the wells tested during 1991-92 were contaminated by fecal coliform. Of those tested during 1994-95, 72 percent were contaminated (Ref. 23).

Ground Water Quality and Quantity

The majority of ground water in eastern Kentucky is obtained from shallow bedrock wells (less than 100 feet deep) and from shallow dug wells in alluvium. Most of the ground water obtained from bedrock wells is from sandstone aquifers, but in many cases water is contributed from various bedrock types including coal seams. The clays and shales that underlie coal are relatively impermeable and inhibit the vertical movement of water. Therefore, the ground water flows horizontally through the coal seams and other highly conductive layers. Maximum ground water yields are usually derived from wells located in valley bottoms.The Breathitt formation provides ground water to drilled wells near Hazard. More than three-quarters of the wells drilled in valley bottoms and almost three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gallons per day [gpd]). Some wells drilled on hilltops or ridgetops are adequate for a modern domestic supply. Nearly all wells drilled in valleys and on hillsides and hilltops are adequate for a minimum domestic supply (more than 100 gpd). Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Within a 4 mile radius of Hazard, five drilled wells and one dug well have been reported with depths ranging from 22 to 144 feet below the ground surface. One of the drilled wells produced 70 gallons per minute (100,800 gpd). Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Generally, salty water in drilled wells probably will not be found less than 200 feet below the level of the principal valley bottoms. However, one drilled well located southeast of Hazard produces salt water as shallow as 125 feet below the ground surface.

Ground water may be obtained in the alluvium of the North Fork. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. Few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

Well Water Supplies Near Vicco

The Breathitt formation provides ground water to drilled wells near Vicco. More than three-quarters of the wells drilled in valley bottoms and almost three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gallons per day [gpd]). Some wells drilled on hilltops or ridgetops are adequate for a modern domestic supply. Nearly all wells drilled in valleys and on hillsides and hilltops are adequate for a minimum domestic supply (more than 100 gpd). Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Within a 4 mile radius of Vicco, seven drilled wells have been reported with depths ranging from 89 to 425 feet below the ground surface. One of the drilled wells produced more than 6 gallons per minute (approximately 8,640 gpd). Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Salty water in drilled wells probably will not be found less than 200 feet below the level of the principal valley bottoms.

Ground water may be obtained in the alluvium of nearby tributaries. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. Few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

Although ground water in Perry County does not provide sufficient supplies of water for significant municipal use, large quantities of water may be available from abandoned underground mines that act as ground water reservoirs.

KNOTT COUNTY

The estimated population of Knott County in 1994 was 18,340. 920 residents were provided water by the Hindman Municipal Water Works, and 230 residents by the Caney Creek Water District (not in the Kentucky River basin). The remaining 17,190 residents, 94 percent of the county, depended on small systems or private supplies for their water.

The historical and projected population of Knott County (Ref.1) is:

Year	Moderate Growth Rate	High Growth Rate
1980	17,940	17,940
1990	17,906	17,906
1995	18,212	18,589
2000	18,436	19,810
2010	18,769	21,682
2020	18,713	22,974

The moderate growth projection indicates an increase in population of 4.5 percent from 1990-2020, while the high growth projection indicates an 28.3 percent increase over the same period.

Hindman Municipal Water Works

Area Served

The Hindman Municipal Water Works serves the City of Hindman and several areas outside of the city around Route 550 (Figure 11).

Hindman depends on wells near Troublesome Creek. There is no reliable surface water source. The Hindman system has three wells permitted to withdraw raw water. Two of the wells are located in the Frogtown area of Hindman; the well closest to the treatment plant was drilled in 1984 and the other well was drilled in 1964. The third well was drilled in 1988 and is located near the Knott County High School. All of the wells are reported to be approximately 290 feet to 300 feet deep. The Hindman system withdrew about 143,800 gallons per day (gpd) of water from two wells in Hindman in 1990. The third well has been out of service for several years.

The Hindman system also receives supplemental water, an estimated 24,000 gpd, from Beaver-Elkhorn Water District. It is assumed that they will continue to receive this amount throughout the planning period.

Available Water During Normal Conditions

The safe yield for the well located in the Frogtown area closest to the water plant was estimated to be 72,000 gpd based on a pump test performed in 1984 by the driller (Ref. 9,13). Pump test data were not available for the well located near Knott County High School. It was assumed to have the same characteristics as the previously mentioned well with an estimated

72,000 gpd safe yield. The third well which was located in the Frogtown area was not in service due to deteriorating conditions of the well. The well was expected to be reconditioned and returned to service. This well was estimated to have a safe yield of 469,440 gpd based on a pump test performed in 1964.

Well Characteristics

The specific capacity of a well is the yield per unit of drawdown of water level in the well for a given time. It is expressed as gallons per minute per foot of draw down (gpm/ft). The specific capacity of the well in the Frogtown area, closest to the water treatment plant, was estimated to be 0.60 gpm per foot based on pump test data performed in 1984 by the driller. Data was not available for the well near Knott County High School. It was assumed to have the same characteristics as the previously mentioned well with an estimated specific capacity of 0.60 gpm per foot. The specific capacity of the third well which is located in the Frogtown area was 5.09 gpm/ft based on a pump test performed in 1964.

Zone of Contribution

The zone of contribution is defined as the area (surface or groundwater) that is contributing to or recharging a well or well field. There was no definitive data available for the contribution areas of the Hindman system. The surface drainage area upgradient of the Hindman wells is approximately 10.9 square miles.

Zone of Influence

The zone of influence is defined as the horizontal distance from the center of the well to the limit of the groundwater surface depressed by pumping the well. This is determined by monitoring wells adjacent to the well in question. There were no data available for the Hindman system to accurately estimate the zone of influence for these wells.

Available Water During Low-Flow Conditions

Operator experience from the summer of 1988, considered a period of drought, indicates that the system (excluding the third well) was able to withdraw an average of 180,000 gpd during the summer months from the two wells in operation (Ref. 9,13). Based on this operator experience and the assumption that the third well would be returned to service, the estimated safe yield for the Hindman well system was 649,440 gpd (Ref. 9,13).

Historical Water Use

The historical water use for the Hindman Municipal Water Works is shown in Table 41.

Projected Water Use

Residential Water Use Forecast

The City of Hindman planned to extend lines to about 60 customers in the Mousie area and 8 customers in the Brinkley area. Other possible line extensions were along Route 899 to Mallie (50 customers), along Route 160 to Littcar (50 customers), and to Route 80 (20 customers).

	Gallons Per Day		Customers [1]	
Type of User	**1987**	**1990**	**1987**	**1990**
Residential	55,800[1]	47,100[1]	210	280
Commercial	69,700[1]	60,200[1]	41	52
Institutional	41,500[1]	47,700[1]	2	3
Industrial	0	0	0	0
Unaccounted	73,400[2]	12,800[2]	-	-
Total	240,400[3]	167,800[4]	253	335

[1] Reported by the City of Hindman.
[2] Difference between total and other uses.
[3] The sum of reported withdrawal from wells: 216,400 gpd (1987); plus the estimated amount of water bought from Beaver-Elkhorn Water District.
[4] The sum of reported withdrawal for wells: 143,800 gpd (1990); plus the estimated amount of water brought from Beaver-Elkhorn Water District.

Table 41. Historical water use, Hindman Municipal Water Works.

Growth in population along planned and existing lines is expected to be in proportion to the population projections of Knott County. If the population declines, future increases in water use will primarily come from expansion of the service area to serve more existing homes in rural areas of the county. The residential service forecast is shown in Table 42.

There is a proposed development of land within the Mountain Coals, Inc. Star Fire surface mine area. The proposed Star Fire development would utilize its own water resources as a source.

Commercial Water Use Forecast

Changes in commercial activity are generally expected to be in proportion to population change.

Institutional Water Use Forecast

Changes in institutional water use are expected to be in proportion to population change.

Industrial Water Use Forecast

Hindman does not currently have a developed industrial park area. The city was attempting to purchase a 30 to 60 acre tract of land for industrial development. It was expected that relatively light industry, requiring only moderate amounts of process water, would locate in the area. This type of activity might include fabrication, metal processing, painting, and assembly. Typical water use for this type of industry is 1000 to 1500 gallons per acre per day. A water use allowance was made for 45,000 gpd based on development of 30 acres during the planning period.

Projected Number of Residential Customers[1] Year moderate/high			
	2000	2010	2020
Existing Service Area	285/310	295/340	295/360
Rte 160/Brinkley	8	8	8
Rte 1087/Mousie	60	60	60
Rte 899/Mallie	43	50	50
Rte 160/Littcarr	0	50	50
Route 80	0	20	20
Total Residential Customers	396/421	483/528	483/548
Projected Residential Service[2]	1,060/1,120	1,290/1,410	1,290/1,460

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period

[2] Based on the number of customers and on 2.67 persons per household in Leslie County from the 1990 census.

Table 42. Residential service forecast, Hindman Municipal Water Works.

Combined Water Use Forecast

The combined water use forecast is shown in Table 43. The annual average water withdrawal of the Hindman Municipal Water Works is projected to increase from 143,800 gpd in 1990 to 236,000 - 273,000 gpd in 2020, depending upon population growth.

The actual peak average monthly withdrawal for the Hindman system has been about 1.1 times the average annual withdrawal. A peak daily withdrawal of 1.5 times annual average withdrawal was used for estimating peak demands during drought conditions. The peak daily water withdrawal for the Hindman system was estimated to increase from 215,700 gpd in 1990 to 354,000 - 410,000 gpd in 2020.

<u>Competing Uses</u>

There are no known irrigation systems in Knott county, therefore, agriculture is not a significant competing use.

Diamond May Coal Company had a permit to withdraw water (0.05 mgd) from a pond adjacent to RM 0.05 of Brushy Fork. This withdrawal should not affect water availability for the public water source at Hindman.

	Average Water Use gpd	Projected Water Use, gpd Year moderate/high		
	1990	2000	2010	2020
Residential[1]	47,100	65,500/69,700	80,000/87,400	80,000/90,700
Commercial	60,200	61,900/66,600	63,100/73,000	64,300/77,300
Institutional	47,700	49,100/52,800	50,000/57,800	50,900/61,200
Industrial	0	45,000	45,000	45,000
Public[2]	0	0	0	0
Subtotal - Water Sold	155,000	221,500/234,100	238,100/263,200	240,200/274,200
Unaccounted[3]	12,800	18,300/19,300	19,700/21,700	19,800/22,600
Total - Water Required	167,800	240,000/253,000	258,000/285,000	260,000/297,000
Average Supplement from Beaver-Elkhorn Water District	24,000	24,000/24,000	24,000/24,000	24,000/24,000
System Demands, gpd	143,800	216,000/229,000	234,000/261,000	236,000/273,000
Peak Daily Demand[4], gpd	215,700	324,000/344,000	351,000/392,000	354,000/410,000

[1] Based on the 1990 per capita water use of approximately 62 gallons per person per day and the population projections in Table 42.
[2] Information not available, included with unaccounted.
[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1990.

Table 43. Combined water use forecast, Hindman Municipal Water Works.

Infrastructure

Existing Treatment and Total Distribution System Capacity

The Hindman water treatment plant, constructed in 1966, has a design capacity of 360,000 gpd. The operator reports that it is capable of producing 360,000 gpd of "good" finished water (Ref. 9,13).

The Hindman water distribution system has an estimated capacity of 195,000 gpd. This estimate is based on the existing storage tank capacity (excluding clearwell storage) of 195,000 gallons and a criteria of one-day minimum allowable storage. It is believed that this is a good indication of the design capacity of the overall distribution system.

System Losses

The total reported unaccounted water for the Hindman and Caney Creek systems was 7.6 percent and 18 percent, respectively (Ref. 9,13).

Water Quality

There are no known water quality concerns for the Hindman system. The Wellhead Protection Area is based on the surface watershed boundary above the wells.

The only public water systems violation reported by the Kentucky Division of Water for the period 1990-October, 1995 at the Hindman system was a bacteria check sampling violation in December, 1991.

Potential sources of contamination in the county given in tables 44-46 (Ref. 22), with geographic locations shown in Figure 12. There were no permitted solid waste landfills in Knott County. These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

NAME	PERMIT
BACKHAM COMBS ELEM SCHOOL	2377
HANDSHOE APTS	2440
JAMESTOWN VILLAGE MHP	1786
EMMALENA ELEM SCH	1191
HINDMAN STP	1328
KTC KNOTT CO MAINT GARAGE	2616
LOTTS CREEK ELEM SCHOOL	2532
CARR CREEK ELEM SCH	1428
USARMY COE/CARR FORK LAKE-LITTCAR	2693
USARMY COE/CARR FORK LAKE	2112
USARMY COE/CARR FORK LAKE-TAILWATERS	2709
COLLINS RESIDENCE	1921

Table 44. Potential sources of pollution, effluent discharge points, Knott County.

NAME	PERMIT
SKBL INC	1805

Table 45. Potential sources of pollution, hazardous waste handlers, Knott County.

NAME	PERMIT
HINDMAN MUNICIPAL WATER WORKS	381
DIAMOND MAY COAL COMPANY	1109

Table 46. Potential sources of pollution, permitted water withdrawers, Knott County.

Water Supply Adequacy

It is concluded that the quantity of water available at the Hindman supply is adequate for projected needs assuming the reconditioning and operation of the third well.

Recommendations

Since well information for these systems is limited and the assumptions made for determination of water supply adequacy are based on this limited information, the values used for the source assessments may not represent the actual yields. A pump test should be performed on each well, and water level monitoring gages be placed in each well to verify the yields of the wells during both normal and drought conditions.

Water Losses

The percentage of the unaccounted water for this system is not considered excessive (Ref. 9,13). Therefore, no estimation of the cost to repair this system has been performed.

Estimated Costs

Proposed project costs are given in Table 47 (Ref. 16).

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
Pump Test	Well Site	$10,000/ N/A	N/A	1
Moussie	Moussie and Ball Branch	$210,000/ 200	$1,000	2
Mallie	KY 899 and KY 1393	$260,000/ 50	$4,000	4
Ogden Branch	Ogden Branch to KY 80	$250,000/ 20	$13,000	5
Brinkley/ Littcarr	KY 160 including Brinkley/Littcarr	$760,000/ 100	$7,000	3[1]
Total Project Cost Estimates		$1,490,000		

Table 47. Project cost estimates, Hindman Municipal Water Works.

Cost of Full Service

About 17,200 people are currently not served by public water in Knott County. Cost estimates for providing full public water service in the county were developed. It was assumed that water service would be provided along every road in the county (as shown on Kentucky Department of Transportation county highway maps). A line extension cost of $10 per foot was used. This unit cost included auxiliary costs: storage tanks, pump stations, land and rights-of-way, etc. It was assumed that 95 percent of the currently unserved population would be served by the new lines, and that usage would be 100 gpd per person. The costs for additional treatment facilities were calculated as $2.50 per gpd for the total new usage. Legal, administrative, engineering, and contingency costs were estimated at 25 percent of construction costs. Costs per customer were based on 2.67 people per household (Ref. 1).

The total estimated cost for providing full public water service to the county is about $30,900,000. An additional 16,300 people, or 6,200 households, in the county would be provided with 1.63 mgd of public water by 390 miles of new water lines. The average cost per household for the region would be about $5,000. Within the county, however, some areas will be more cheaply served than others. A prioritization of line extensions based on serving low-cost areas first was beyond the scope of this project. An additional source of water would be required to meet the added needs of full public water service.

Private Water Supplies

<u>Population Served</u>

About 94 percent of the county, or 6,440 households were served by private water supplies in 1994.

<u>Types of Supplies</u>

Based on private water supply usage in 1990 (Ref. 1), it is estimated that about 5,410 (84 percent) of the private supplies were drilled wells, 580 (9 percent) were dug wells, and 450 (7 percent) were cisterns, hauled water, or other sources.

<u>Well Contamination</u>

56 percent of the domestic wells tested during 1991-92 were contaminated with fecal coliform. 83 percent of those tested during 1994-95 were contaminated (Ref. 23).

<u>Ground Water Quality and Quantity</u>

The majority of ground water in eastern Kentucky is obtained from shallow bedrock wells (less than 100 feet deep) and from shallow dug wells in alluvium. Most of the ground water obtained from bedrock wells is from sandstone aquifers, but in many cases water is contributed from various bedrock types including coal seams. The clays and shales that underlie coal are relatively impermeable and inhibit the vertical movement of water. Therefore, the ground water flows horizontally through the coal seams and other highly conductive layers. Maximum ground water yields are usually derived from wells located in valley bottoms.

The Breathitt formation provides ground water to drilled wells near Hindman and Pippa Passes. More than three-quarters of the wells drilled in valley bottoms and almost three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gallons per day [gpd]). Some wells drilled on hilltops or ridgetops are adequate for a modern domestic supply. Nearly all wells drilled in valleys and on hillsides and hilltops are adequate for a minimum domestic supply (more than 100 gpd). Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Within a 4 mile radius of Hindman, five drilled wells have been reported with depths ranging from 34 to 194 feet below the ground surface. Three of the drilled wells produced yields ranging from 30 to 100 gallons per minute (43,200 to 144,000 gpd). Within a 4 mile radius of Pippa Passes, five drilled wells have been reported with depths ranging from 50 to 75 feet below the ground surface. Two of the drilled wells produced yields ranging from 10 to 63 gallons per minute (14,400 to 90,720 gpd). Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Generally, salty water in drilled wells will not be found less than 200 feet below the level of the principal valley bottoms. However, three drilled wells located southeast of Pippa Passes produce salt water as shallow as 75 feet below the ground surface.

Ground water may be obtained in the alluvium of Caney Creek and other nearby tributaries. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. Few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

Based on their reported yields, well fields may have the ability to supply limited quantities of water to small municipal systems.

LETCHER COUNTY

The estimated population of Letcher County in 1994 was 27,000. 1,900 residents were provided water by the Fleming-Neon Water Company, 1,700 residents by Whitesburg Municipal Water, and 2,500 residents by the Jenkins Water System (water supply not in the Kentucky River basin). The remaining 20,900 residents (77%) depended on small systems or private supplies for their water.

The historical and projected population of Letcher County (Ref 1.) is:

Year	Moderate Growth Rate	High Growth Rate
1980	30,687	30,687
1990	27,000	27,000
1995	26,638	27,296
2000	26,203	28,726
2010	25,445	30,344
2020	24,478	30,929

The moderate growth projection indicates a decline in population of 9.3 percent from 1990-2020, while the high growth projection indicates an 14.6 percent increase over the same period.

Whitesburg Municipal Water

Area Served

Whitesburg Municipal Water supplies water to the City of Whitesburg and the communities of Ermince and Colly. The existing service area is shown in Figure 13. Whitesburg uses the North Fork as its source of water supply. Its point of withdrawal is at milepoint 406.3, 45.07 miles upstream of Hazard's water intake (Figure 7).

At the point of withdrawal the river channel bottom is concreted and the city's water intake is within a pool created by a six-foot high dam. The volume of water in the pool has been estimated to be between three and four million gallons. The storage benefits of this structure are minimal. Also, the impoundment is subject to serious and continued siltation (Ref. 2). The pool was dredged in 1988, and eighteen months later it was estimated that two-thirds of the storage capacity was lost because of renewed siltation.

Available Water During Normal Conditions

A USGS stream gage (gage #03277300) is located on the North Fork of the Kentucky River at Whitesburg. The average flow during the month of lowest average monthly flow at this gage is estimated to be 7.8 mgd. Ten percent of this value is 0.78 mgd.

Available Water During Low-Flow Conditions

Low stream flows at the Whitesburg gage have been estimated to be:

- 7Q10 1.3 mgd
- 7Q20 0.65 mgd

The Whitesburg intake is upstream of Carr Fork Lake, so the stream flow is not regulated by a reservoir. The Kentucky Division of Water reported that during the 1988 drought, the city was withdrawing at a rate that was 23 percent of the 7Q10, which was "significant and indicates problems."

The backup source for this system is a non-permitted well that formerly was the primary source of water for the system.

Historical Water Use

The historical water use for the Whitesburg Municipal Water Works system is shown in Table 48.

	Gallons Per Day[1]			Customers [1]		
Type of User	1986	1990	1994[5]	1986	1990	1994[6]
Residential	103,000	161,600	161,600	435	682	680
Commercial	11,800	21,200	21,200	69	124	124
Institutional	15,900	21,200	21,200	3	4	4
Industrial	0	0	0	0	0	0
Public[2]	N/A	N/A	N/A	--	--	--
Subtotal[3]	130,700	204,000	204,000			
Unaccounted	169,700	89,900	73,000			
Total[4]	300,400	293,900	277,000	507	810	808

[1] From Whitesburg Municipal Water Works.
[2] Segregated information, not available for this category.
[3] Water sold.
[4] Water withdrawn.
[5] Estimated values except for Total.
[6] Estimated values except for Residential.

Table 48. Historical water use, Whitesburg Municipal Water Works.

Projected Water Use

Residential Water Use Forecast

If the population declines, future increases in water use will primarily come from expansion of the service area to existing homes in rural areas of the county. With the projected high growth rate, future increases in water use would occur through system expansion and through population growth.

The Whitesburg Municipal Water Works system had several water line extension projects in various stages of planning and construction. The Whitco/Ice/Dongola project was expected to serve 497 houses. The planned Mayking project was estimated to serve 375 customers within 10-15 years. Possible extensions to Route 931 and Route 2034 would serve an estimated 110 and 50 houses, respectively.

The served residential population forecast is shown in Table 49.

	Projected Number of Residential Customers[1] Year moderate/high		
	2000	2010	2020
Existing Service Area	682/725	682/765	682/780
Whitco Area	350	497	505
Mayking Area	319	375	380
Route 2034	0	50	50
Route 931	0	110	110
Total Residential Customers	1,351/1,394	1,714/1,797	1,727/1,825
Projected Residential Service[2]	3,380/3,480	4,280/4,490	4,320/4,560

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period

[2] Based on the number of customers and on 2.5 persons per household in Letcher County from the 1990 census.

Table 49. Residential service forecast, Whitesburg Municipal Water Works.

Commercial Water Use Forecast

Changes in commercial activity are generally expected to be in proportion to population change.

Institutional Water Use Forecast

Changes in institutional water use is expected to be in proportion to population change.

Industrial Water Use Forecast

The City of Whitesburg owns one undeveloped industrial site. It is expected that such development would be relatively light industry requiring moderate amounts of process water. This type of activity might include fabrication, metal processing, painting, and assembly. Typical water use for this type of industry is 1,000 to 1,500 gallons per acre per day. At a water use of 1,500 gallons per acre per day this represents the development and occupancy of a 15 acre industrial park during the planning period. An allowance of 22,400 gpd was made to accomodate industrial development.

Combined Water Use Forecast

The combined water use forecast is shown in Table 50.

	Average Water Use gpd	Projected Water Use, gpd Year moderate/high		
	1994	2000	2010	2020
Residential[1]	161,600	321,100/330,600	406,600/426,600	410,400/433,200
Commercial	21,200	21,200/22,550	21,200/23,800	21,200/24,250
Institutional	21,200	21,200	21,200	21,200
Industrial	0	22,400	22,400	22,400
Public[2]	N/A	N/A	N/A	N/A
Subtotal - Water Sold	204,000	386,000/397,000	471,000/494,000	475,000/501,000
Unaccounted[3]	73,000	138,000/142,000	169,000/177,000	170,000/179,000
Total - Water Withdrawn	277,000	524,000/539,000	640,000/671,000	645,000/680,000
Peak Daily Demand[4], gpd	415,500	786,000/808,000	960,000/1,006,000	968,000/1,020,000

[1] Based on the 1990 per capita water use of about 95 gallons per person per day and the population projections in Table 49.

[2] Information not available, included in unaccounted.

[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1990.

[4]Peak daily demand equals 1.5 times average annual demand.

Table 50. Combined water use forecast, Whitesburg Municipal Water Works.

Average daily demands are expected to increase from 277,000 gpd in 1994 to 645,000 - 680,000 gpd in 2020 depending upon population growth.

The actual peak average monthly withdrawal for the Whitesburg Municipal Water Works system has been about 1.1 times the average annual withdrawal. A peak daily withdrawal of 1.5 times annual average withdrawal was used for estimating peak demands during drought conditions. Peak daily demand is projected to increase from .42 mgd in 1994 to 0.97 to 1.02 mgd in 2020.

Competing Uses

Agricultural use in Letcher County was estimated to be negligible. Therefore, agriculture is not a significant competing use.

There are six permitted withdrawals at coal mining operations in Letcher County as shown in Table 51 (Ref. 18) and on Figure 14. None of these permitted withdrawals, nor the Fleming-Neon system, should affect water availability for the public water source at Whitesburg. There are no known competing users upstream of the Whitesburg Municipal Water Works intake.

NAME	SOURCE	PERMITTED WITHDRAWAL mgd	AVERAGE WITHDRAWAL, mgd	PERMIT
DLX INC.	NORTH FORK KENTUCKY RIVER - RM 391.45	0.01	0.001	1310
ENTERPRISE COAL COMPANY	NORTH FORK KENTUCKY RIVER - RM 393.5	0.04	0.01	827
FOX MINING CORPORATION	WELL, .2 MI. WEST OF DEFEATED CREEK OF LINE FORK	0.02	0.001	971
GOLDEN OAK MINING COMPANY	RM 13.05L OF ROCKHOUSE CREEK	0.57	0.15	907
KENTUCKY CRITERION COAL COMPANY	WELL IN UNDERGROUND MINE IN ELKHORN #3, .5 MI. WEST OF DEANE	0.65	0.15	1272
KENTUCKY CRITERION COAL COMPANY	IMPOUNDMENT OF RAZORBLADE BRANCH OF ROCKHOUSE CREEK	0.65	0.00	1275

Table 51. Non-municipal water withdrawers, Letcher County.

Infrastructure

Existing Treatment and Total Distribution System Capacity

The Whitesburg Municipal Water Works water treatment plant, constructed in 1965, has a design capacity of 500,000 gpd. The operator reports that it is capable of producing 385,000 gpd of "good" finished water (Ref. 5,14).

The Whitesburg Municipal Water Works water distribution system has an estimated capacity of 275,000 gpd. This estimate is based on the existing storage tank capacity (excluding clearwell storage) of 275,000 gallons and a criteria of one-day minimum allowable storage. It is believed that this is a good indication of the design capacity of the overall distribution system.

Intake Limitations

The existing intake is located on the North Fork of the Kentucky River about 1 mile upstream of the City of Whitesburg. The intake is located just upstream of a small water retention structure and near the bottom of the river. This configuration allows withdrawal from the river over a wide range of river flow and does not present any limitations.

System Losses

The total unaccounted water is 26 percent of water withdrawn (Ref. 5,14). This rate of leak loss is high compared to an acceptable value of 15 percent.

Water Quality

The water quality was reported as good by the water plant staff. The raw water is most difficult to treat during periods of heavy rainfall which causes the water to be highly turbid.

System violations for Whitesburg Municipal Water, as reported by the Kentucky Division of Water for the period 1990-October, 1995, are shown in Table 52 (Ref. 20). M/R are monitoring and reporting (administrative) violations.

Violation Date	Violation Type	Contaminant
September, 1992	Minor M/R	Bacteria
October, 1994	Regular sampling	Nitrates
November, 1994	SWTR Turbidity	Turbidity
August, 1995	SWTR Turbidity	Turbidity

Table 52. Public water systems violations, Whitesburg Municipal Water Works.

Potential sources of contamination in the county are shown in Tables 58-61, with geographic locations shown in Figure 15 (Ref. 22). These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

Water Supply Adequacy

Based on the low values of 7Q10 and 7Q20 in relation to the projected demands, it was concluded that the quantity of water available at the Whitesburg Municipal Water Works intake is inadequate for current and projected water supply needs (drought classification B). Also, 7Q10 flows would be impacted by the projected withdrawals.

Recommendations

Additional Water Source

A preliminary feasibility study, conducted by engineers for the Kentucky River Area Development District, concluded that the most promising alternative source of water for the Whitesburg system would be the use of an abandoned, flooded, underground mine which would serve as a groundwater reservoir. This would require the construction of a well to retrieve the raw water, and raw water lines and pumps to pipe the raw water to the treatment plant. To obtain preliminary cost estimates, it was assumed that a suitable mine could be found within 5 miles of the water treatment plant.

The Whitesburg Municipal Water Works is in the planning stages of constructing a new water treatment facility. The proposed plant would treat 800,000 gpd.

Water Losses

The water loss analysis is taken from the LRWSP (Ref. 5,14).

The estimated total length of water line for the Whitesburg system was approximately 11 miles. The estimated leak survey cost for this system was $5,000.

The estimated unaccounted-for water loss due to leaks was approximately 66,400 gpd. Based on this water loss, it was estimated that a leak survey could detect six possible leaks. The estimated leak repair cost was $4,800.

The total estimated cost of repair including the leak survey for the Whitesburg system was $9,800.

Estimated Costs

Estimated costs of proposed projects are given in Table 53 (Ref. 16). Recommendations for full public water service in the county are given under the Fleming-Neon recommendations.

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
Additional Water Source	Deep mine within 5 miles of Whitesburg	$800,000/ N/A	N/A	1
Leak Survey/ Repair	Systemwide	$10,000/ N/A	N/A	1
Mayking	Northeast of Whitesburg along Pine Creek	$270,000/ 375	$1,000	2
KY 931	Along KY 931 and Sandlick Creek	$560,000/ 110	$5,000	3
Craft's Colly Creek	Along KY 2034 and Craft's Colly Creek	$460,000/ 50	$9,000	4
Total Project Cost Estimates		$2,100,000		

Table 53. Estimated project costs, Whitesburg Municipal Water Works.

Fleming-Neon Water System

<u>Area Served</u>

The Fleming-Neon Water System supplies water to Fleming-Neon and the area within one to three miles of the city. The existing service area is shown in Figure 13. Groundwater is the source of raw water for this system. The primary source of water is a well drilled 153 feet into a deep mine on She Fork (Ref 5,14). The secondary source is a well drilled into a different break of the same mine on Tom Biggs Branch. A third (backup) source is an unpermitted well drilled 123 feet on Tom Biggs Branch of Wright Fork that used to serve as the source of raw water for the old water treatment plant. Future expansion of this system is limited by the Jenkins system to the east, the Whitesburg system to the west, and the low density of houses to the north.

<u>Available Water During Normal Conditions</u>

Primary Source - Deep Mine Well on She Fork. The well is supplied by an abandoned deep mine. The volume of the mine was estimated to be 126 acre - feet (41 million gallons) (Ref. 5,14). The estimated recharge rate of the mine was 135 gallons per minute (gpm). According to operator experience, a pumping rate of 320 gpm for 12 hours a day (or 230,400 gpd) does not affect the water level of the mine.

Secondary Source - Deep Mine Well on Tom Biggs Branch. The well is supplied by an abandoned deep mine of unknown volume. According to operator experience, a pumping rate of 75 gpm for 12 hours per day (or 54,000 gpd) does not affect the water level of the mine. From this, an approximate volume of 10 million gallons might be inferred.

Backup Source - Well on Tom Biggs Branch. The backup well, drilled in the 1930s, is not a permitted well. According to operator experience, a constant water level can be maintained at a pumping rate of 150 gpm. This well is used only when repairs are required on the other wells because of reported poor water quality.

Available Water During Low-Flow Conditions

It has been estimated that during a drought period, the storage and recharge of the primary water source could produce 288,000 gpd for one year on a 24-hour-per-day production basis (Ref. 5,14). It was also estimated that the secondary source well could supply an additional 113,750 gpd on a long-term basis. The combined supply from both wells is 401,750 gpd.

According to guidelines established by the Division of Water, reservoirs must be capable of supplying water at the average user rate for at least 200 days which is equivalent to a 6-month drought. The estimated safe yield from the primary source was 435,400 gpd based on the estimated storage volume of 41,000,000 gallons yielding water for 200 days (205,000 gpd) and operator experience of a safe pumping rate of 320 gpm for 12 hours (230,400 gpd).

The estimated safe yield from the secondary source was 54,000 gpd based on operator experience of a safe pumping rate of 75 gpm for 12 hours. The estimated combined safe yield from both sources is 489,400 gpd. This assumes normal recharge during the drought.

A very conservative estimate of drought supply could be obtained by assuming only the combined storage of the primary and secondary sources, 51 million gallons over the 200 day period, 255,000 gpd. The safe yield during a drought should lie somewhere between 255,000 gpd and 489,000 gpd.

Historical Water Use

The system withdrew about 171,000 gallons per day (gpd) of water in 1994. Historical water use for the Fleming-Neon Water System is shown in Table 54.

	Gallons Per Day[1]			Customers [1]		
Type of User	**1987**	**1990**	**1994[5]**	**1987**	**1990**	**1994[6]**
Residential	93,300	95,300	105,400	738	711	759
Commercial	16,400	21,800	23,300	52	49	49
Institutional	2,300	2,800	3,000	5	3	3
Industrial	0	0	0	0	0	0
Public[2]	500	800	800	1	1	1
Subtotal[3]	112,500	120,700	132,500			
Unaccounted	48,600	44,400	38,500			
Total[4]	161,100	165,100	171,000	796	764	812

[1] From Fleming-Neon Water System.
[2] Fire Protection and county use.
[3] Water sold.
[4] Water withdrawn.
[5] Estimated values except for Total.
[6] Estimated values except for Residential.

Table 54. Historical water use, Fleming-Neon Water System.

Projected Water Use

Residential Water Use Forecast

A project serving the Haymond area was expected to serve approximately 330 houses. A project in the Hemphill/Jackhorn area would serve approximately 250 houses within the next 10 to 15 years.

If the population declines, future increases in water use will primarily come from expansion to existing homes in rural areas of the county. With the projected high growth rate, future increases in water use would occur through system expansion and through population growth. The residential service forecast is shown in Table 55.

Commercial Water Use Forecast

Changes in commercial activity are expected to be in proportion to population change.

Institutional Water Use Forecast

Change in institutional water use is expected to be in proportion to population change.

Industrial Water Use Forecast

Letcher County has several undeveloped industrial sites at this time. The City of Fleming-Neon owns an undeveloped 8 acre potential industrial site. It is expected that relatively light industry, requiring moderate amounts of process water, would locate in the area. This type of activity might include fabrication, metal processing, painting, and assembly. Typical water use for this type of industry is 1,000 to 1,500 gallons per acre per day. At a typical water use of 1,500 gallons per acre per day this 8 acre site would represent a 12,000 gpd demand when it is developed.

	Projected Number of Residential Customers[1] Year moderate/high		
	2000	2010	2020
Existing Service Area	711/760	711/800	711/810
Haymond Area	243	330	330/335
Hemphill/Jackhorn Area	150	250	250/255
Total Residential Customers	1,104/1,153	1,291/1,380	1,291/1,400
Projected Residential Service[2]	2,760/2,880	3,230/3,450	3,230/3,500

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period

[2] Based on the number of customers and on 2.5 persons per household in Letcher County from the 1990 census.

Table 55. Residential service forecast, Fleming-Neon Water System.

Combined Water Use Forecast

The combined water use forecast is shown in Table 56. Average daily water use is expected to increase from 171,000 gpd to 288,000 - 310,000 gpd by the year 2020 depending upon population growth. The actual peak average monthly withdrawal for the Fleming-Neon Water System has been about 1.2 times the average annual withdrawal. A peak daily withdrawal of 1.5 times annual average withdrawal was used to calculate peak demands during drought conditions. The peak daily water withdrawal was estimated to increase from 256,000 gpd in 1990 to 432,000 - 465,000 gpd in 2020, depending upon population growth.

Competing Uses

Agricultural use in Letcher County was estimated to be negligible. Therefore, agriculture is not a significant competing use.

There are six permitted withdrawals at coal mining operations in Letcher County as shown in Table 51 (Ref. 18) and on Figure 14. None of these permitted withdrawals should affect water availability for the public water sources at Fleming-Neon.

Infrastructure

Existing Treatment and Total Distribution System Capacity

The Fleming-Neon Water System water treatment plant, renovated in 1983, has a design capacity of 250,000 gpd. The operator reports that it is capable of producing 250,000 gpd of "good" finished water (Ref. 5,14).

The Fleming-Neon water distribution system has an estimated capacity of 500,000 gpd. This estimate is based on the existing storage tank capacity (excluding clearwell storage) of 500,000 gallons and a criteria of one-day minimum allowable storage. It is believed that this is a good indication of the design capacity of the overall distribution system (Ref. 5,14).

	Average Water Use gpd	Projected Water Use, gpd Year moderate/high		
	1994	2000	2010	2020
Residential[1]	105,400	148,000/155,000	173,000/185,000	173,000/188,000
Commercial	23,300	23,300/23,500	23,300/24,700	21,300/25,000
Institutional	3,000	3,000	3,000	3,000
Industrial	0	22,400	22,400	22,400
Public[2]	800	1,160/1,220	1,360/1,450	1,360/1,480
Subtotal - Water Sold	132,500	198,000/205,000	223,000/237,000	223,000/240,000
Unaccounted[3]	38,500	57,000/59,000	65,000/69,000	65,000/70,000
Total - Water Withdrawn	171,000	255,000/264,000	288,000/306,000	288,000/310,000
Peak Daily Demand[4], gpd	256,000	382,000/396,000	432,000/459,000	432,000/465,000

[1]Based on the 1990 per capita water use of about 134 gallons per customer per day and the population projections in Table 55.
[2] Fire protection estimated to increase in proportion to the number of customers.
[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1990.
[4]Peak daily demand equals 1.5 times average annual demand.

Table 56. Combined water use forecast, Fleming-Neon Water System.

Intake Limitations

There are no known intake limitations for this system.

System Losses

The total unaccounted water is 23 percent of water withdrawn. This rate of leak loss is high compared to an acceptable value of 15 percent (Ref. 5,14).

Water Quality

The water quality was reported by the water plant staff to be generally good. The raw water is most difficult to treat during dry periods when the water contains more suspended solids. The water from the backup source (well) on Tom Biggs Branch is reported to have high turbidity. The Wellhead Protection Area is based on the surface watershed boundary above the wells.

System violations as reported by the Kentucky Division of Water for the period 1990-October, 1995 are shown in Table 57 (Ref. 20.). M/R are monitoring and reporting (administrative) violations.

Violation Date	Violation Type	Contaminant
February, 1990	Regular sampling	Bacteria
June, 1993	Minor M/R	Bacteria

Table 57. Public water systems violations, Fleming-Neon Water Company.

Potential sources of contamination in the county are given in Tables 58-61 (Ref. 22), with geographic locations shown in Figures 15 and 16. These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

NAME	PERMIT
US 60 BODY SHOP	2521
CONTEL OF KENTUCKY INC	2483
T & W FORD SALES & SERVICE	2522
SUPERAMERICA 5538	3086
KENTUCKY MOTIVE POWER INC	1156
ISONS GULF & TIRE STORE	799
SHELL SERVICE STATION	1438
CHEVRON FOOD MART/JENKINS	2520
J D LARKEY & SONS INC	2519
ASHLAND BRANDED MARKETING 261-000	2726
CHEVRON FOOD MART/NEON	2518
CLASSIC CLEANERS #160	1652
RIVERPORT IMAGING	1472
AUBURN HOSIERY MILLS INC	1902

Table 58. Potential sources of pollution, hazardous waste handlers, Letcher County.

NAME	PERMIT
KENTUCKY CRITERION COAL	1275
KENTUCKY CRITERION COAL	1272
FLEMING-NEON WATER SYSTEM	910
FLEMING-NEON WATER SYSTEM	809
GOLDEN OAK MINING	907
WHITESBURG MUNICIPAL WATER	353
ENTERPRISE COAL	827
DLX, INC.	1310
FOX MINING	971

Table 59. Potential sources of pollution, permitted water withdrawer, Letcher County.

NAME	PERMIT
KENTUCKY CRITERION COAL CO	67
LINDSEY & ELLIOTT OIL & GAS CO	2343
JOHNSON-ELKHORN COAL CO	342
BECKHAM BATES ELEM SCHOOL	1132
HEMPHILL ELEM SCHOOL	2292
LETCHER COUNTY LANDFILL	2756
GOLDEN OAK DELTA SUPREME COAL	103
GOLDEN OAK MINING CO OFFICE	525
P C & H CONST INC	941
DUTY RESIDENCE	1993
SOUTHEAST COAL CO INC	1357
J D LARKEY & SONS INC	617
BANKS RESTAURANT & APTS	1359
TAYLOR BODY SHOP	1358
BREEDINGS APARTMENTS	2510
FLEMING NEON STP	853
FISHPOND LAKE RECREATION	904
ENERGY EXPRESS INC	1413
POTTER MARTHA JANE SCH	1392
LETCHER CONSOLIDATED SCHOOL	1847
STANDARD LABORATORIES INC	1505
MAYKING MALL	1506
SAVE A LOT	1507
DRY FORK MARKET	1849
BLACKEY HEAD START	1026
PARKWAY MOTEL	1412
KTC LETCHER CO MAINT GARAGE	2615
WHITESBURG STP	1846
ASHLAND BRANDED MARKETING #579-006	635
WHITESBURG WTP	1848
CHILDERS OIL CO INC	905
ENTERPRISE COAL CO	926
ENTERPRISE COAL CO ROXANA	2181
CAMPBELL BRANCH ELEM SCHOOL	2291
SWENTON, MICHAEL/D LEWIS LEASE	2306
COWAN ELEM SCHOOL	2290
KINGDOM COME ELEM SCH	1411
NALLY & HAYDON INC	581

Table 60. Potential sources of pollution, permitted effluent discharge sites, Letcher County.

NAME	PERMIT
LETCHER COUNTY LANDFILL	232

Table 61. Potential sources of pollution, solid waste landfills, Letcher County.

Water Supply Adequacy

The estimated safe withdrawal during a drought from the raw water sources of the Fleming-Neon system is between 255,000 gpd and 489,400 gpd. It is concluded that the quantity of water available to the Fleming-Neon Water System is adequate for current needs. The system may not be able to meet peak demands during a drought by the year 2000, however, and by the year 2010 may not meet average demands during a drought.

Recommendations

Plant Capacity

Estimated costs to expand the existing plant capacity from 250,000 to 400,000 gpd, and associated facility renovation costs are given below (Ref. 16).

Water Losses

The water loss analysis was taken from the LRWSP (Ref. 5,14). The estimated total length of water line for the Fleming-Neon system is approximately 11 miles. The estimated leak survey cost for this system is $4,800.

The estimated unaccounted-for water loss due to leaks is approximately 31,200 gpd. Based on this water loss, it is estimated that a leak survey could detect three possible leaks. The estimated leak repair cost is $2,400.

The total estimated cost of repair including the leak survey for the Fleming-Neon system is $7,200.

Estimated Costs

Estimated costs for proposed projects are given in Table 62 (Ref. 5,14).

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
Leak Survey/ Repair	Systemwide	$10,000/ N/A	N/A	1
Water plant renovation and expansion	Existing plant site	$600,000/ N/A	N/A	1
Hemphill/ Jackhorn	Along Yonts Creek and Little Creek	$730,000/ 200	$4,000	2
Total Project Cost Estimates		$1,340,000		

Table 62. Estimated project costs, Fleming-Neon Water System.

Cost of Full Service

About 20,900 people are currently not served by public water in Letcher County. Cost estimates for providing full public water service in the county were developed. It was assumed that water service would be provided along every road in the county (as shown on Kentucky Department of Transportation county highway maps). A line extension cost of $10 per foot was used. This unit cost included auxiliary costs: storage tanks, pump stations, land and rights-of-way, etc. It was assumed that 95 percent of the currently unserved population would be served by the new lines, and that usage would be 100 gpd per person. The costs for additional treatment facilities were calculated as $2.50 per gpd for the total new usage. Legal, administrative, engineering, and contingency costs were estimated at 25 percent of construction costs. Costs per customer were based on 2.50 people per household (Ref. 1).

The total estimated cost for providing full public water service to the county is about $34,800,000. An additional 19,900 people, or 7,500 households, in the county would be provided with 2 mgd of public water by 430 miles of new water lines. The average cost per household for the region would be about $4,600. Within the county, however, some areas will be more cheaply served than others. A prioritization of line extensions based on serving low-cost areas first was beyond the scope of this project. Additional sources of water would be required to meet the additional needs of full public water service. The establishment of a Letcher County Water District would facilitate the expansion of public water service.

Private Water Supplies

<u>Population Served</u>

About 77 percent of the county, or 8,360 households were served by private water supplies in 1994.

<u>Types of Supplies</u>

Based on private water supply usage in 1990 (Ref. 1), it is estimated that about 6,600 (79 percent) of the private supplies were drilled wells, 1,030 (12 percent) were dug wells, and 730 (9 percent) were cisterns, hauled water, or other sources.

<u>Well Contamination</u>

54 percent of the domestic wells tested during 1991-92 were contaminated with fecal coliform. 56 percent of those tested during 1994-95 were contaminated.

<u>Ground Water Quality and Quantity</u>

The majority of ground water in eastern Kentucky is obtained from shallow bedrock wells (less than 100 feet deep) and from shallow dug wells in alluvium. Most of the ground water obtained from bedrock wells is from sandstone aquifers, but in many cases water is contributed from various bedrock types including coal seams. The clays and shales that underlie coal are relatively impermeable and inhibit the vertical movement of water. Therefore, the ground water flows horizontally through the coal seams and other highly conductive layers. Maximum ground water yields are usually derived from wells located in valley bottoms.

Well Water Supplies Near Whitesburg

The Breathitt and Lee formations and rocks of Mississippian and Devonian ages provide ground water to wells near Whitesburg.

In the Breathitt formation, more than three-quarters of the wells drilled in valley bottoms and almost three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gpd). Some wells drilled on hilltops or ridgetops are adequate for a modern domestic supply. Nearly all wells drilled in valleys and on hillsides and hilltops are adequate for a minimum domestic supply (more than 100 gpd). Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Within a four mile radius of Whitesburg, nine drilled wells have been reported with depths ranging from 80 to 225 feet below the ground surface. Seven of the drilled wells produced yields ranging from 25 to 150 gallons per minute (36,000 to 216,000 gpd). The average yield of these seven wells was approximately 64 gallons per minute (92,160 gpd). Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Salty water in drilled wells probably will not be found less than 200 feet below the level of the principal valley bottoms.

In the Lee formation, most wells drilled in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gpd). Nearly all wells drilled in valley bottoms and on hillsides are adequate for a minimum domestic supply (more than 100 gpd). Fewer than three-quarters of the wells drilled on hilltops and ridges are adequate for a minimum domestic supply. About a third of the wells on hilltops and ridges are adequate for a modern domestic supply. Deep wells penetrating the entire thickness of the Lee formation where it exceeds 500 feet in thickness may yield enough water for small municipal or industrial supplies. Most wells dug in valley bottoms and about half the wells dug on hills are adequate for a minimum domestic supply. A few dug wells in valley bottoms and on hills are adequate for a modern domestic supply. Within a four mile radius of Whitesburg, one dug well has been reported with a depth of 22 feet below the ground surface. The dug well produced more than 2 gallons per minute (approximately 2,880 gpd). Ground water obtained from most wells in this area is moderately hard and contains noticeable amounts of iron. Salty water may be found in wells in this area at depths ranging from 50 feet to several hundred feet. Nearly all wells tapping the Lee formation yield salty water where the Lee lies beneath the Breathitt formation and below the principal drainage.

In rocks of Mississippian age, wells drilled below drainage in faulted areas may yield as much as several hundred gallons per minute. Wells that are drilled down-dip from their outcrop on Pine and Cumberland Mountains may yield large quantities of water. Within a four mile radius of Whitesburg, one drilled well has been reported with a depth of 363 feet below the ground surface. This drilled well produced less than 70 gpd (approximately 0.05 gallons per minute).

Devonian age shales yield small amounts of water to wells.

Ground water may be obtained in the alluvium of nearby tributaries. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. A few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

The use of well fields may produce sufficient supplies for small municipal systems.

Well Water Supplies Near Fleming-Neon

The Breathitt and Lee formations and rocks of Mississippian and Devonian ages provide ground water to drilled wells near Fleming-Neon.

In the Breathitt formation, more than three-quarters of the wells drilled in valley bottoms and almost three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gallons per day [gpd]). Some wells drilled on hilltops or ridgetops are adequate for a modern domestic supply. Nearly all wells drilled in valleys and on hillsides and hilltops are adequate for a minimum domestic supply (more than 100 gpd). Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Surrounding Fleming-Neon and Jenkins, 29 drilled wells have been reported with depths ranging from 75 to 325 feet below the ground surface. Nineteen of the drilled wells produced yields ranging from 25 to 330 gallons per minute (36,000 to 475,200 gpd). The average yield of these 19 wells was approximately 175 gallons per minute (252,000 gpd). Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Salty water in drilled wells probably will not be found less than 200 feet below the level of the principal valley bottoms.

In the Lee formation, most wells drilled in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gpd). Nearly all wells drilled in valley bottoms and on hillsides are adequate for a minimum domestic supply (more than 100 gpd). Fewer than three-quarters of the wells drilled on hilltops and ridges are adequate for a minimum domestic supply. About a third of the wells on hilltops and ridges are adequate for a modern domestic supply. Deep wells penetrating the entire thickness of the Lee formation where it exceeds 500 feet in thickness may yield enough water for small municipal or industrial supplies. Ground water obtained from most wells in this area is moderately hard and contains noticeable amounts of iron. Salty water may be found in wells in this area at depths ranging from 50 feet to several hundred feet. Nearly all wells tapping the Lee formation yield salty water where the Lee lies beneath the Breathitt formation and below the principal drainage.

In rocks of Mississippian age, wells drilled below drainage in faulted areas may yield as much as several hundred gallons per minute. Wells that are drilled down-dip from their outcrop on Pine and Cumberland Mountains may yield large quantities of water.

Devonian age shales yield small amounts of water to wells.

Ground water may be obtained in the alluvium of nearby tributaries. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. A few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

The use of well fields may produce sufficient supplies for small municipal systems.

Well Water Supplies Near Blackey

The Breathitt formation provides ground water to drilled wells near Blackey. More than three-quarters of the wells drilled in valley bottoms and almost three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gpd). Some wells drilled on hilltops or ridgetops are adequate for a modern domestic supply. Nearly all wells drilled in valleys and on hillsides and hilltops are adequate for a minimum domestic supply (more than 100 gpd). Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Within a four mile radius of Blackey, three drilled wells have been reported with depths ranging from 43 to 93 feet below the ground surface. One of the drilled wells produced more than 3 gallons per minute (approximately 4,320 gpd). Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Salty water in drilled wells probably will not be found less than 200 feet below the level of the principal valley bottoms.

Ground water may be obtained in the alluvium of the North Fork. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. Few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

The use of well fields may produce sufficient supplies for small municipal systems.

MIDDLE FORK KENTUCKY RIVER BASIN

The Hyden-Leslie Water District in Leslie county is the only municipal water system in the basin (Figure 16). The Middle Fork basin lies within the Kentucky River Area Development District (KRADD). A Long-Range Water Supply Plan (LRWSP, Ref. 4,10) for Leslie County was completed in 1994, and provided much of the information below.

It is projected that the number of residential customers served will be about 40 percent greater by the year 2000, and 60-70 percent greater by the year 2010, both through line extensions to new areas and population growth.

Water supplies for the Hyden-Leslie Water District were considered inadequate for current and anticipated future needs. The District is considering the use of flooded deep mines in the area for additional water.

LESLIE COUNTY

The estimated population of Leslie County in 1994 was 13,810. About 2,660 residents (19%) were provided water by the Hyden-Leslie Water District. The remaining 11,150 residents depended upon small systems or private supplies for their water.

The historical and projected population of Leslie County (Ref. 1) is:

Year	Moderate Growth Rate	High Growth Rate
1980	14,882	14,882
1990	13,642	13,642
1995	13,692	14,000
2000	13,659	14,903
2010	13,637	16,083
2020	13,472	16,795

The moderate growth projection indicates a decline in population of 1.2 percent from 1990-2020, while the high growth projection indicates an 23.1 percent increase over the same period.

Hyden-Leslie Water District

Area Served

There is one significant permitted public water system in Leslie County; Hyden-Leslie County Water District (H-LCWD). The H-LCWD serves the City of Hyden and several areas outside of the city. The existing service area is shown in Figure 17. Hyden withdraws from an impoundment on the Middle Fork of the Kentucky River at mile 75.6, upstream of Buckhorn Lake. The most recent estimated storage of Hyden's Middle Fork impoundment was 16 million gallons by the DOW (Ref. 4,10).

Available Water During Normal Conditions

Water withdrawal permitting program criteria allow up to 10 percent of available water under normal conditions to be withdrawn. "Available" water under normal conditions is defined as 10 percent of the average flow during the month of lowest average monthly flow, September.

A USGS stream gage (gage #03280600) is located on the Middle Fork of the Kentucky River at the Hyden water intake. The average flow at this gage for September is 21 mgd. Ten percent of this value is 2.1 mgd.

Available Water During Low-Flow Conditions

In June, 1988, Hyden was withdrawing the full flow of the Middle Fork. DOW drought response recommendations imply water rationing at that level. On July 5, 1988, 65 percent of the flow was being withdrawn. This corresponds to the emergency phase of water shortage. If the Middle Fork flow falls to 181,000 gpd at a point below the Hyden intake, the city must reduce or cease water withdrawals, according to its permit.

Water withdrawal regulations (and most withdrawal permits) state that withdrawals must be reduced when flows approach the 7-day, 10-year (7Q10) low flow level to protect aquatic life. When 7Q10 flows are experienced for four consecutive days, withdrawals must cease. This minimum stream flow requirement can be waived by the regulatory authority in the case of a governor's declaration of a "water emergency" as occurred in 1988.

Low stream flows at the Hyden gage (and intake) have been estimated to be:

- 7Q10 0.18 mgd
- 7Q20 0.06 mgd

The Hyden intake is upstream of Buckhorn Lake, so the stream flow is not regulated by a reservoir.

Flow Duration

Flow duration data for the USGS station at Hyden is summarized in Table 63. Flow duration data from the USGS indicates that the flow in the river at Hyden has equaled or exceeded 1.09 mgd only 98 percent of the time.

Duration[2] (%)	Discharge, mgd Historical 1958 - 1990
100.0	0.00
99.5	0.06
99.0	0.43
98.0	1.09

[1] From USGS unpublished data.

[2] The percentage of time during the period of record that flow equaled or exceeded the listed value.

Table 63. Flow duration data, Middle Fork of the Kentucky River at Hyden.

System Losses

The total unaccounted water is 34 percent of water withdrawn (Ref. 4,10). Leak losses are probably no more than about 26 percent to 31 percent. This rate of leak loss is high compared to an acceptable value of 15 percent. However, the plant operator felt that the plant flow meter read high and the loss figures may be exaggerated. The operator also believes the losses to be significantly affected by flood damage to lines.

Water Quality

The water quality was reported by water plant staff to be generally good. As at most plants, the chemical use must be increased during high raw water turbidity periods following rainfall. The most difficult water treatment problems occur in low-flow periods and in the fall when leaves fall into the source. There are no other known water quality problems.

The DOW database indicates no significant Public Water Systems violations for the Hyden-Leslie Water District for the period 1/90-10/95.

Potential sources of contamination in the county are given in Tables 68 nd 69 (Ref. 22), with geographic locations shown in Figures 19 and 20. There are no permitted solid waste landfills or hazardous waste handlers in the county. These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

NAME	PERMIT
WB MUNCY ELEM SCH	2455
THOUSANDSTICKS UNITED METH CH	2482
HYDEN STP	1339
MELTONS MHP	1869
KTC LESLIE CO MAINT GARAGE	2641
APPALACHIA MOTEL	1340
ROARK RESIDENCE	2463
HYDEN SHOPPING CTR	1341
HYCO TRAILER PK	1342
LEWIS CONSTRUCTION CO	1343
HYDEN MANOR NURSING HOME	1344
LESLIE CO HIGH/MIDDLE SCH	2588
LESLIE COUNTY HIGH SCH	755
MOORE & BRASHEAR RESIDENCES	2492
HYDEN LESLIE CNTY WTP	754
KY PRINCE COAL COMPANY	2195
HAYES LEWIS ELEM SCH	1874
STINNETT ELEM SCHOOL	2454
SWENTON, MICHAEL J	2305
LEECO INC	22
CYPRUS CUMBERLAND COAL COMPANY	2830

Table 68. Potential sources of pollution, effluent discharge sites, Leslie County.

NAME	PERMIT
HYDEN-LESLIE WATER DISTRICT	650
LEECO #31	954
LEECO	979
CYPRUS CUMBERLAND COAL	1114
SHAMROCK COAL	1036
SHAMROCK COAL	1037
BITUMINOUS-LAUREL MINING	840
CYPRUS CUMBERLAND COAL	1113
CYPRUS CUMBERLAND COAL	1116
SHAMROCK COAL	1154
SHAMROCK COAL	1153
CYPRUS CUMBERLAND COAL	1115

Table 69. Potential sources of pollution, permitted water withdrawers, Leslie County.

Water Supply Adequacy

Based on the low values of 7Q10 and 7Q20, it is concluded that the quantity of water available at the H-LCWD intake is inadequate for current and projected water supply needs. Also, there exists the potential for conflicts between the water use of coal mining operations and that of H-LCWD even under normal stream conditions.

The H-LCWD water system and competing withdrawals are not expected to impact downstream users because there are no permitted users along the Middle Fork of the Kentucky River between Hyden and Buckhorn Lake. However, the Division of Water generally considers it necessary to protect stream flows below the 7Q10 flow rate in order to protect water quality. The H-LCWD would impact downstream 7Q10 flows and possibly water quality.

Recommendations

Additional Water Source

A preliminary feasibility study conducted by engineers for the Kentucky River Area Development District recommended a series of wells constructed in flooded deep mine works as an additional source of water. The deep mines are located approximately 6 miles from the existing treatment plant. The estimated costs are given below.

Water Losses

The estimated cost of repair is divided into two separate estimates: leak survey cost and corrective repair cost (Ref. 4,10).

The leak survey cost estimate was based on the estimated total length of water line for the Hyden-Leslie County system being approximately 61 miles and an estimated leak survey cost of $225 per mile of water line. The estimated leak survey cost for this system was $14,800.

The corrective repair cost estimate was based on data from Georgia and Mississippi leak detection surveys and an estimated $800 to repair each leak. The Georgia and Mississippi leak detection surveys indicated that the average water loss per leak located was approximately 6,000 gpd and that most leaks are small spot repairs. Also, it was assumed that system leak losses could be reduced by 50 percent by conducting a leak survey with follow-up repairs. This assumption was based on experience of the Georgia survey that reported a 53 percent reduction in unaccounted-for water by conducting a leak survey with follow-up repairs. The Mississippi survey reported a 68 percent reduction in unaccounted-for water loss.

Based on an estimated unaccounted-for water loss due to leaks of 145,600 gpd, it was estimated that a leak survey could detect 12 possible leaks. The estimated leak repair cost was $9,600.

The total estimated cost of repair, including the leak survey, for the Hyden-Leslie County system was $24,400.

Estimated Costs

Estimated costs of proposed projects are given in Table 70 (Ref. 16).

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
Alternative Supply Source	Abandoned Deep Mines	$950,000/ N/A	N/A	1
Cutshin Creek	KY 699 along Cutshin Creek to Yeaddiss	$490,000/ 200	$2,500	3
Bob's Fork	US 421 / KY 80 - South of Big Creek to Clay County Line	$210,000/ 140	$2,000	2
Leak Survey/ Repair	Systemwide	$25,000/ N/A	N/A	1
Total Project Cost Estimates		$1,675,000		

Table 70. Estimated project costs, Hyden-Leslie County Water District.

Cost of Full Service

About 11,200 people are currently not served by public water in Leslie County. Cost estimates for providing full public water service in the county were developed. It was assumed that water service would be provided along every road in the county (as shown on Kentucky Department of Transportation county highway maps). A line extension cost of $10 per foot was used. This unit cost included auxiliary costs: storage tanks, pump stations, land and rights-of-way, etc. It was assumed that 95 percent of the currently unserved population would be served by the new lines, and that usage would be 100 gpd per person. The costs for additional treatment facilities were calculated as $2.50 per gpd for the total new usage. Legal, administrative, engineering, and contingency costs were estimated at 25 percent of construction costs. Costs per customer were based on 2.71 people per household (Ref. 1).

The total estimated cost for providing full public water service to the county is about $21,500,000. An additional 10,600 people, or 4,000 households, in the county would be provided with 1.06 mgd of public water by 280 miles of new water lines. The average cost per household for the region would be about $5,400. Within the county, however, some areas will be more cheaply served than others. A prioritization of line extensions based on serving low-cost areas first was beyond the scope of this project. An additional source of water would be required to meet the added needs of full public water service.

Private Water Supplies

Population Served

About 81 percent of the county, or 4,110 households were served by private water supplies in 1994.

Types of Supplies

Based on private water supply usage in the 1990 census, it is estimated that about 3,370 (82 percent) of the private supplies were drilled wells, 360 (9 percent) were dug wells, and 380 (9 percent) were cisterns, hauled water, or other sources.

Well Contamination

53 percent of the domestic wells tested during 1991-92 were contaminated with fecal coliform. 58 percent of those tested during 1994-95 were contaminated (Ref. 23).

Ground Water Quality and Quantity

The majority of ground water in eastern Kentucky is obtained from shallow bedrock wells (less than 100 feet deep) and from shallow dug wells in alluvium. Most of the ground water obtained from bedrock wells is from sandstone aquifers, but in many cases water is contributed from various bedrock types including coal seams. The clays and shales that underlie coal are relatively impermeable and inhibit the vertical movement of water. Therefore, the ground water flows horizontally through the coal seams and other highly conductive layers. Maximum ground water yields are usually derived from wells located in valley bottoms.

In the Breathitt formation northwest of Hyden, most wells drilled in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply (more that 500 gallons per day [gpd]). Nearly all wells drilled in valleys and more than three-quarters of the wells drilled on hillsides are adequate for a minimum domestic supply (more than 100 gpd). Wells drilled on hilltops and ridges yield smaller quantities of water. Within a 4 mile radius of Hyden, six drilled wells have been reported with depths ranging from 40 to 150 feet below the ground surface. One of the drilled wells produced 16 gallons per minute (23,040 gpd). Ground water obtained from most drilled wells in this area is extremely hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms.

In the Breathitt formation southeast of Hyden, more than three-quarters of the wells drilled in valley bottoms and about three-quarters of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gpd). Some wells drilled on hilltops or ridgetops are adequate for a modern domestic supply. Nearly all wells drilled in valleys and on hillsides and hilltops are adequate for a minimum domestic supply (more than 100 gpd). Drilled wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. Within a 4 mile radius southeast of Hyden, two drilled wells have been reported with depths ranging from 49 to 80 feet below the ground surface. One of the drilled wells produced 540 gpd (approximately 0.4 gallons per minute). Ground water obtained from most drilled wells in this area is moderately hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms.

Ground water may be obtained in the alluvium of the Kentucky River. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a modern domestic supply. A few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

Ground water supplies in Leslie County do not have the potential to provide significant municipal supplies.

SOUTH FORK KENTUCKY RIVER BASIN

The South Fork basin lies within the Kentucky River Area Development District (KRADD) and the Cumberland Valley Area Development District (CVADD). Most of the basin lies within Owsley and Clay counties (Figure 20). A Long-Range Water Supply Plan (LRWSP, Ref. 8,15) for Owsley county in the KRADD was completed in 1994, and preliminary data for a LRWSP (Ref. 17) for Clay County has been gathered by the CVADD. These documents and data provided much of the information below.

About 28,200 people lived in the region in 1994. 12,550 people received their water from municipal supplies, 12,500 from drilled wells, 1,900 from dug wells, and 1,250 from small systems, cisterns, hauled water, and other sources.

Population projections with moderate and high growth assumptions for the region given in Table 71 (Ref. 1).

Year	Moderate Growth	High Growth
1980	28,461	28,461
1990	26,782	26,782
1995	26,675	28,365
2000	26,573	29,327
2010	26,569	30,554
2020	26,309	30,724

Table 71. Population projections for the South Fork Kentucky River region.

Moderate growth, in fact, projects a 1.8 percent decline in regional population from 1990 to the year 2020. High growth assumptions project a 14.7 percent increase in population over the same period. The population dynamics are not uniform over the basin, however. As shown in Table 72, Owsley county's population projections differ markedly under the different assumptions.

County	Percent Change 1990-2020 Moderate Growth	Percent Change 1990-2020 High Growth
Owsley	-16	18
Clay	-1	14

Table 72. Projected relative changes in population, Owsley and Clay counties.

The projected growth in the number of residential customers served, both through line extensions to new areas and population growth, as a percentage of 1994 service, is shown in Table 73.

	Percentage Growth in Residential Customer Service[1] Year moderate/high		
SYSTEM	2000	2010	2020
Booneville Water & Sewer	7/20	20/32	20/35
Manchester Water Works	2	4/7	4/7
Hima-Sibert Water District	56	57/62	57/62
North Manchester Water District	29	30/35	30/35
REGION	15/17	18/24	18/25

[1] As a percentage of 1994 service level.

Table 73. Residential service forecast, South Fork Kentucky River basin.

Water supplies for Booneville Water & Sewer and Manchester Water Works were considered inadequate for current and future needs. Booneville was considering a new intake in Kentucky River Pool 14 as the most feasible source of reliable water. Manchester had not begun an evaluation of additional supply. Water losses for all systems was less than 15 percent.

OWSLEY COUNTY

The estimated population of Owsley County in 1994 was 5,410. 2,760 residents (51%) were on the Booneville Water & Sewer system, and 2,650 residents depended on small systems or private supplies for their water.

The historical and projected population of Owsley County (Ref. 1) is:

Year	Moderate Growth Rate	High Growth Rate
1980	5,709	5,709
1990 (census)	5,036	5,036
1995	4,874	5,449
2000	4,722	5,624
2010	4,482	5,842
2020	4,258	5,958

The moderate growth projection indicates a decline in population of 16 percent from 1990-2020, while the high growth projection indicates an 18 percent increase over the same period.

Booneville Water & Sewer

Area Served

There is one significant public water system in Owsley County, Booneville Water & Sewer District which is owned and operated by the City of Booneville. The Booneville system serves the City of Booneville and the central part of Owsley County (Figure 21). The city withdraws water at river mile 12.6 of the South Fork of the Kentucky River (Figure 7).

Available Water During Normal Conditions

A USGS gage is located on the South Fork of the Kentucky River at Booneville (gage #03281500), downstream of the water treatment plant. The average flow during the month of lowest average monthly flow at the Booneville USGS gage is 87 million gallons per day (mgd), in September. Ten percent of this value is 8.7 mgd.

Available Water During Low-Flow Conditions

Low stream flows at the Booneville gage have been estimated to be:

- 7Q10 0.65 mgd
- 7Q20 0.32 mgd

Flow Duration

Flow duration data for the USGS station at Booneville is summarized in Table 74 (Ref. 8). Historical flow duration information indicates that the flow has equaled or exceeded 0.30 mgd 99.5 percent of the time during the historical monitoring periods of 1926 - 1931 and 1940 - 1990.

	Discharge, mgd
Duration[2] (%)	Unregulated/Historical 1926-1931, 1940-1990
100.0	0.00
99.5	0.30
99	0.74
98	2.41

[1] From USGS unpublished data.
[2] The percentage of time during the period of record that flow equaled or exceeded the listed value.

Table 74. Flow duration data, Booneville gage.

Historical Water Use

The historical water use for the Booneville system is shown in Table 75.

Gallons Per Day				Customers		
Type of User	1986	1990	1994[1]	1986	1990	1994[1]
Residential	112,100	194,000	240,700	806	936	1,166
Commercial	8,800	9,600	9,600	18	19	19
Institutional	13,600	16,000	16,000	4	4	4
Industrial	0	0	0	0	0	0
Public	700	1,100	1,100	--	--	--
Subtotal	135,200	220,700	267,400			
Unaccounted	3,900	6,300	41,600			
Total	139,100	227,000	309,000	828	959	1,189

[1] Estimated values except for Total.

Table 75. Historical water use, Booneville Water & Sewer District.

Projected Water Use

Residential Water Use Forecast

The City of Booneville is currently in the process of extending lines to the Island City, Stay, and Judd Road areas to about 200 customers. An extension of lines to the Cowcreek, Arnett, Ricetown, and Gabbard areas to about 183 customers was in the planning stages.

Other potential line extensions are to the areas of Endee and Major to about 80 customers.

If the population declines, future increases in water use will primarily come from expansion of the service area to serve more existing homes in rural areas of the county. With the projected high growth rate, future increases in water use would occur through system expansion and through population growth.

The residential service forecast is shown in Table 76.

Commercial Water Use Forecast

Changes in commercial activity are generally expected to be in direct proportion to population change.

Institutional Water Use Forecast

The institutional water use is expected to change during the planning period (2000 - 2020) in proportion to population.

Industrial Water Use Forecast

Owsley County does not have an industrial park. However, an allowance of about 10 percent of other projected year 2010 water uses was made to allow for industrial development.

It is generally expected that relatively light industry, requiring only moderate amounts of process water, would come to Owsley County. This type of industry might include fabrication, metal processing, painting, and assembly. Typical design values for estimating water use from this type of industry are 1,000 to 1,500 gallons per acre per day. At a typical water use of 1,500 gallons per acre per day, this represents the development and occupancy of a 21 acre industrial park during the planning period.

	Projected Number of Residential Customers[1] Year moderate/high		
	2000	2010	2020
Existing Service Area	936/1,045	936/1,086	936/1,107
Island City/Stay/Judd Road	200	200	200
Cowcreek/Arnett/ Ricetown/Gabbard Areas	155	183	183
Endee/Major Areas	0	80	80
Total Residential Customers	1,291/1,400	1,399/1,537	1,399/1,570
Projected Served Population[2]	3,100/3,360	3,360/3,690	3,360/3,770

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period

[2] Based on the number of customers and on 2.4 persons per household in Owsley County from the 1990 census.

Table 76. Residential service forecast, Booneville Water & Sewer District.

Combined Water Use Forecast

The combined water use forecast is shown in Table 77.

The actual peak average monthly withdrawal for the Booneville system has been about 1.2 times the average annual withdrawal. A peak daily withdrawal of 1.5 times annual average withdrawal was used for estimating peak demands during drought conditions.

The annual average water withdrawal of Booneville Water and Sewer District is projected to increase from 309,000 gpd in 1994 to 406,000 - 449,000 gpd in 2020 depending upon population growth. The increase in demands with moderate growth are primarily due to extension of water lines. The peak daily water withdrawal was estimated to increase from 463,500 gpd in 1994 to 609,000 gpd with moderate growth or 674,000 gpd with high growth in 2020.

Competing Uses

About 250 acres of cropland is irrigated in Owsley County (Ref 8,15). Approximately 200 acres are used for tobacco, 25 acres for vegetables, and 25 acres for plant beds. At a typical irrigation rate of 120,000 gallons per acre per month, irrigation use is about 1 mgd. Therefore, agriculture water use can be a significant competing use during low flow conditions. It is estimated that 85 percent of the irrigated land lies in the area above the Booneville intake. There are no other known competing uses that could impact water availability.

Average Water Use gpd		Projected Water Use, gpd Year moderate/high		
	1994	2000	2010	2020
Residential[1]	240,700	266,500/289,000	288,800/317,200	290,000/324,000
Commercial	9,600	9,600/10,400	10,400/11,400	10,400/11,700
Institutional	16,000	16,000/17,300	17,300/19,000	17,300/19,400
Industrial	0	16,000	32,000	32,000
Public[2]	1,100	1,500/1,620	1,600/1,800	1,600/1,800
Subtotal - Water Sold	267,400	309,600/334,320	350,100/381,400	351,300/388,900
Unaccounted[3]	41,600	48,200/52,000	54,500/59,300	54,700/60,500
Total - Water Withdrawn	309,000	357,800/386,300	404,600/440,700	406,000/449,000
Peak Daily Demand[4], gpd	463,500	537,000/579,000	607,000/661,000	609,000/674,000

[1] Based on a per capita water use of 86 gallons per person per day and the population projections in Table 76.
[2] Fire protection, estimated to increase in proportion to the number of customers.
[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1990.
[4] Peak daily demand equals 1.5 times average annual demand.

Table 77. Combined water use forecast, Booneville Water & Sewer District.

Infrastructure Assessment

Existing Treatment and Total Distribution System Capacity

The Booneville water treatment plant, constructed in 1986 and renovated in 1988, has a design capacity of 864,000 gpd. The operator reports that it is capable of producing 600,000 gpd of "good" finished water (Ref. 8,15).

The Booneville water distribution system has an estimated capacity of 536,000 gpd. This estimate is based on the existing storage tank capacity (excluding clearwell storage) of 536,000 gallons and a criteria of one-day minimum allowable storage. It is believed that this is a good indication of the design capacity of the overall distribution system.

Intake Limitations

The existing intake is located on the South Fork of the Kentucky River. The intake is in a natural pool of the river. Extreme low flow conditions produce the only known limitation on the intake and may result in difficulty due to shallow intake submergence.

System Losses

The total unaccounted water was estimated to be 13.5 percent of water withdrawn in 1994 (Ref. 8,15). This rate of loss is below an acceptable rate of about 15 percent and should not pose a problem for the Booneville system.

Water Quality

The overall quality of Booneville's source of water is reported as being good. The only quality concerns arise in the fall season when leaves fall into the river and make the water hard to treat due to high turbidity. The higher turbidity levels result in increased chemical usage to treat the raw water. There are no other known quality problems.

System violations as reported by the Kentucky Division of Water for the period 1990-October, 1995 are shown in Table 78 (Ref. 20). M/R are monitoring and reporting (administrative) violations.

Violation Date	Violation Type	Contaminant
July, 1992	Initial Pb/Cu Tap M/R	Pb/Cu
January, 1993	Initial Pb/Cu Tap M/R	Pb/Cu
October, 1994	Regular sampling	Nitrates
September, 1995	Minor M/R	Bacteria
September, 1995	SWTR M/R Filtered	Turbidity

Table 78. Public water systems violations, Booneville Water & Sewer District.

Potential sources of contamination in the county are given in Tables 79-81 (Ref. 22), with geographic locations shown in Figure 22. There are no permitted solid waste landfills in the county. These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

NAME	PERMIT
CAMP BRENT LANEER	2737
BOONEVILLE STP	1034
SEARCY & STRONG FUNERAL HOME	1679

Table 79. Potential sources of pollution, effluent discharge sites, Owsley County.

NAME	PERMIT
UNITED PARCEL SERVICE CONSOLIDATED BILLING CENTER	3322

Table 80. Potential sources of pollution, hazardous waste handlers, Owsley County.

NAME	PERMIT
BOONEVILLE WATER & SEWER	752

Table 81. Potential sources of pollution, permitted water withdrawers, Owsley County.

Water Supply Adequacy

The 1994 average withdrawal of 309,000 gpd gives the Booneville system a drought classification of B, indicating possible shortages during drought conditions. With no measures taken, the system would have a drought classification of C before the year 2000, indicating that the system would be likely to have water shortage during drought. Also, agriculture could be a major competing use during drought conditions.

Recommendations

Additional Water Source

In order to insure an adequate supply during drought periods, the construction of a new intake in Kentucky River Pool 14 near Beattyville was proposed as the most feasible alternative (Ref. 16). Additional tank storage would also be required by the year 2000.

The Long Range Water Supply Plan for the Booneville system identified two water line extension projects for the areas of Endee/Major and Cow Creek, which would add approximately 260 customers to the service area.

Estimated Costs

Estimated costs for proposed projects are given in Table 82 (Ref. 16).

Project	Location	Est. Project Cost/ No. Customers	Cost per Customer	Priority
Water Supply	Pool 14, North Fork of the Kentucky River	$1,400,000/ N/A	N/A	1
Endee/Major	Along KY 2025 Including Endee and Major	$490,000/ 80	$6,000	3
Cow Creek	Cow Creek, Arnett, Ricetown, Gabbard	$1,000,000/ 180	$6,000	2
Total Project Cost Estimates		$2,890,000		

Table 82. Estimated project costs, Booneville Water & Sewer District.

Cost of Full Service

About 2,650 people are currently not served by public water in Owsley County. Cost estimates for providing full public water service in the county were developed. It was assumed that water service would be provided along every road in the county (as shown on Kentucky Department of Transportation county highway maps). A line extension cost of $10 per foot was used. This unit cost included auxiliary costs: storage tanks, pump stations, land and rights-of-way, etc. It was assumed that 95 percent of the currently unserved population would be served by the new lines, and that usage would be 100 gpd per person. The costs for additional treatment facilities were calculated as $2.50 per gpd for the total new usage. Legal, administrative, engineering, and contingency costs were estimated at 25 percent of construction costs. Costs per customer were based on 2.40 people per household (Ref. 1).

The total estimated cost for providing full public water service to the county is about $12,500,000. An additional 2,520 people, or 950 households, in the county would be provided with 0.25 mgd of public water by 180 miles of new water lines. The average cost per household for the region would be about $13,000. Within the county, however, some areas will be more cheaply served than others. A prioritization of line extensions based on serving low-cost areas first was beyond the scope of this project.

Private Water Supplies

Population Served

About 49 percent of the county, or 1,120 households were served by private water supplies in 1994.

Types of Supplies

Based on private water usage in the 1990 census, it is estimated that about 800 (71 percent) of the private supplies were drilled wells, 200 (18 percent) were dug wells, and 120 (11 percent) were cisterns, hauled water, or other sources.

Well Contamination

Two out of three wells tested in Owsley County from July 1, 1991 through June 30, 1992 were found to be contaminated with fecal coliform. For the period July 1, 1994 through June 30, 1995, three out of four tested wells were found to be contaminated with fecal coliform (Ref. 23).

Ground Water Quality and Quantity

The majority of ground water in eastern Kentucky is obtained from shallow bedrock wells (less than 100 feet deep) and from shallow dug wells in alluvium. Most of the ground water obtained from bedrock wells is from sandstone aquifers, but in many cases water is contributed from various bedrock types including coal seams. The clays and shales that underlie coal are relatively impermeable and inhibit the vertical movement of water. Therefore, the ground water flows horizontally through the coal seams and other highly conductive layers. Maximum ground water yields are usually derived from wells located in valley bottoms.

The Breathitt and Lee formations provide ground water to drilled wells near Booneville.

In the Breathitt formation which intermittently surrounds Booneville, most wells drilled in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gallons per day [gpd]). Nearly all wells drilled in valleys and more than three-quarters of the wells drilled on hillsides are adequate for a minimum domestic supply (more than 100 gpd). Wells drilled on hilltops and ridges yield smaller quantities of water. Within a 4 mile radius of Booneville, two drilled wells have been reported with depths ranging from 26 to 47 feet below the ground surface, no yield was reported for either well. Ground water obtained from most drilled wells in this area is extremely hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms.

In the Lee formation north of Booneville, about three-quarters of the wells drilled on hilltops and ridgetops are adequate for a minimum domestic supply (more than 100 gpd). Some wells yield enough water for a modern domestic supply (more than 500 gpd). Within a 4 mile radius of Booneville, two drilled wells have been reported with depths ranging from 59 to 87 feet below the ground surface, the actual yield of the wells was not reported. However, these wells reportedly yield adequate amounts of water for their purpose with a hand-powered pump-bucket, bailer, pitcher, or force. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms.

In the Lee formation which partially surrounds Booneville, most wells drilled in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply (more than 500 gpd). Nearly all wells drilled in valley bottoms and on hillsides are adequate for a minimum domestic supply (more than 100 gpd). Fewer than three-quarters of the wells drilled on hilltops and ridges are adequate for a minimum domestic supply. About a third of the wells on hilltops and ridges are adequate for a modern domestic supply. Deep wells penetrating the entire thickness of the Lee formation where it exceeds 500 feet in thickness may yield enough water for small municipal or industrial supplies. Within a 4 mile radius of Booneville, ten drilled wells have been reported with depths ranging from 18 to 363 feet below the ground surface. Five of the drilled wells produced yields ranging from 4 to 10 gallons per minute (5,760 to 14,400 gpd). Ground water obtained from most wells in this area is moderately hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below the level of the principal valley bottoms. Nearly all wells tapping the Lee formation yield salty water where the Lee lies beneath the Breathitt formation and below the principal drainage.

Ground water may be obtained in the alluvium of the South Fork. Nearly all wells in the alluvium in this area are dug. Most dug wells are adequate for a minimum domestic supply. A few are adequate for a modern domestic supply. Screened drilled wells probably can be developed in the alluvium where sands are present and the saturated thickness is at least several feet. However, few screened wells have been developed in the alluvium because they are expensive and probably would yield small amounts of water.

One large producing well has been identified in Owsley County. Overall, however, wells in Owsley County do not have the potential to provide significant municipal supplies.

CLAY COUNTY

The estimated population of Clay County in 1994 was 22,776 (Ref. 1). About 9,790 residents (43%) were provided water by the Manchester Water Works either directly (6,110) or indirectly through the Hima-Sibert Water District (1,300) or the North Manchester Water District (2,380). The remaining 12,986 residents depended on small systems or private supplies for their water.

The historical and projected population of Clay County (Ref. 1) is:

Year	Moderate Growth Rate	High Growth Rate
1980	22,752	22,752
1990	21,746	21,746
1995	21,801	22,916
2000	21,851	23,703
2010	22,087	24,712
2020	22,051	24,770

The moderate growth projection indicates a growth in population of 1.4 percent from 1990-2020, while the high growth projection indicates an 13.9 percent increase over the same period.

Manchester Water Works - Hima-Sibert Water District - North Manchester Water District

Area Served

Manchester is located in the headwaters of the South Fork of the Kentucky River, far from the mainstem. Manchester Water Works supplies water to the city and the central section of Clay County. The existing service area is shown in Figure 23. The city has a water intake in Bert Combs Lake, a 936 acre-foot impoundment of Beech Creek. The drainage area at the dam is 41.2 square miles (Ref. 48). Alternative sources are a permanent intake at mile 19.5 of Goose Creek upstream of the new sewage treatment plant, and one well at the filtration plant, just downstream from Bert Combs Lake. Manchester Water Works sells water to the Hima-Sibert Water District and to the North Manchester Water Association. Hima-Sibert has 17 customers in Laurel County, and buys some water from the Woods Creek Water District in Laurel County.

Available Water During Normal Conditions

The capacity of Bert Combs Lake is 305 million gallons. The average flow at the Goose Creek intake for September, the month of lowest average flow, is approximately 32 mgd (Ref. 41), so average available flow is 3.2 mgd. The specific capacity of the well is 144,000 gpd.

Available Water During Low-Flow Conditions

Lake levels in Bert Combs Lake dropped 8 to 10 feet during the 1988 drought (Ref. 2). The DOW estimated at that time that 150 to 220 days supply still remained in the lake. In September, 1988, water was pumped form Goose Creek to refill the lake. Average daily withdrawals from the lake in 1994 were 1.529 mgd. At that rate of withdrawal, the total storage in the lake represents 199 days supply. The 7Q10 on Goose Creek near the Manchester intake is about 485,000 gpd. Withdrawals from Goose Creek in 1994 were 573,000 gpd, or 118 percent of the 7Q10. The safe yield of the well is 100,000 gpd.

Historical Water Use

Average daily withdrawals from Bert Combs Lake have increased from .898 mgd in 1990 to 1.529 mgd in 1994. Average withdrawals from Goose Creek have increased from .295 mgd in 1992 to .573 mgd in 1994. Water use from the Clay County Water Supply Plan is shown in Table 83 (Ref. 17).

	Gallons per day				Customers			
Type of User	MANCHESTER	HIMA-SIBERT	NORTH MANCHESTER	Total GPD	MANCHESTER	HIMA-SIBERT	NORTH MANCHESTER	TOTAL CUSTOMERS
Residential	994,000	93,333	180,000	1,267,333	1,784	457	794	3,035
Commercial	392,000	6,667	37,567	436,234	206	26	15	247
Industrial	13,333	0	6,667	20,000	10	0	1	11
Subtotal	1,399,333	100,000	224,234	1,723,567				
Unaccounted	105,326	16,279	33,506	155,111				
Total	1,504,659	116,279	257,740	1,878,678	2,000	483	810	3,293

Data from Clay County Water Supply Plan

Table 83. Water use, Manchester, Hima-Sibert, North Manchester Water Districts.

Estimated disaggregated water use for 1994 is given in Table 84.

	Gallons per day				Customers			
Type of User	MANCHESTER	HIMA-SIBERT	NORTH MANCHESTER	Total GPD	MANCHESTER	HIMA-SIBERT	NORTH MANCHESTER	Total Customers
Residential	507,000	97,000	197,000	801,000	2,230	474	868	3,572
Commercial	495,000	7,000	38,000	540,000	260	26	15	247
Industrial	13,000	0	7,000	20,000	10	0	1	11
Institutional and Other	675,000	0	0	675,000				
Subtotal	1,690,000	104,000	242,000	2,036,000				
Unaccounted	100,000	16,900	36,100	153,000				
Total	1,790,000	120,900	278,100	2,189,000[1]	2,500	500	884	3,884

[1] Total from Kentucky Division of Water records.

Table 84. Estimated 1994 water use, Manchester, Hima-Sibert, North Manchester Water Districts.

Projected Water Use

Residential Water Use Forecast

Line extension during the next five years are expected to add 1,093 residential customers to the system: Manchester, 500; Hima-Sibert, 281; and North Manchester, 312 (Ref. 17). Additional growth in residential service will depend upon population growth. The residential service forecast is shown in Table 85.

	Projected Number of Residential Customers[1] Year moderate/high		
	2000	2010	2020
Manchester Water Works	2,284	2,310/2,380	2,310/2,390
Hima-Sibert Water District	738	745/770	745/770
North Manchester Water Association	1,122	1,130/1,170	1,130/1,170
Total Residential Customers	4,144	4,185/4,320	4,185/4,330
Projected Served Population[2]	11,350	11,470/11,840	11,470/11,860

[1] In some cases, all customers are not expected to connect to the water line when it becomes available. The initially unconnected homes are projected to be connected during the planning period

[2] Based on the number of customers and on 2.74 persons per household in Clay County from the 1990 census.

Table 85. Residential service forecast, Manchester, Hima-Sibert, North Manchester Water Districts.

Commercial Water Use Forecast

Manchester Water Works expects to add 60 new commercial customers during the next five years. Additional growth in commercial service will depend upon population growth.

Industrial Water Use Forecast

No additional industrial water use was anticipated.

Combined Water Use Forecast

The combined water use forecast is show in Table 86. The annual average water withdrawal of the Manchester Water Works is expected to increase from 2,189,000 gpd in 1994 to 2,354,000 - 2,559,000 gpd in 2020, depending upon population growth. A peak daily withdrawal of 1.5 times average daily withdrawal was used for estimating peak demands during drought conditions. The peak daily water withdrawal is estimated to increase from 3,284,000 gpd to 3,531,000 - 3,838,000 gpd depending upon population growth.

Competing Uses

There is no competing use from agricultural irrigation.

Mountain Clay Inc. has a permitted withdrawal of 0.042 mgd at mile 25.0 of Goose Creek, but, according to records at the Kentucky Division of Water, no water has been withdrawn since 1985.

	Average Water Use gpd	Projected Water Use, gpd[6] Year moderate/high		
	1994	2000	2010	2020
Residential[1]	801,000	942,000/980,000	942,000/1,022,000	942,000/1,024,000
Commercial	540,000	552,000/574,000	552,000/599,000	552,000/600,000
Industrial	20,000	20,000/20,000	20,000/22,000	20,000/22,000
Institutional and Other	675,000	675,000/702,000	675,000/732,000	675,000/734,000
Subtotal - Water Sold	2,036,000	2,189,000/2,276,000	2,189,000/2,375,000	2,189,000/2,380,000
Unaccounted[3]	153,000	165,000/171,000	165,000/178,000	165,000/179,000
Total - Water Withdrawn	2,189,000	2,354,000/2,447,000	2,354,000/2,553,000	2,354,000/2,559,000
Peak Daily Demand[4], gpd	3,284,000	3,531,000/3,670,000	3,531,000/3,830,000	3,531,000/3,838,000

[1] Based on the 1992 per capita water use of about 83 gallons per person per day and the population projections in Table 85.
[2] Fire protection and other public water use is estimated to increase in proportion to the number of customers.
[3] Unaccounted water (leaks, main breaks, tank overflows, and filter backwash when not reused)is projected to remain at the same percentage of metered water as in 1992.
[4]Peak daily demand equals 1.5 times average annual demand.
[6] Includes Hima-Sibert and North Manchester

Table 86. Combined water use forecast, Manchester Water Works.

Infrastructure Assessment

Existing Treatment

The Manchester treatment plant was constructed in 1992 and has a capacity of 2.3 mgd.

Intake Limitations

None noted.

System Losses

Water losses for each system are: Manchester, 7%; Hima-Sibert, 14%; North Manchester, 13 %.

Water Quality

Raw water quality was reported as good.

System violations as reported by the Kentucky Division of Water for the period 1990-October, 1995 are shown in Table 87. M/R are monitoring and reporting (administrative) violations.

System	Violation Date	Violation Type	Contaminant
Hima-Sibert	February, 1993	Major M/R	Bacteria
Hima-Sibert	January, 1994	Initial Pb/Cu Tap M/R	Pb/Cu
North Manchester	May, 1991	Regular sampling	Bacteria
Manchester	July, 1992	Initial Pb/Cu Tap M/R	Pb/Cu
Manchester	October, 1992	Minor M/R	Bacteria
Manchester	April, 1993	Regular sampling	Nitrates
Manchester	January, 1994	Regular sampling	Nitrates

Table 87. Public water systems violations, Hima-Sibert, North Manchester, and Manchester Water Districts.

Potential sources of contamination in the county, as reported by the Kentucky Natural Resources and Environmental Protection Cabinet are given in Tables 88-91 (Ref. 22) and shown in Figure 24 by location. These potential sources of pollution obviously differ in type and degree of threat presented. No attempt was made in this study to evaluate the relative risks of each potential source.

NAME	PERMIT
MANCHESTER LANDFILL	151
HELTON SANITATION INC.	152

Table 88. Potential sources of pollution, sanitary landfills, Clay County.

NAME	PERMIT
MANCHESTER WATER WORKS	1027
MANCHESTER WATER WORKS	418
MANCHESTER WATER WORKS	1217
MOUNTAIN CLAY INC.	937

Table 89. Potential sources of pollution, permitted water withdrawers, Clay County.

NAME	PERMIT
MID SOUTH ELECTRICS INC	9
KENTUCKY UTILITIES CO	2248
MEMORIAL HOSPITAL INC	1323
SUPERAMERICA 5551	3092
DRY CLEANING PLUS	1366
KENTUCKY MOUNTAIN INDUSTRIES INC	1158

Table 90. Potential sources of pollution, hazardous waste handlers, Clay County.

NAME	PERMIT
MID SOUTH ELECTRICS INC	53
ONEIDA BAPTIST INST	1579
LAURA LOU MHP	1490
LAUREL CREEK ELEM SCH	1491
CLAY COUNTY AREA VOC CTR	466
KY MOUNTAIN HOUSING DEV CORP	2208
LAUREL CREEK HEALTH CARE CTR	1494
KTC CLAY CO MAINT GARAGE	2658
BIG CREEK ELEM SCH	1025
MANCHESTER STP	1488
MANCHESTER RECREATIONAL CTR	1495
MANCHESTER WTP	1487
HACKER ELEM SCH	1492
SHAMROCK COAL CO/CLOVER DIV	101
SHAMROCK COAL CO/CLOVER DIV	102
MOUNTAIN CLAY INC GOOSE CRK	519
GOOSEROCK ELEM SCH	1493
RED BIRD MISSION HIGH & ELEM SCH	2386
RED BIRD MISSION HOSPITAL	2123
ANDALEX RESOURCES	16

Table 91. Potential sources of pollution, permitted effluent discharge sites, Clay County.

Water Supply Adequacy

At current and projected usage rates, the Manchester system falls in drought classification B, i.e. it is susceptible to water shortage during drought.

Recommendations

Additional Water Source

Begin feasibility study of alternative sources of additional water.

Cost of Full Service

About 13,000 people are currently not served by public water in Clay County. Cost estimates for providing full public water service in the county were developed. It was assumed that water service would be provided along every road in the county (as shown on Kentucky Department of Transportation county highway maps). A line extension cost of $10 per foot was used. This unit cost included auxiliary costs: storage tanks, pump stations, land and rights-of-way, etc. It was assumed that 95 percent of the currently unserved population would be served by the new lines, and that usage would be 100 gpd per person. The costs for additional treatment facilities were calculated as $2.50 per gpd for the total new usage. Legal, administrative, engineering, and contingency costs were estimated at 25 percent of construction costs. Costs per customer were based on 2.74 people per household (Ref. 1).

The total estimated cost for providing full public water service to the county is about $33,500,000. An additional 12,300 people, or 4,700 households, in the county would be provided with 1.23 mgd of public water by 450 miles of new water lines. The average cost per household for the region would be about $7,200. Within the county, however, some areas will be more cheaply served than others. A prioritization of line extensions based on serving low-cost areas first was beyond the scope of this project. The added water needs of full public service should be considered as new sources of supply are developed in the county.

Private Water Supplies

Population Served

About 57 percent of the county, or 4,740 households were served by private water supplies in 1994.

Types of Supplies

Based on private water supply usage in the 1990 census, it is estimated that about 3,860 (81 percent) of the private supplies were drilled wells, 520 (11 percent) were dug wells, and 360 (8 percent) were cisterns, hauled water, or other sources.

Well Contamination

72 percent of the domestic wells tested during 1991-92 were contaminated with fecal coliform. 67 percent (only 3 wells tested) of those tested during 1994-95 were contaminated (Ref. 23).

Ground Water Quality and Quantity

The Breathitt and Lee formations provide ground water to drilled wells near Manchester.

Most wells drilled in the southeastern part of the county (between Bell and Leslie counties) in the Breathitt formation located in valley bottoms are adequate for a modern domestic supply. About three quarters of wells located on hillsides and some wells located on hilltops or ridges are adequate for a modern domestic supply. Nearly all wells in this formation are adequate for a minimum domestic supply. Wells more than 200 feet deep in valleys may yield enough water for small municipal or industrial supplies. No wells were reported within this subarea in Clay County. Ground water obtained from most wells in this area is moderately hard and contains noticeable amounts of iron. Salty water will generally not be found in wells less than 200 feet below the principal valley bottoms.

For the remainder of the county, most drilled wells in the Breathitt formation located in valley bottoms are adequate for a modern domestic supply (more than 500 gallons per day). Less than half of the wells drilled on hillsides are adequate for a modern domestic supply. Nearly all wells located in valleys and over three quarters of wells drilled on hillsides are adequate for a minimum domestic water supply (more than 100 gallons per day). Wells located on hilltops and ridges yield lesser quantities of water. Within a 4 mile radius of Manchester, one well was reported having a depth of 21 feet. No yield was reported for the well. Ground water obtained from most wells in this area is extremely hard and contains noticeable amounts of iron. Salty water may be found in wells less than 100 feet below principal valley bottoms.

Most drilled wells in the Lee formation in valley bottoms and fewer than half of the wells drilled on hillsides are adequate for a modern domestic supply. About a third of wells on hilltops and ridges are adequate for a modern domestic supply. Nearly all wells in valley bottoms and on hillsides are adequate for a minimum domestic supply. Fewer than 75% of wells in hilltops and ridges are adequate for a minimum domestic supply. Deep wells penetrating the entire thickness of the Lee formation where it exceeds 500 feet in thickness may yield enough water for small municipal or industrial supplies. Within a 4 mile radius of Manchester, five wells have been reported with depths ranging from 25 to 105 feet. Yields from two of the wells were estimated to be 5 and 10 gallons per day, respectively. Ground water obtained from most of the wells in this area is moderately hard and contains noticeable amounts of iron. Salty water may be found in wells drilled less than 100 feet below principal valley bottoms. Nearly all wells tapping the Lee formation yield salty water where the Lee lies beneath the Breathitt formation and below the principal drainage.

EVALUATION OF WATER SUPPLIES IN THE UPPER FORKS OF THE KENTUCKY RIVER BASIN

DATA SOURCES

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3. Kentucky River Area Development District, Mr. Paul E. Hall, Executive Director, Hazard, KY.

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5. Final Plan Document, Long Range Water Supply Plan, Letcher County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1993.

6. Final Plan Document, Long Range Water Supply Plan, Perry County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1993.

7. Final Plan Document, Long Range Water Supply Plan, Breathitt County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1993.

8. Final Plan Document, Long Range Water Supply Plan, Owsley County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1993.

9. Final Plan Document, Long Range Water Supply Plan, Knott County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1993.

10. Phase II Final Plan Document, Long Range Water Supply Plan, Leslie County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1994.

11. Phase II Final Plan Document, Long Range Water Supply Plan, Perry County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1994.

12. Phase II Final Plan Document, Long Range Water Supply Plan, Breathitt County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1994.

13. Phase II Final Plan Document, Long Range Water Supply Plan, Knott County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1994.

14. Phase II Final Plan Document, Long Range Water Supply Plan, Letcher County, Kentucky, Kentucky River Area Development District and Commonwealth Technology, Inc., 1994.

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17. Clay County, Kentucky, Water Supply Planning, Cumberland Valley Area Development District, Tammy R. Brown, London, KY.

18. Water Withdrawal Permit File, Kentucky Division of Water, 1994.

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32. Fleming-Neon Water System, Mr. David Maggard, Fleming-Neon, KY.

33. Hindman Municipal Water Works, Mr. Michael Webb, Hindman, KY.

34. Jackson Municipal Water, Mr. Darrell King, Jackson, KY.

35. Vicco Water System, Mr. Dean Feltner, Vicco, KY.

36. Booneville Water & Sewer, Mr. Jolly Cooper, Booneville, KY.

37. Hazard Water Works, Mr. Paul Feltner, Hazard, KY.

38. Hyden-Leslie County Water, Mr. Don Roark, Hyden, KY.

39. Whitesburg Municipal Water Works, Mr. Steve Taylor, Whitesburg, KY.

40 Mountain Association for Community Economic Development, Mr. Don Harker, Berea, KY.

41. Water Resources Data - Kentucky, U.S. Geological Survey.

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FIGURES

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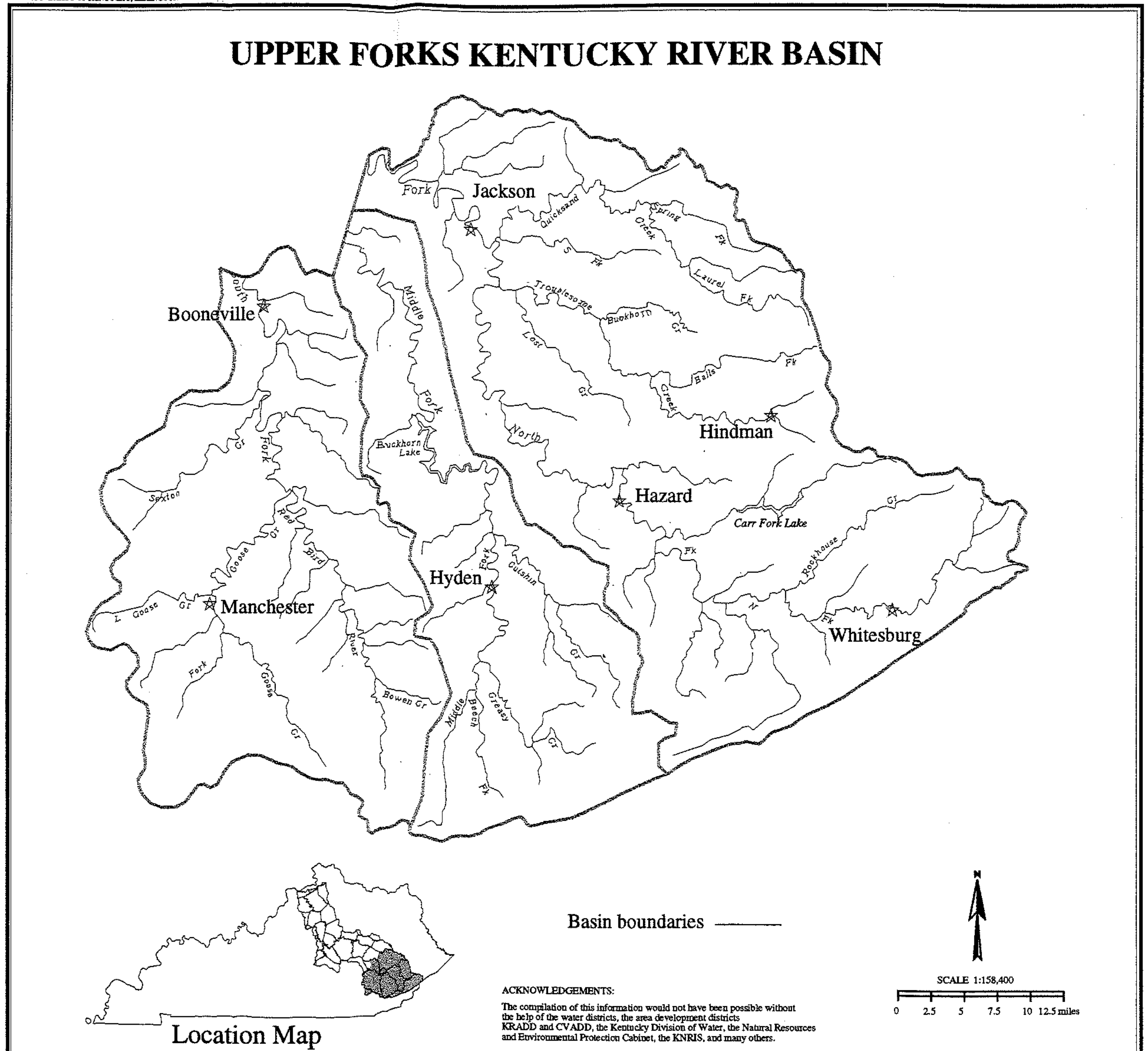

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The compilation of this information would not have been possible without the help of the water districts, the area development districts KRADD and CVADD, the Kentucky Division of Water, the Natural Resources and Environmental Protection Cabinet, the KNRIS, and many others.

Figure 1. Upper Forks Kentucky River Basin.

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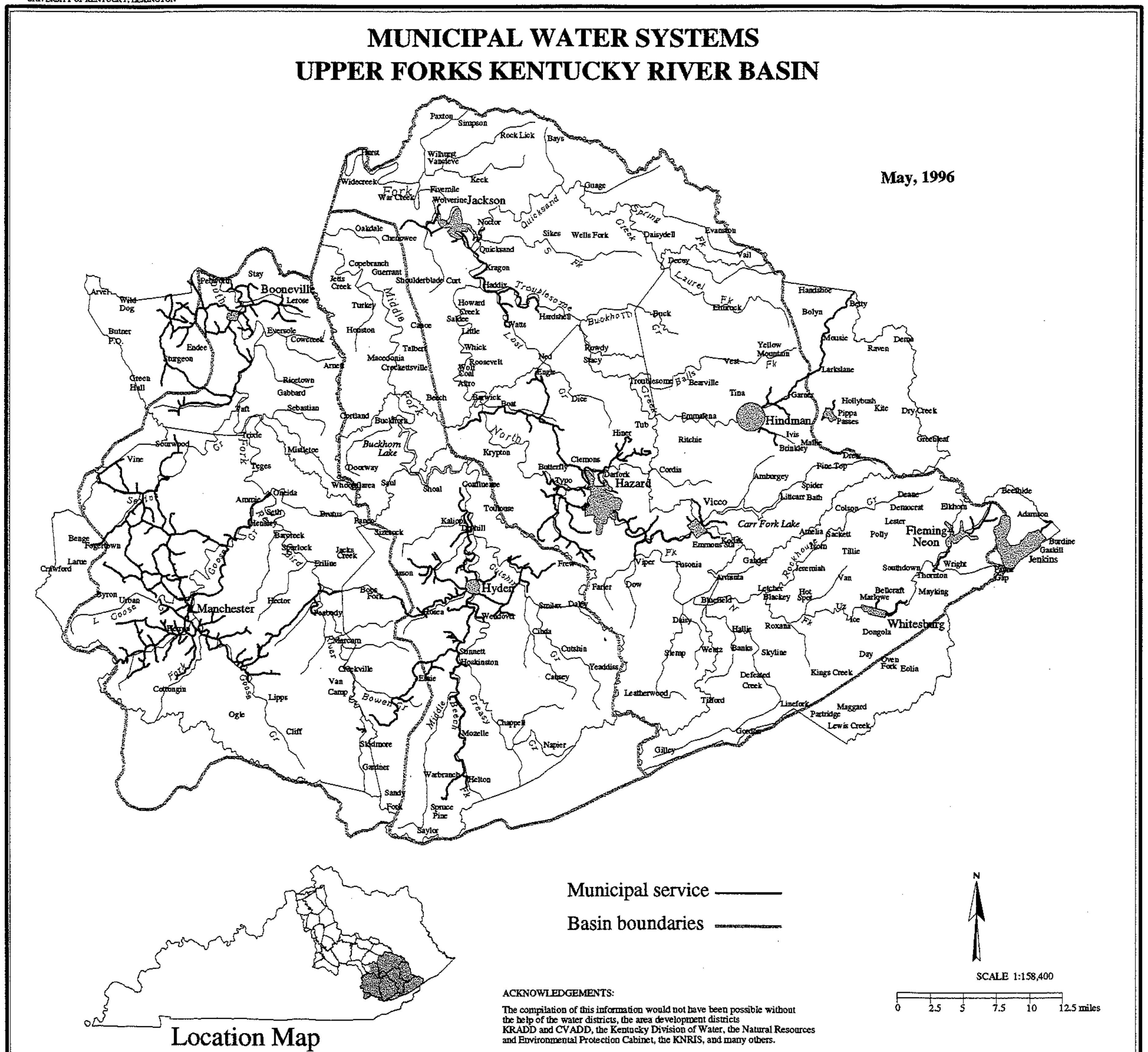

Figure 2. Municipal water systems - Upper Forks Kentucky River Basin.

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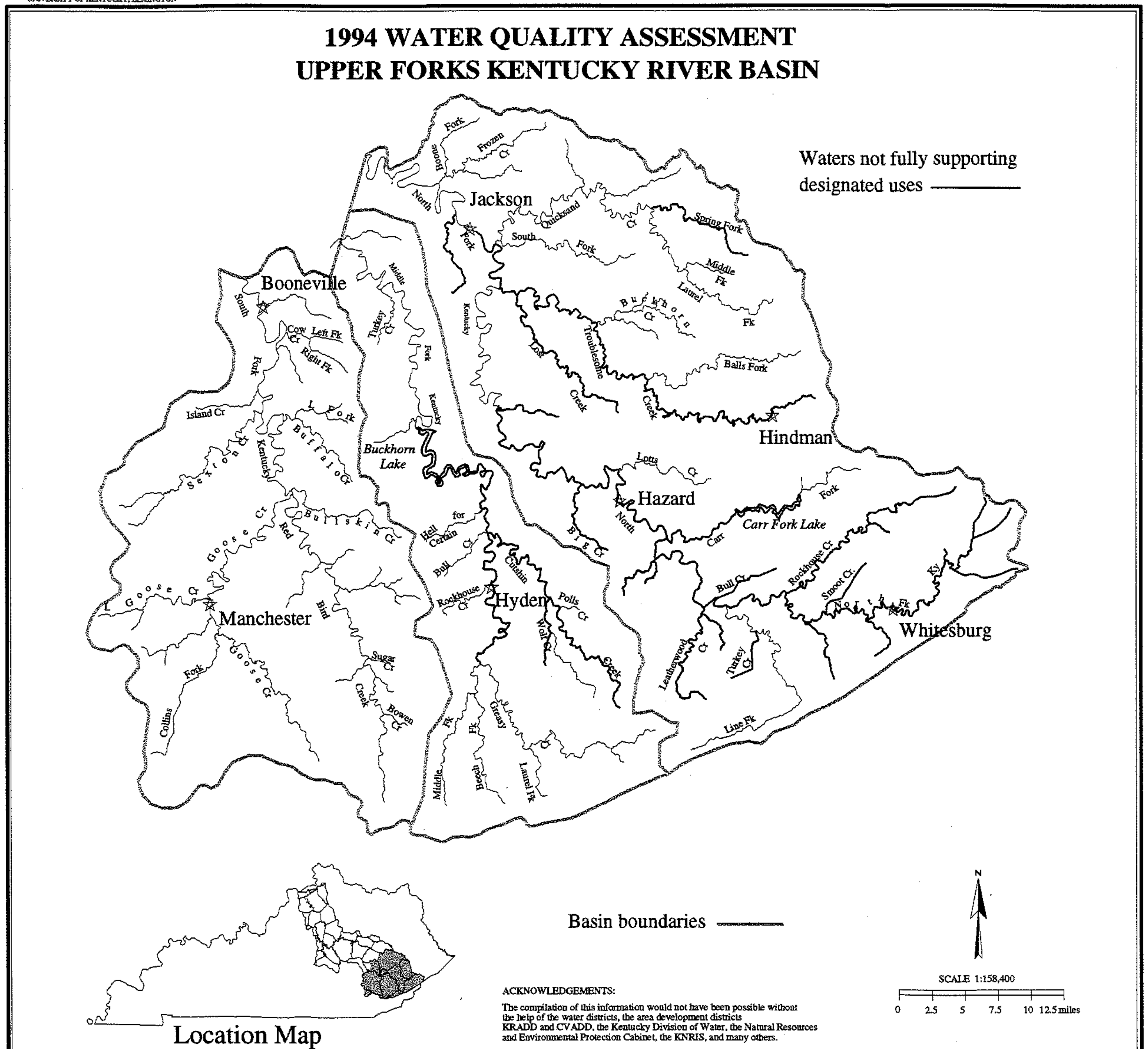

Figure 3. 1994 Water quality assessment - Upper Forks Kentucky River Basin.

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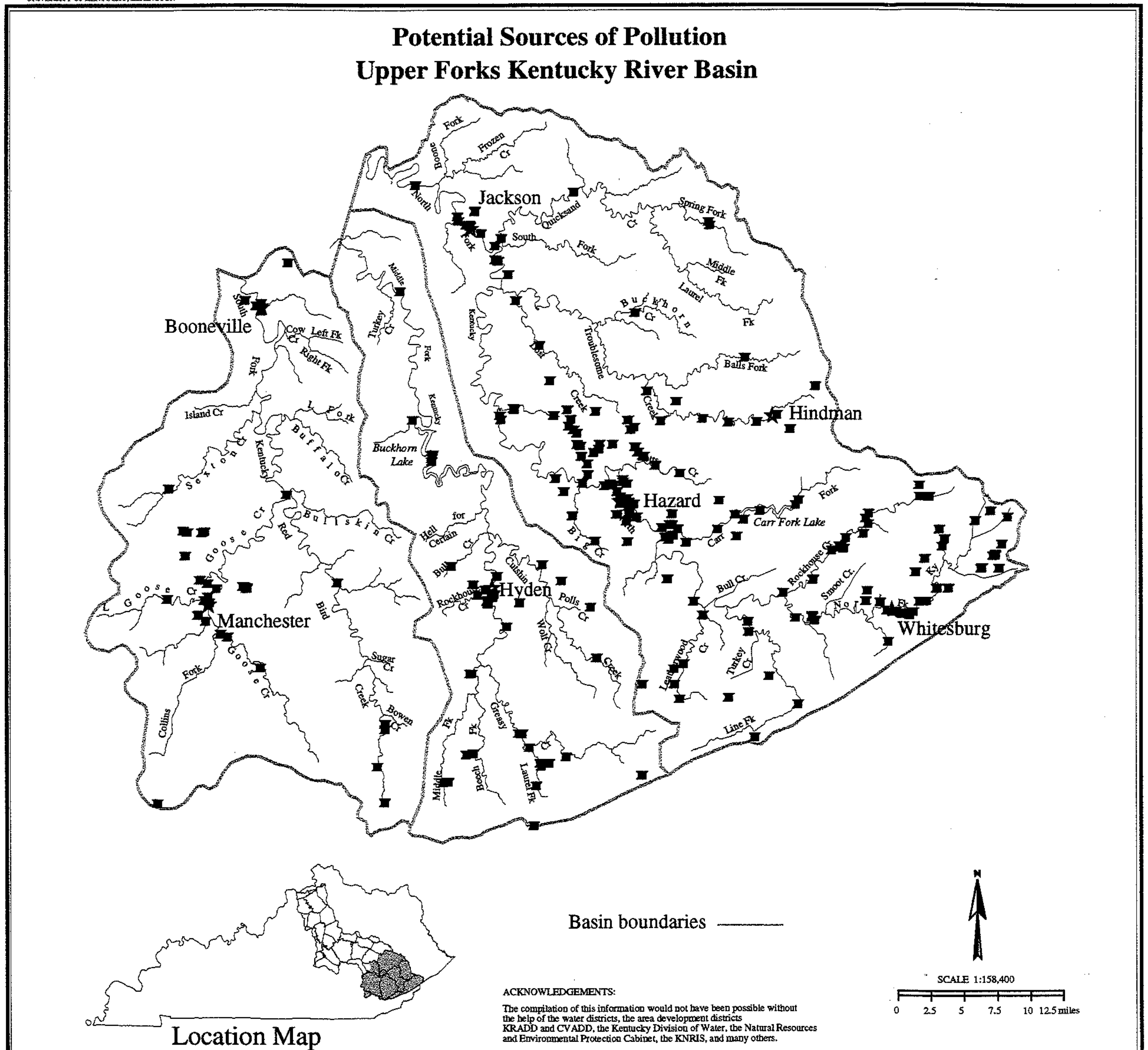

Figure 4. Potential sources of pollution - Upper Forks Kentucky River Basin.

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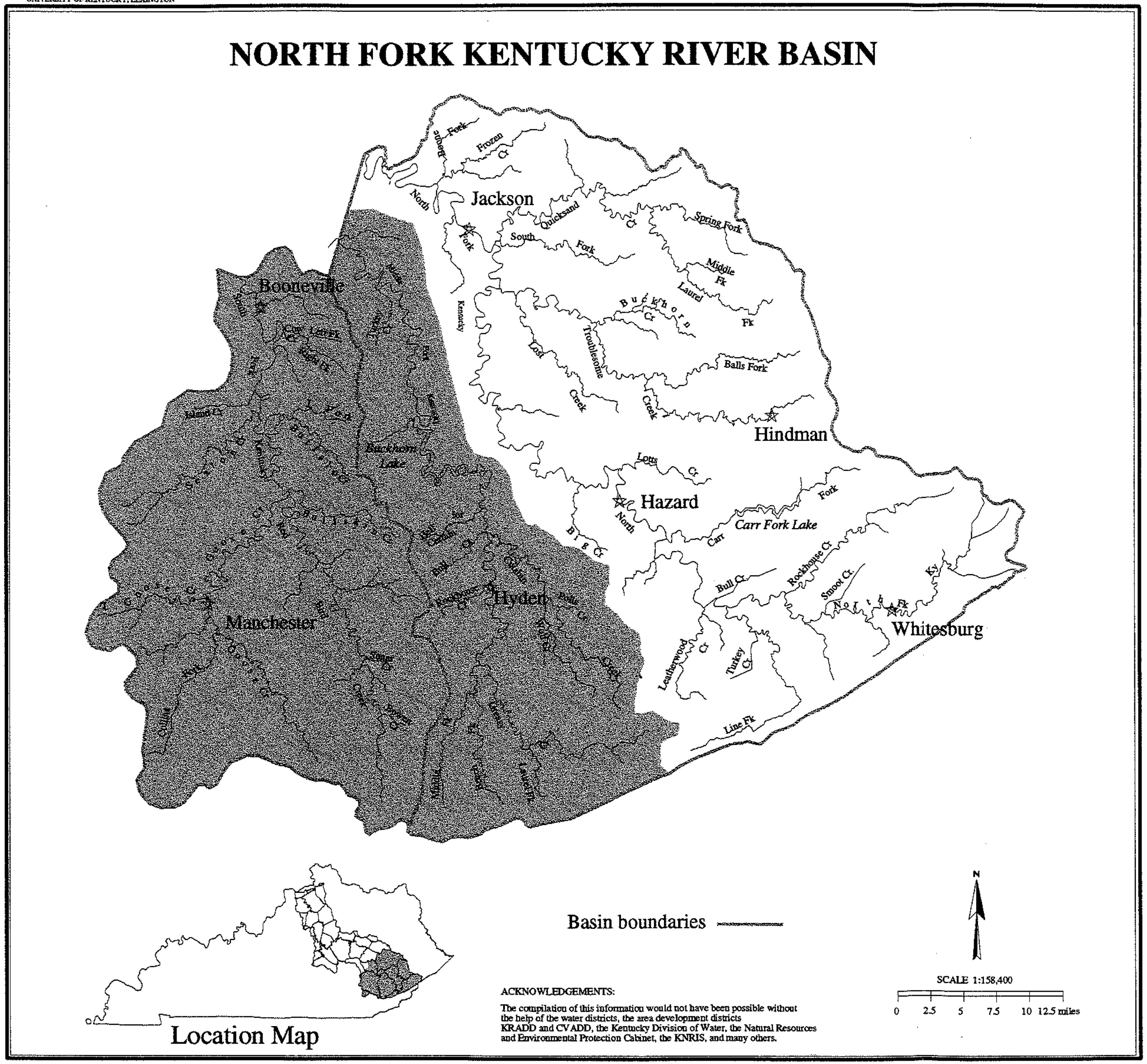

Figure 5. North Fork Kentucky River Basin.

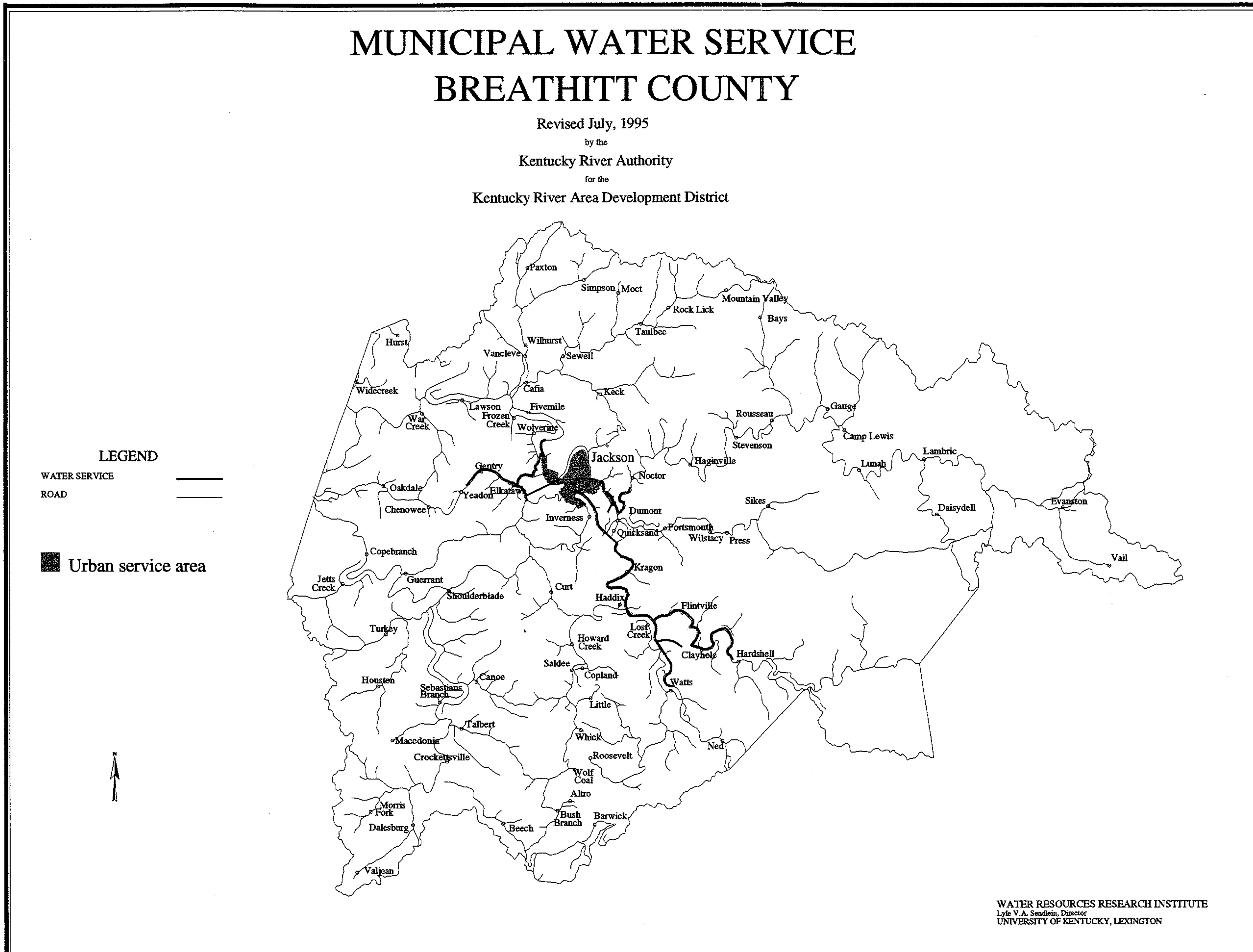

Figure 6. Municipal water service - Breathitt County

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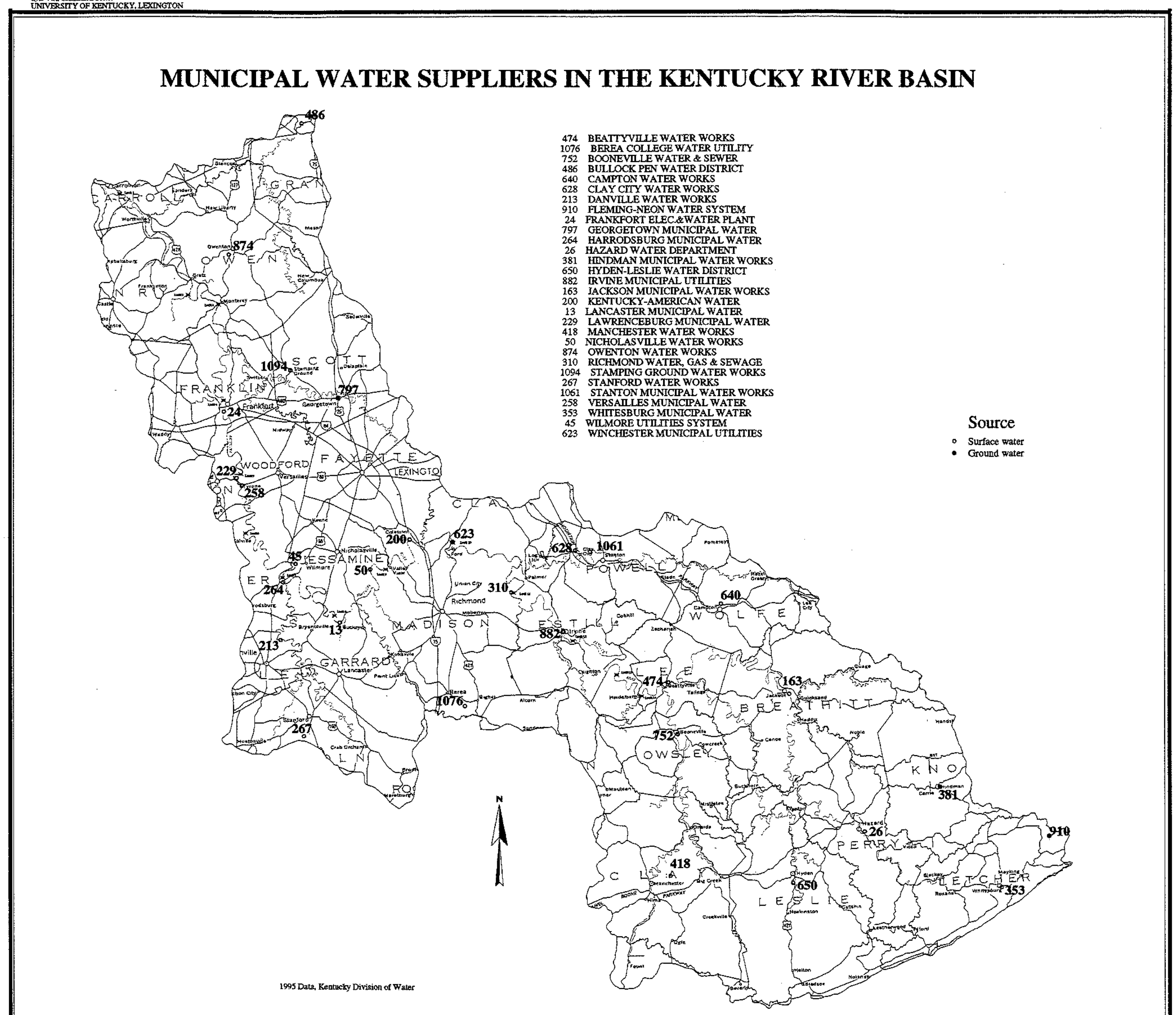

Figure 7. Municipal water suppliers in the Kentucky River Basin

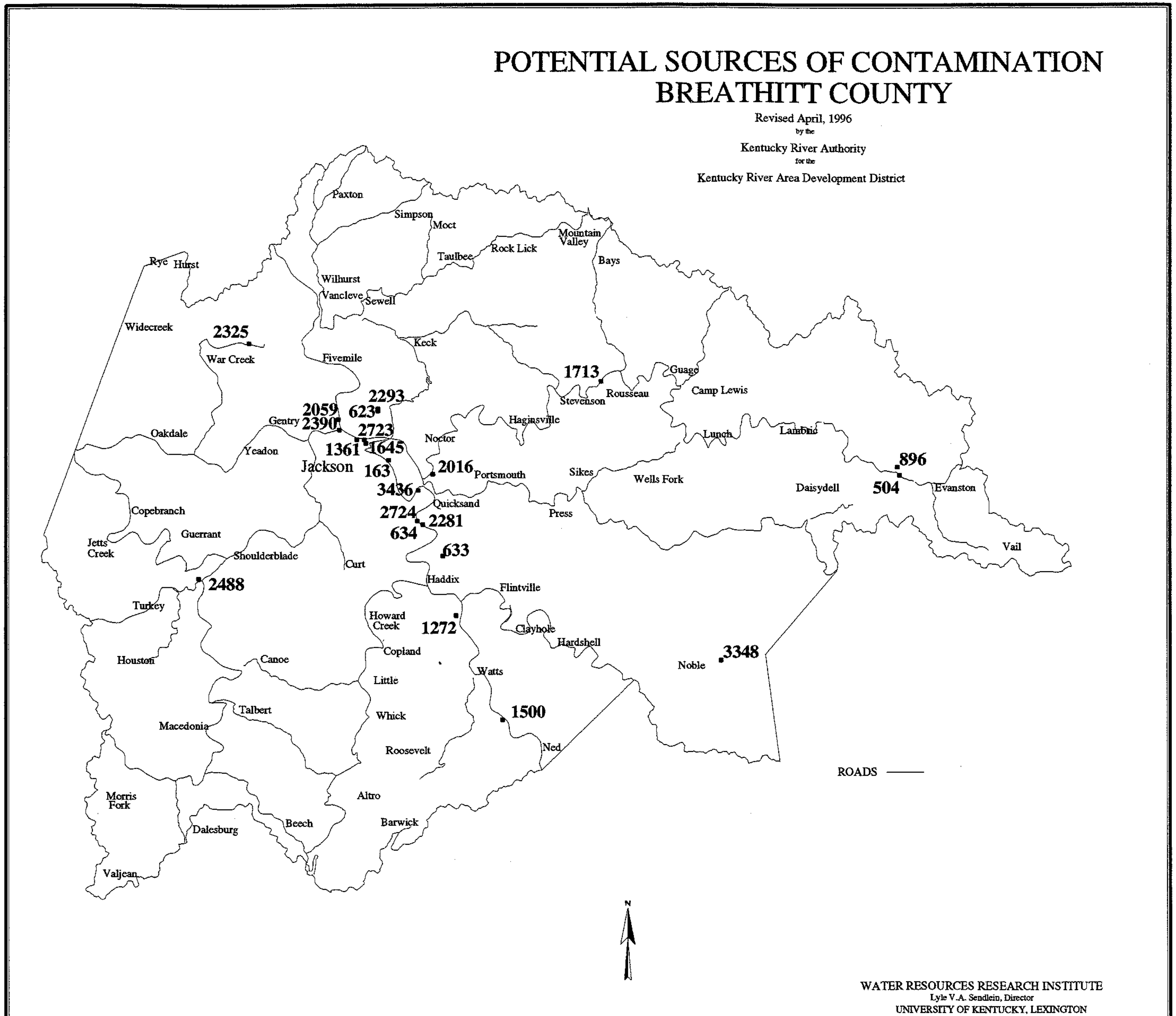

Figure 8. Potential sources of contamination - Breathitt County

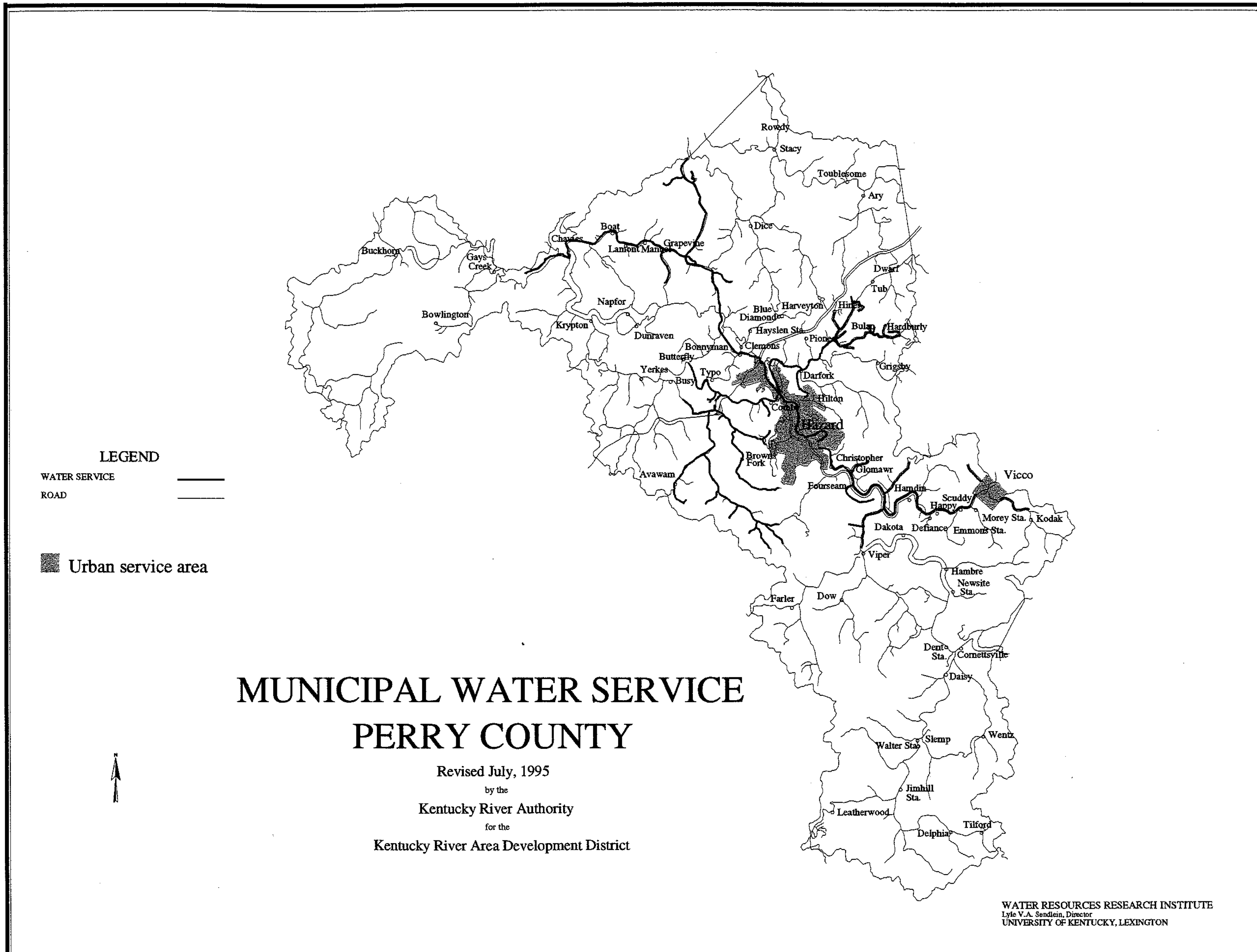

Figure 9. Municipal water service - Perry County

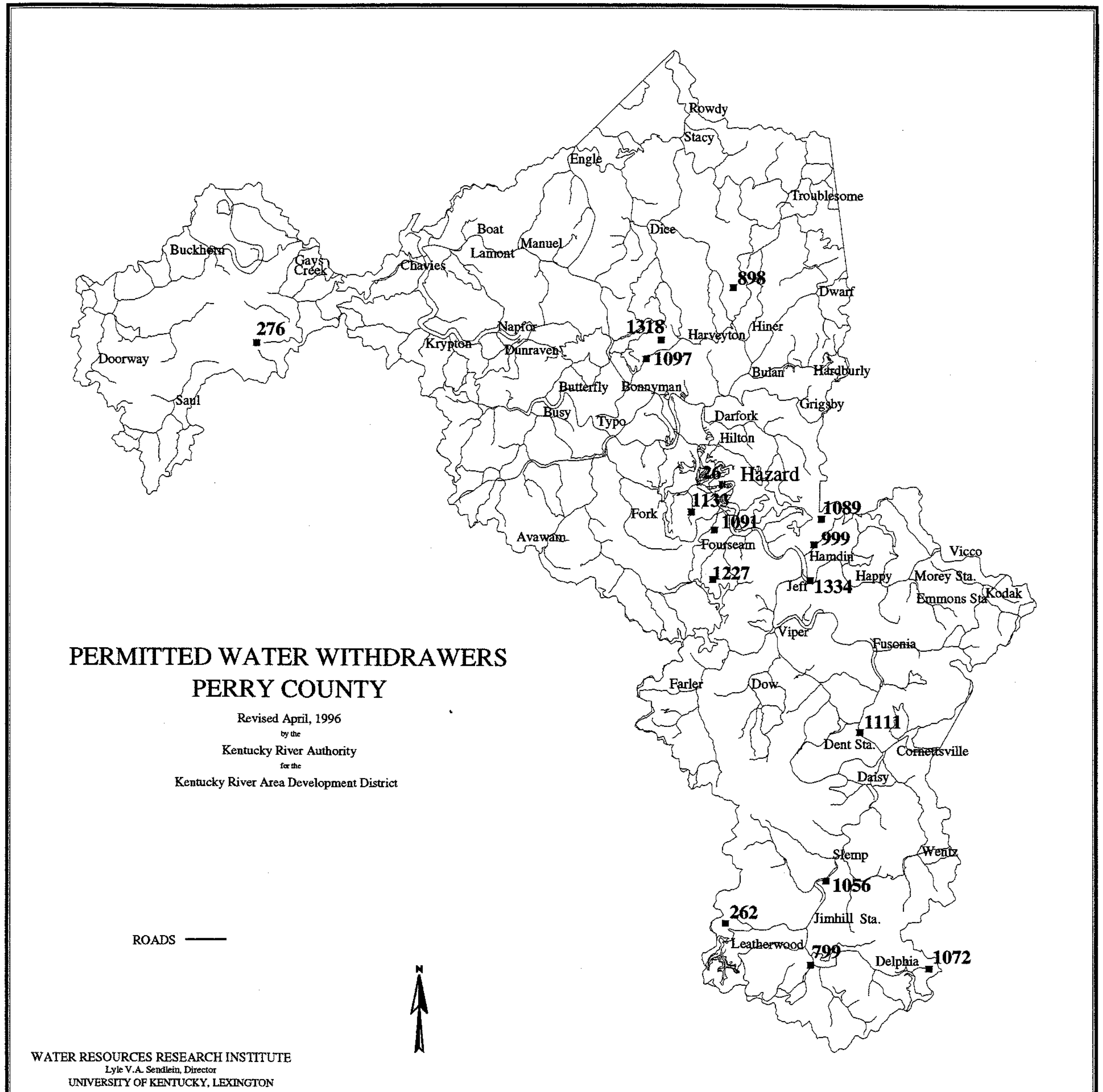

Figure 10. Permitted water withdrawers - Perry County

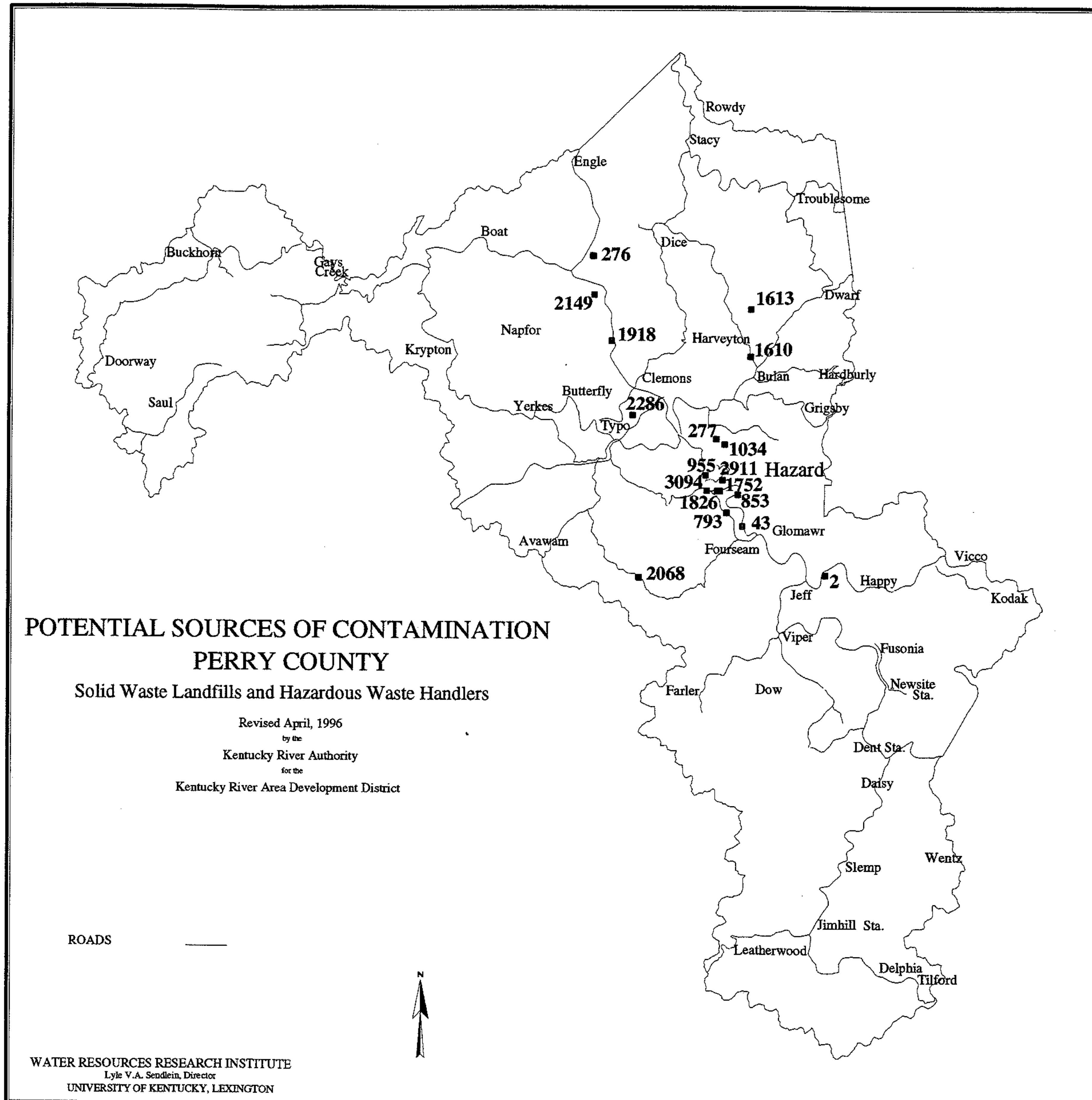

Figure 11A. Potential sources of contamination - solid waste landfills and hazardous waste handlers - Perry County

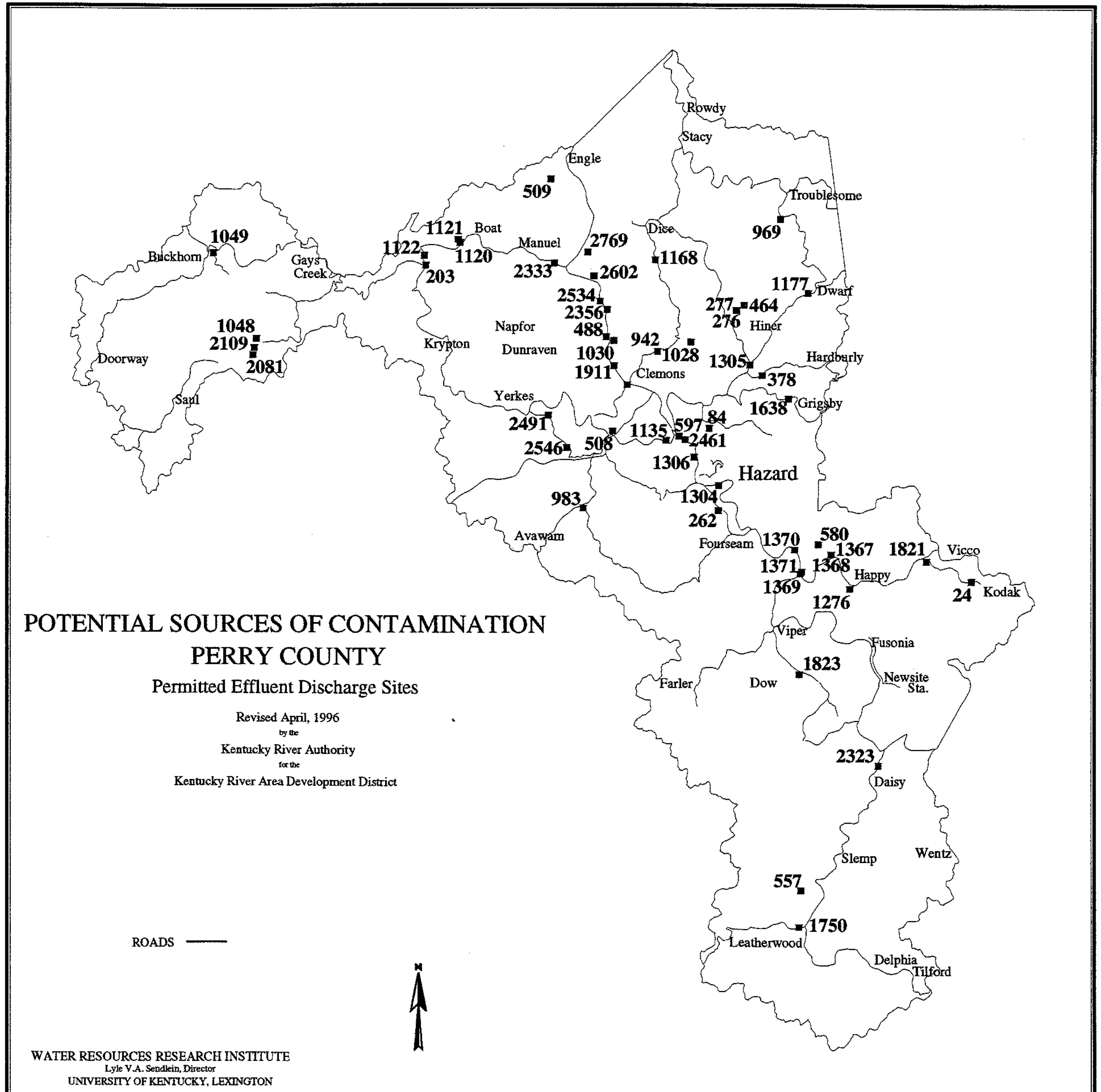

Figure 11B. Potential sources of contamination - permitted effluent discharge sites - Perry County

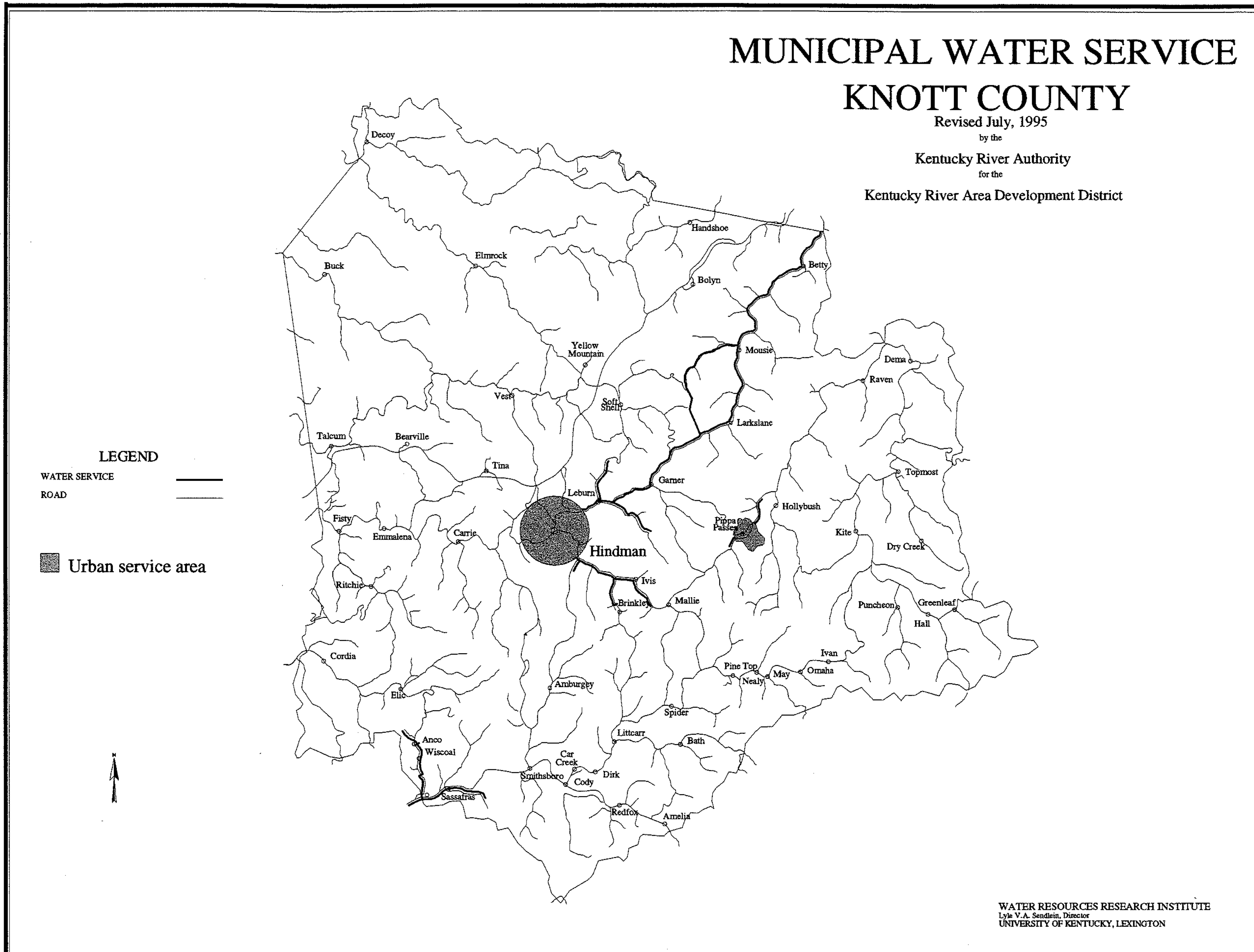

Figure 12. Municipal water service - Knott County

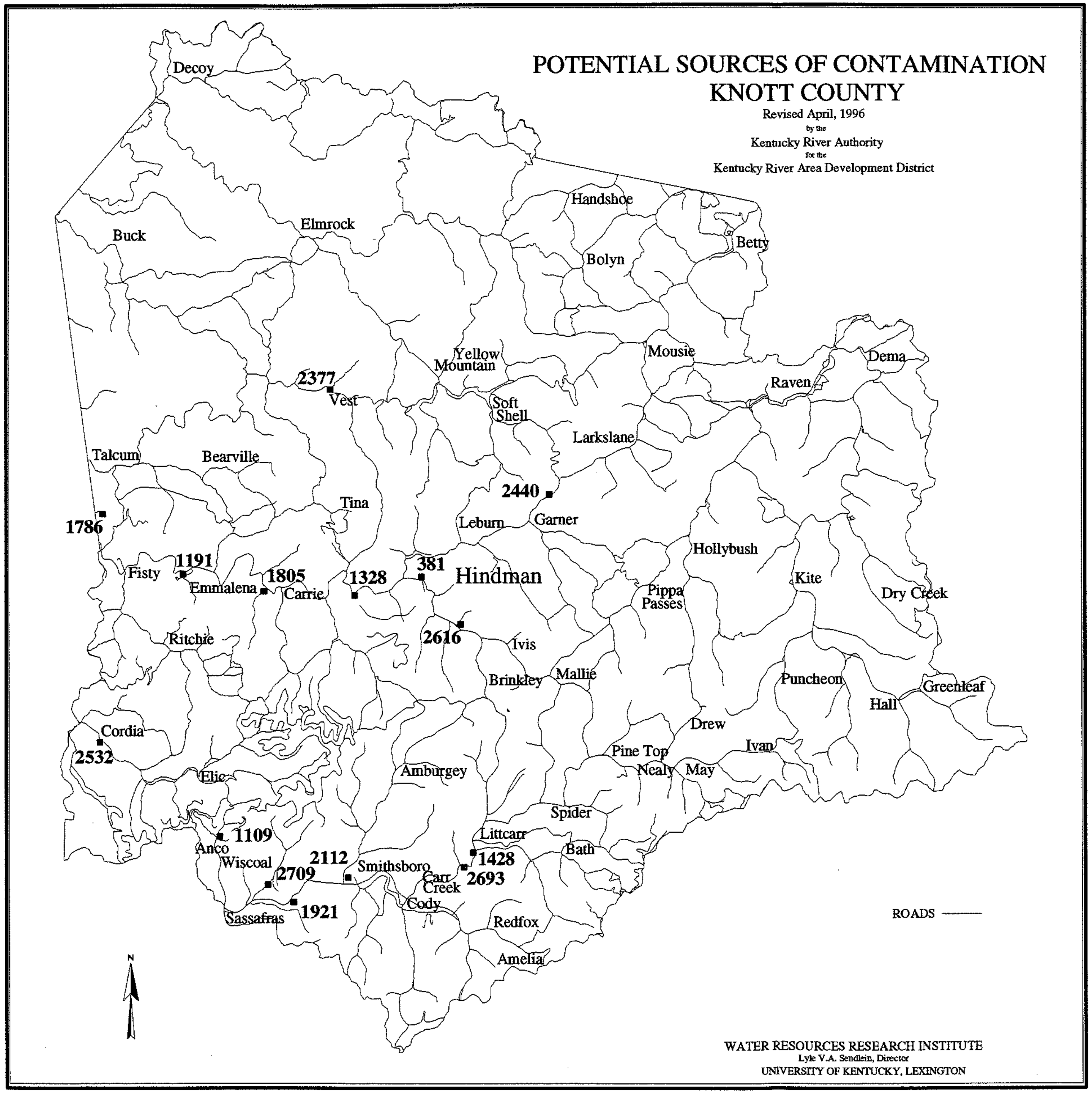

Figure 13. Potential sources of contamination - Knott County

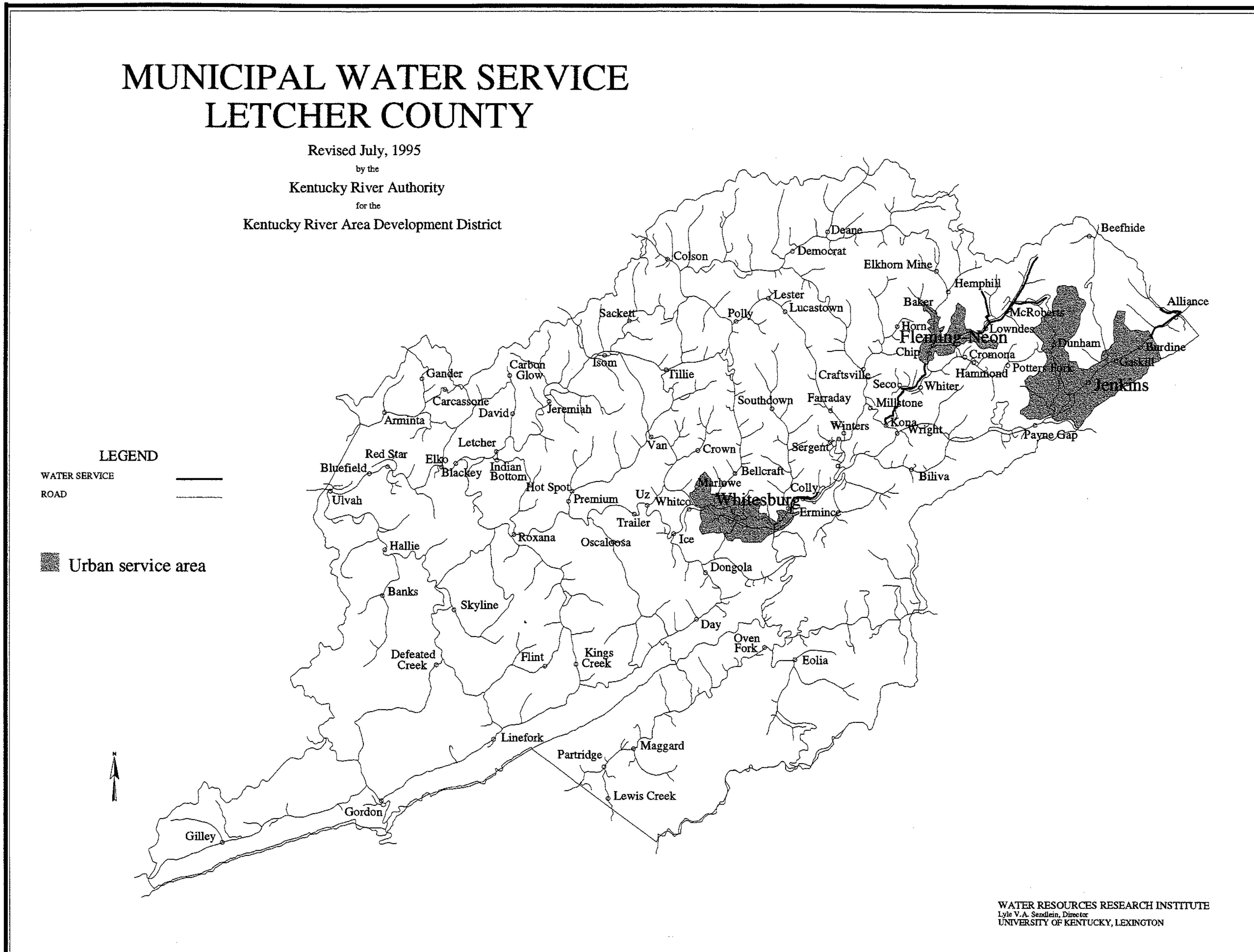

Figure 14. Municipal water service - Letcher County

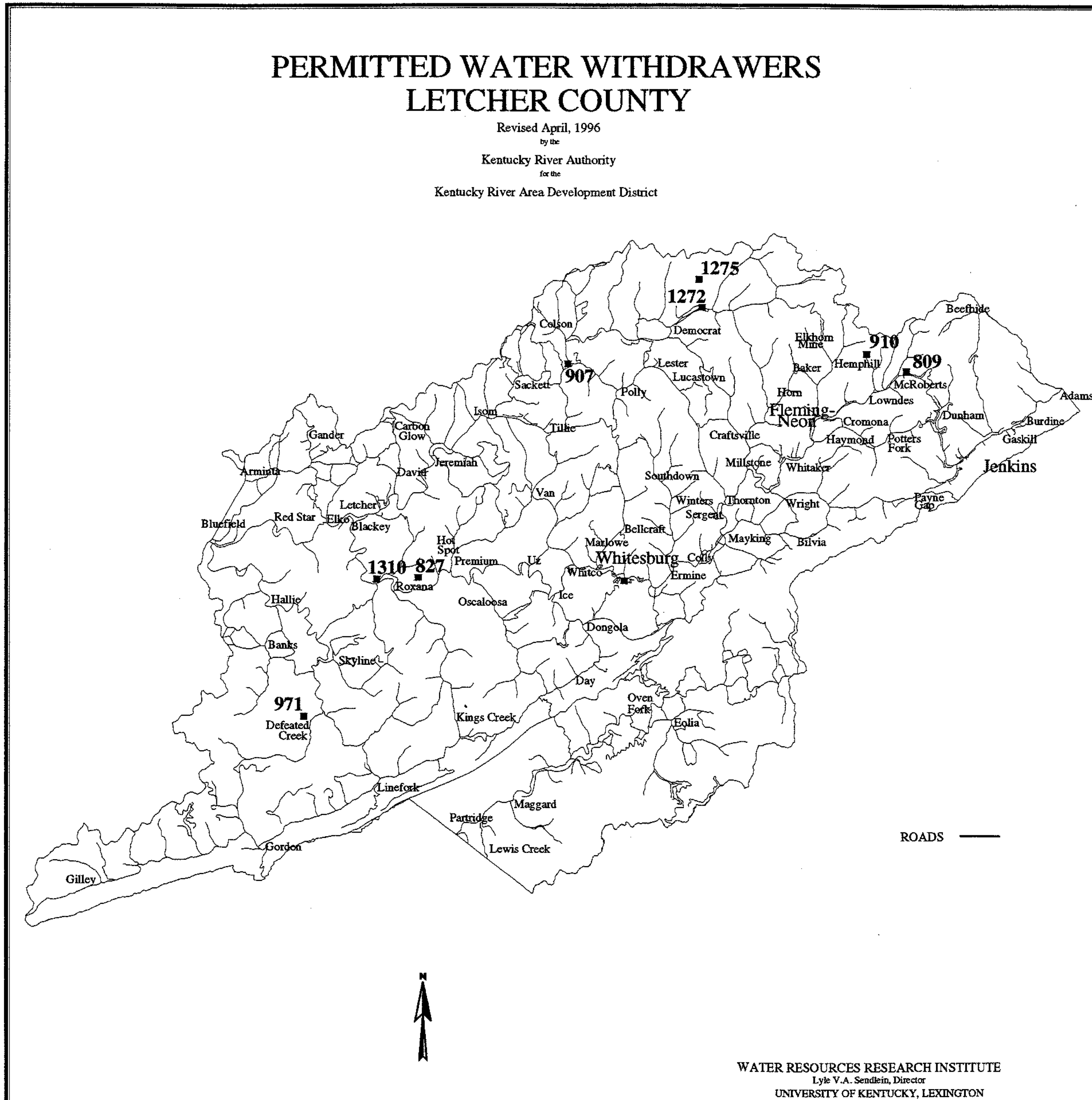

Figure 15. Permitted water withdrawers - Letcher County

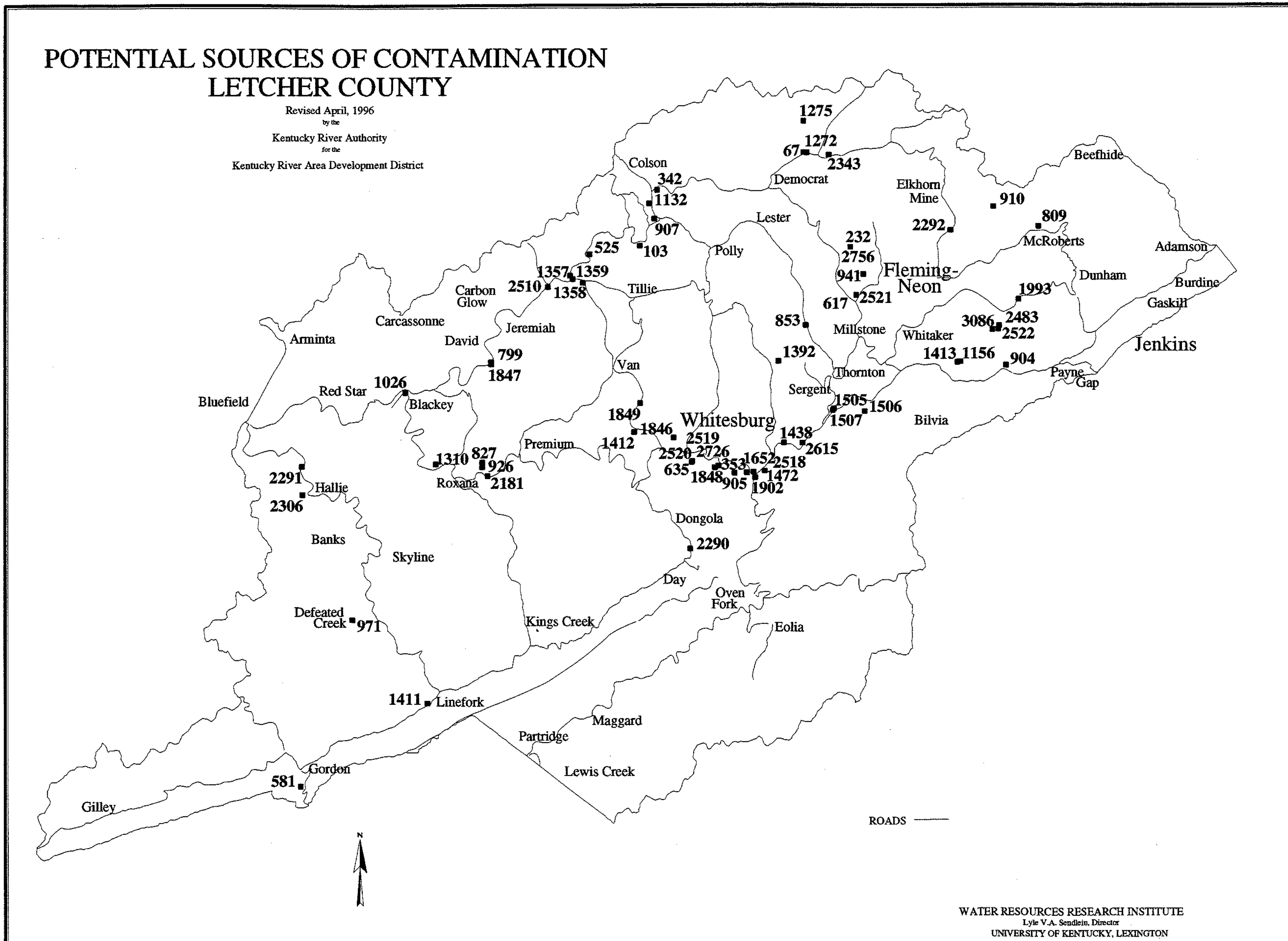

Figure 16. Potential sources of contamination - Letcher County

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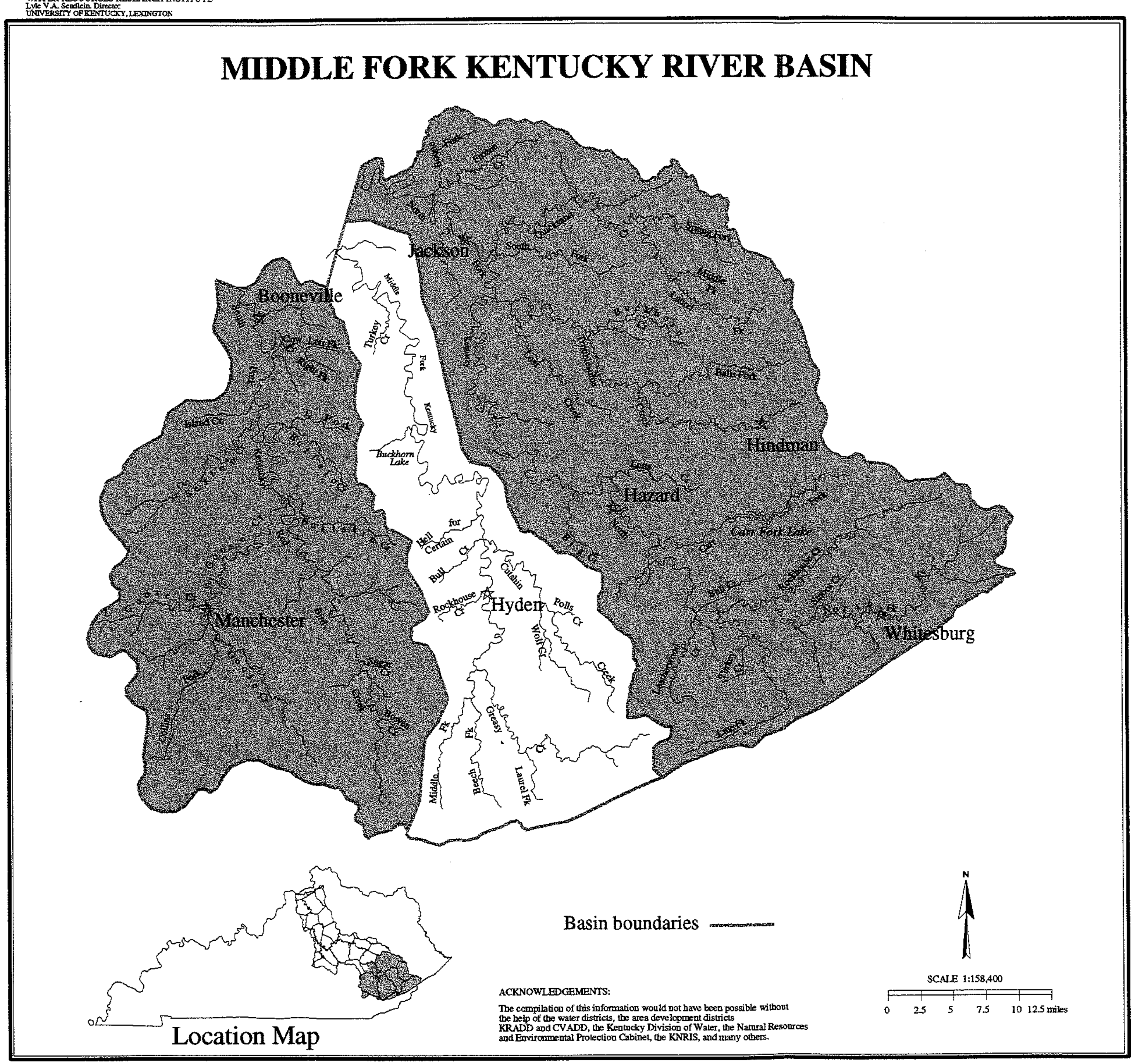

Figure 17. Middle Fork Kentucky River Basin

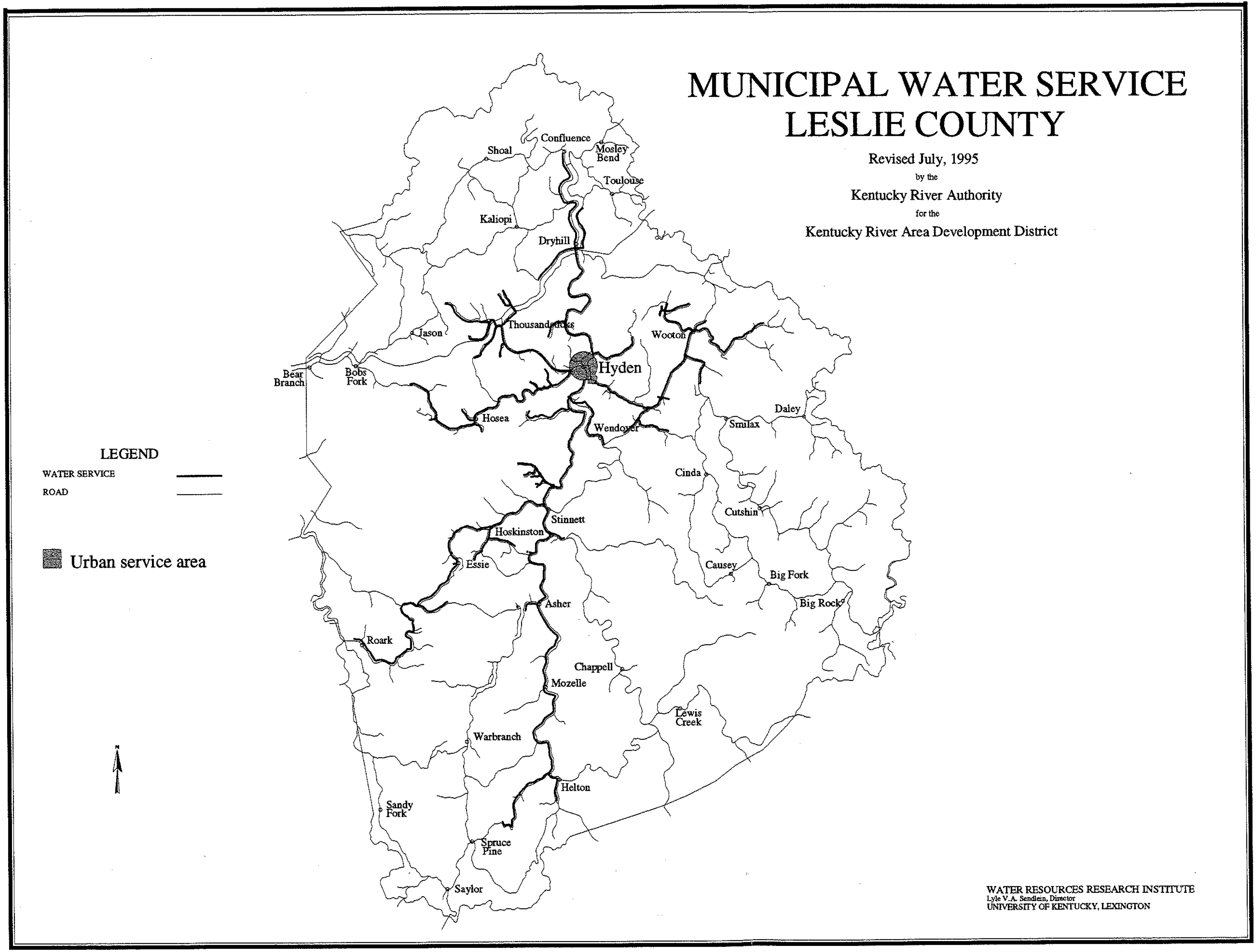

Figure 18. Municipal water service - Leslie County

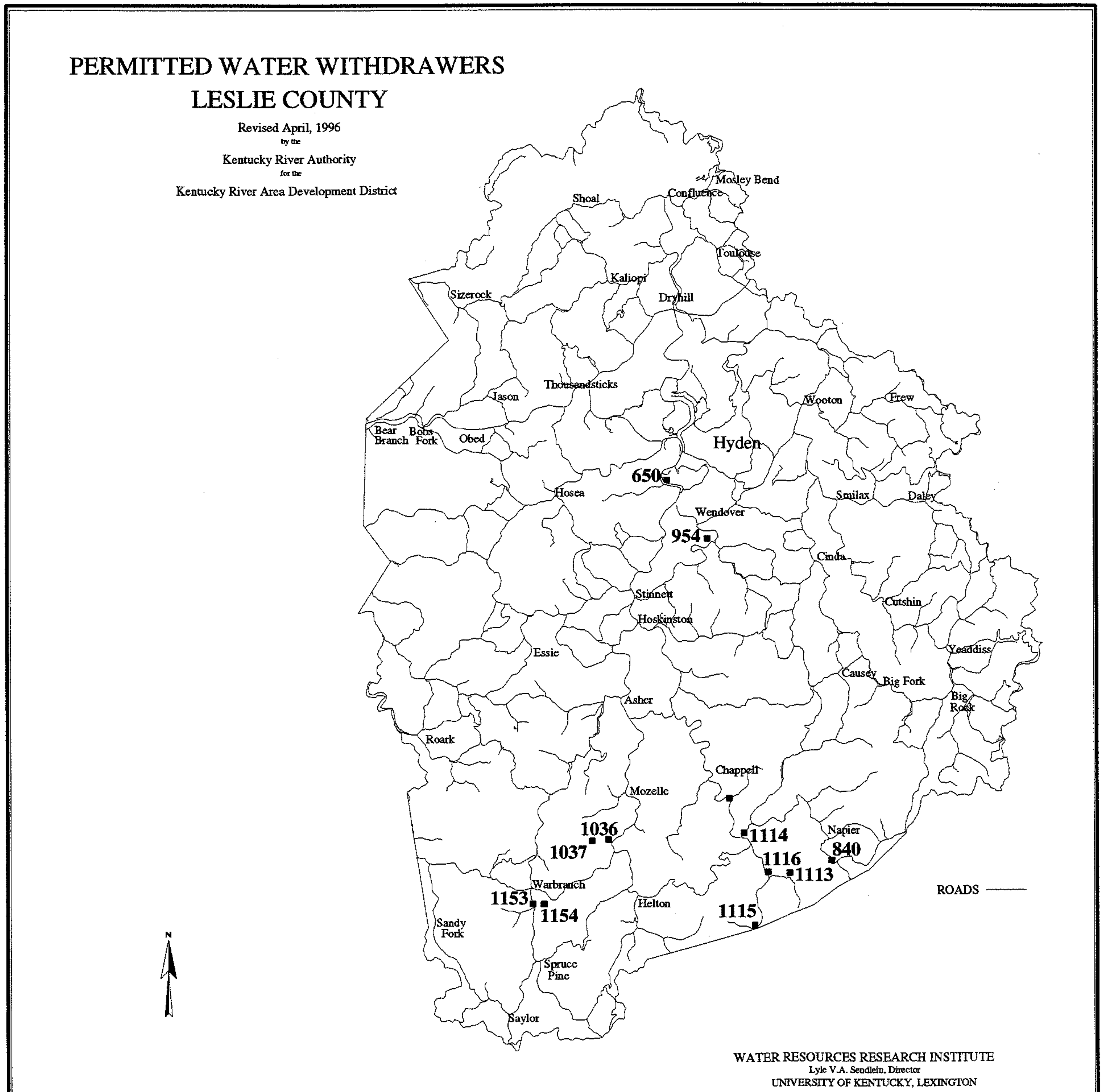

Figure 19. Permitted water withdrawers - Leslie County

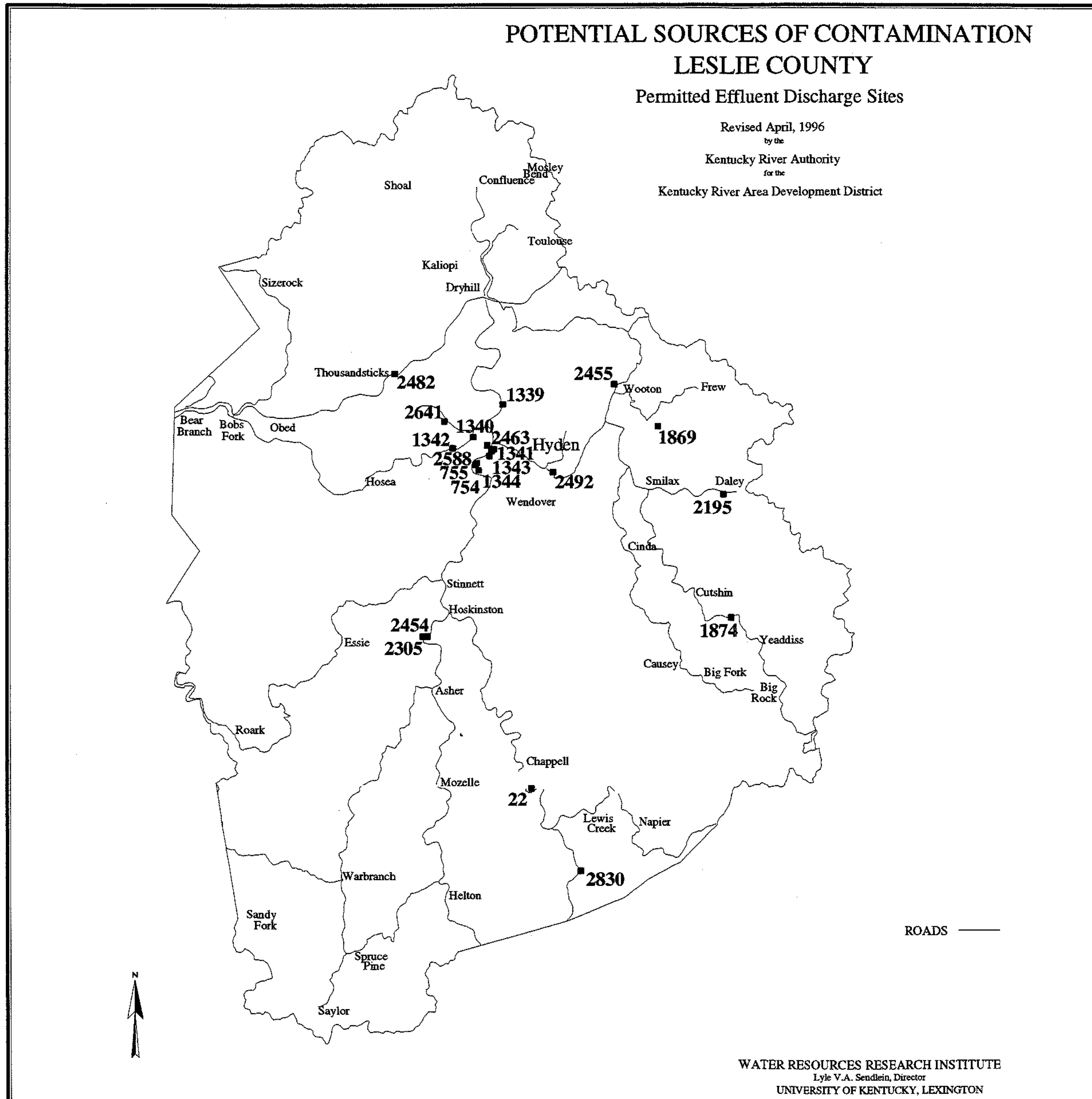

Figure 20. Potential sources of contamination - permitted effluent discharge sites - Leslie County

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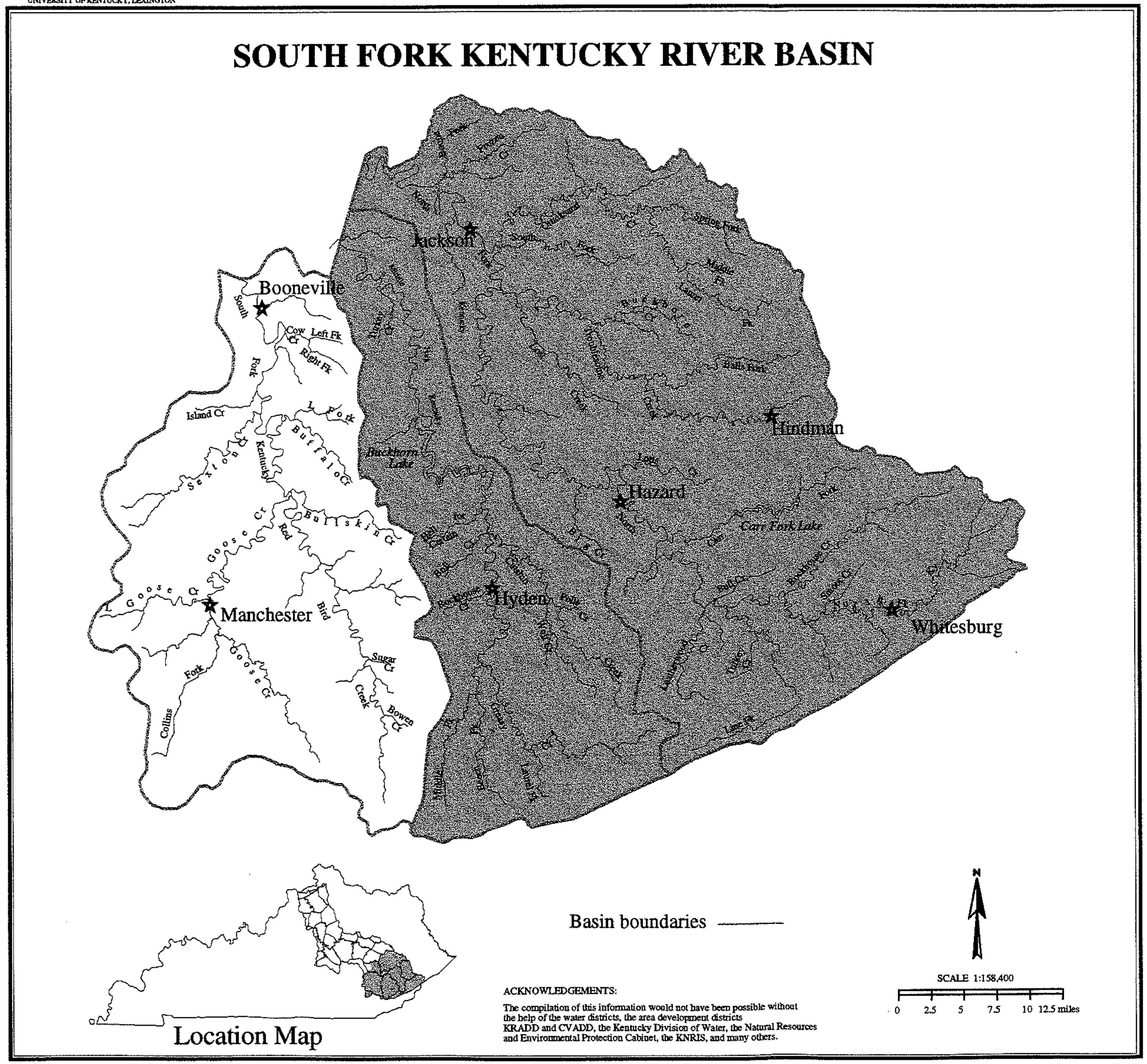

Figure 21. South Fork Kentucky River Basin

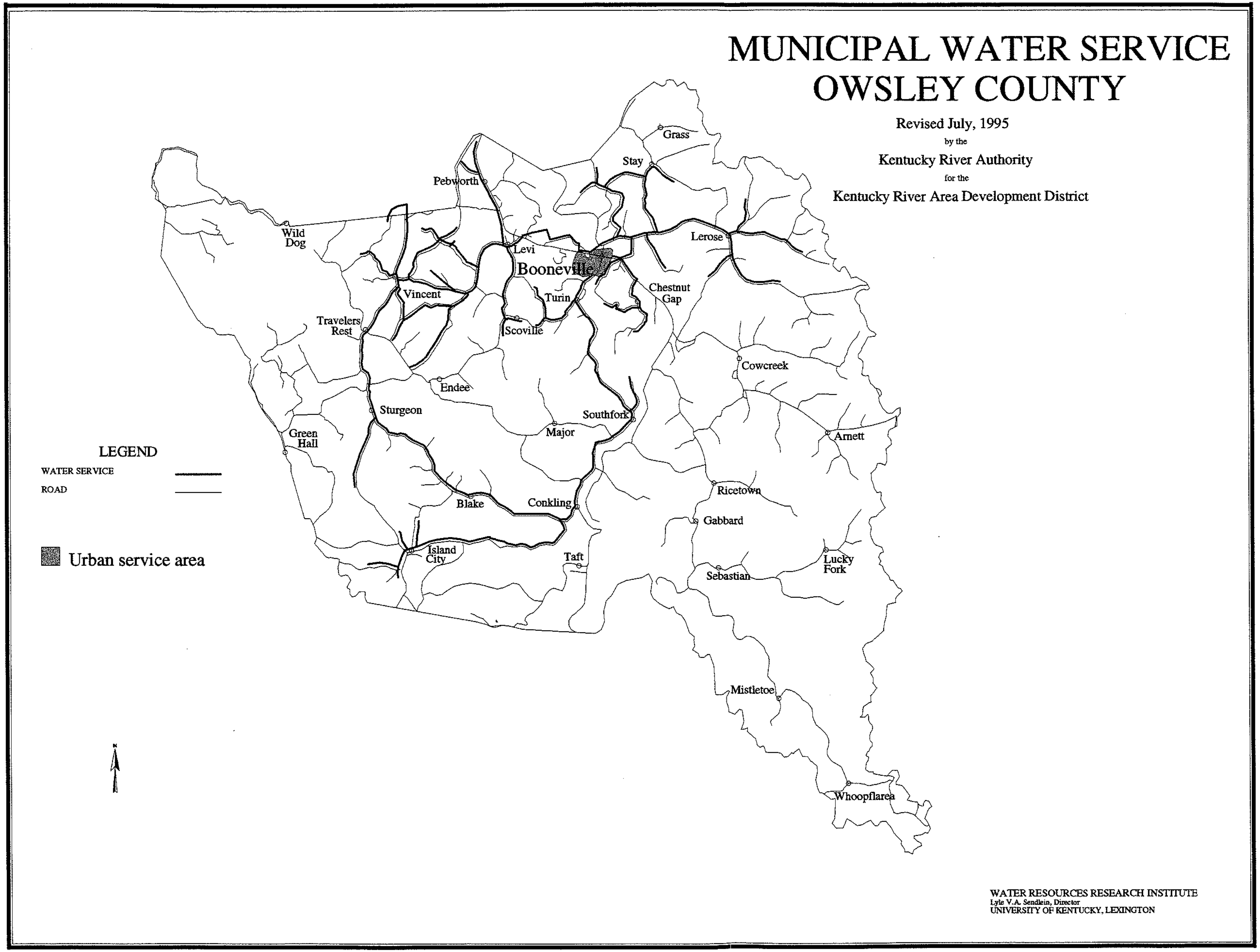

Figure 22. Municipal water service - Owsley County

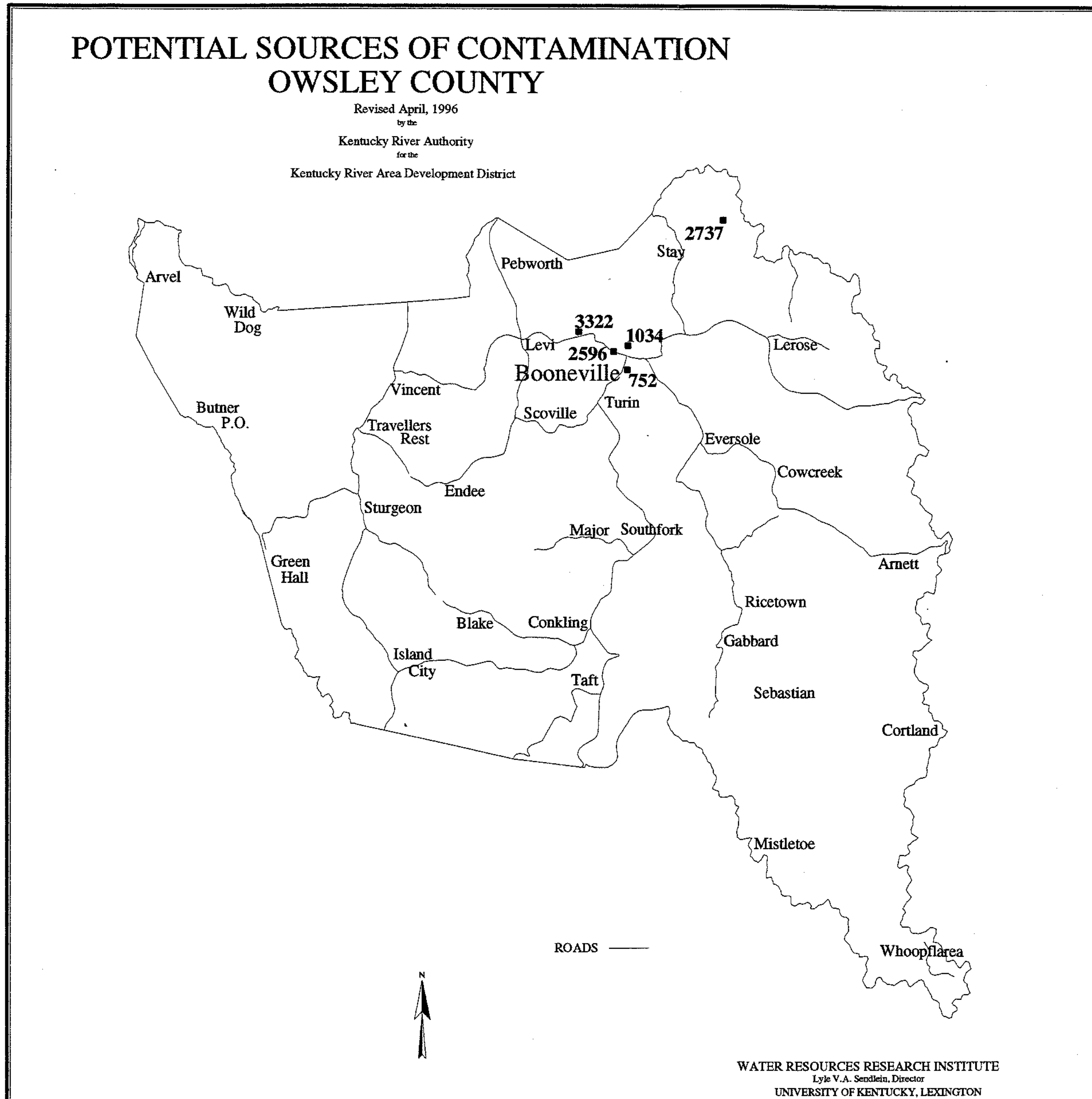

Figure 23. Potential sources of contamination - Owsley County

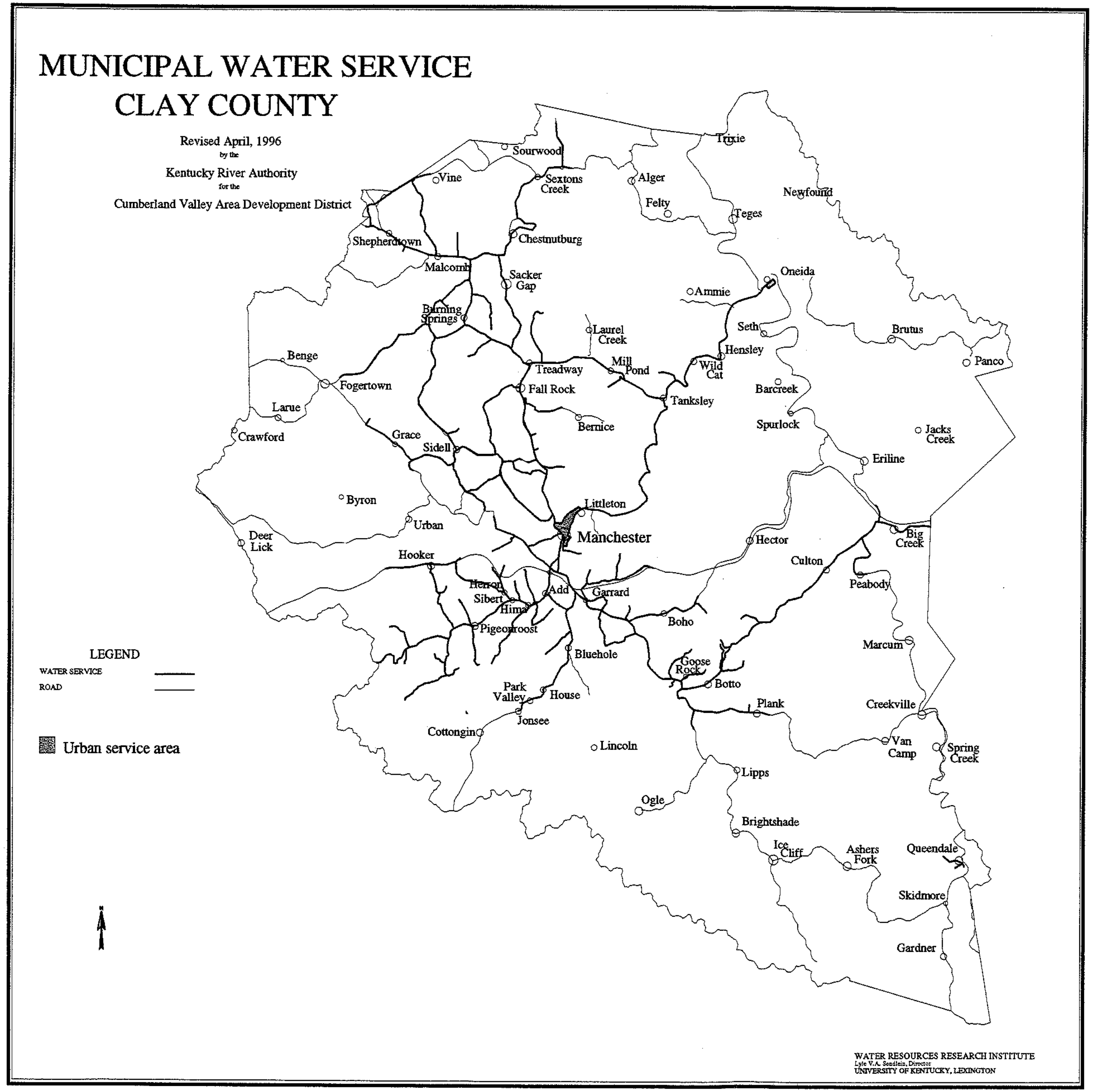

Figure 24. Municipal water service - Clay County

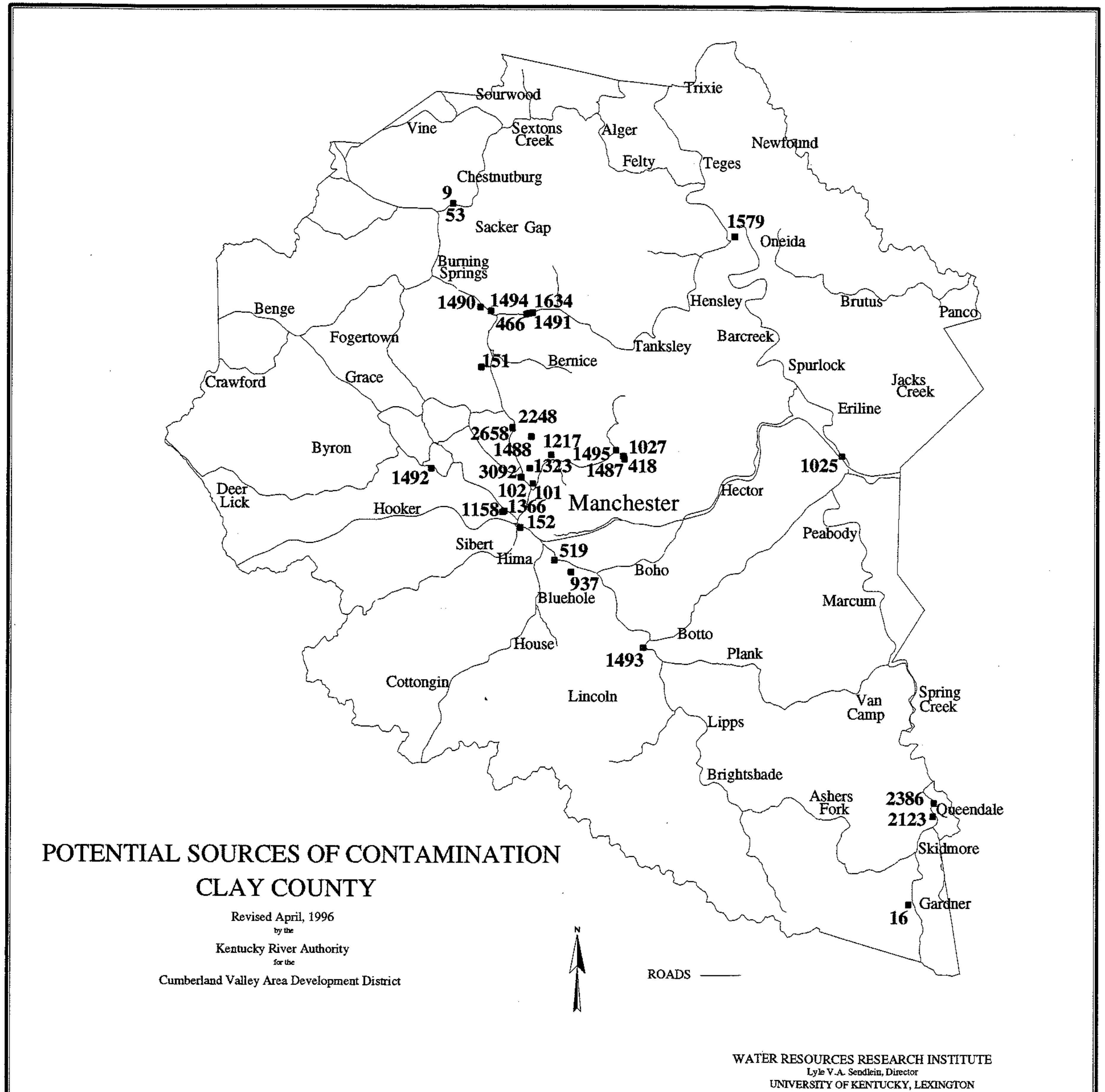

Figure 25. Potential sources of contamination - Clay County