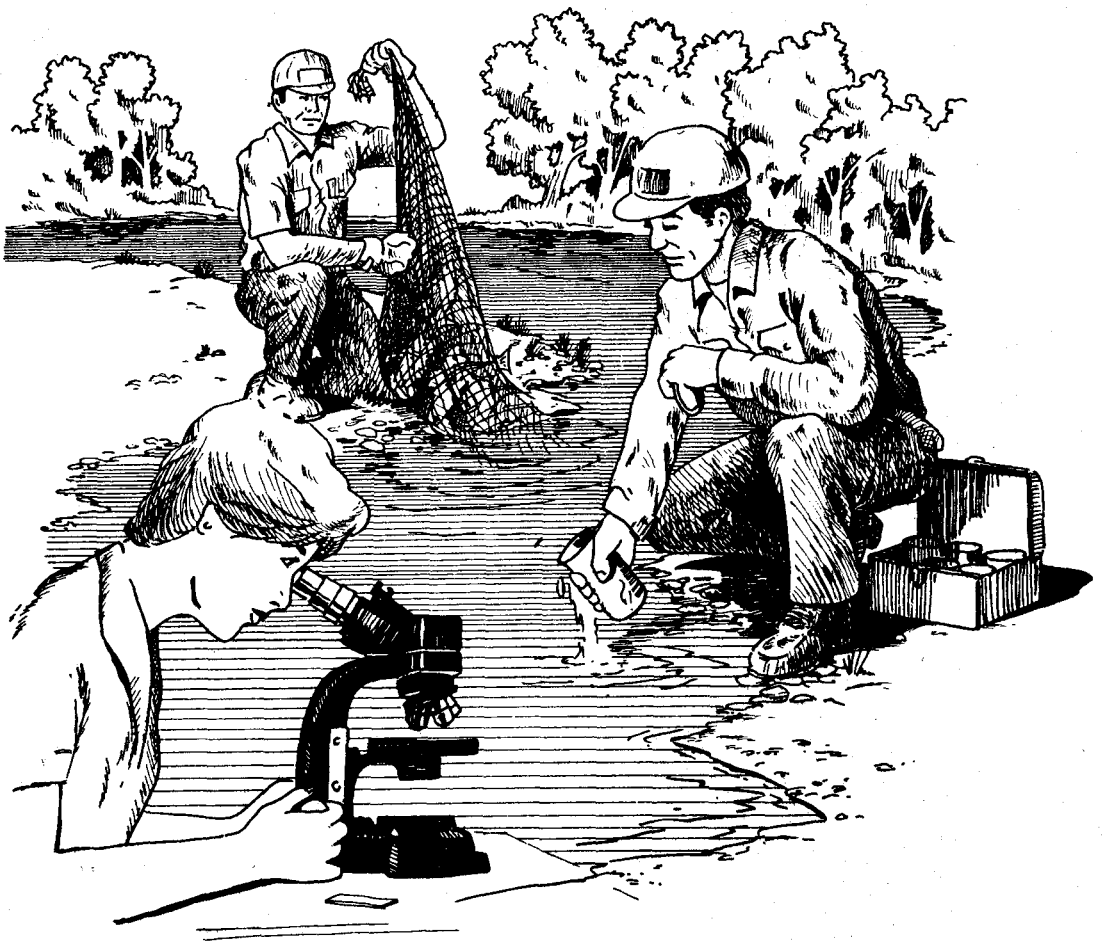
1984 KENTUCKY REPORT TO CONGRESS ON WATER QUALITY



COMMONWEALTH OF KENTUCKY
KENTUCKY NATURAL RESOURCES AND
ENVIRONMENTAL PROTECTION CABINET
DIVISION OF WATER

1984

KENTUCKY

REPORT TO CONGRESS

ON

WATER QUALITY

COMMONWEALTH OF KENTUCKY
NATURAL RESOURCES AND
ENVIRONMENTAL PROTECTION CABINET
DEPARTMENT FOR ENVIRONMENTAL PROTECTION

DIVISION OF WATER

MAY, 1984

THE COST OF THIS PRINTING IS

PAID FROM FEDERAL FUNDS,

(KRS 57:375)

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ACKNOWLEDGEMENTS

In addition to the contribution by numerous staff members within the Division of Water, the Biological Branch of the Division of Environmental Services provided much of the information contained in Chapter I and Appendices A, B and D. Special recognition is also given to Gary Redmon within the Department of the Arts for the cover illustration.

EXECUTIVE SUMMARY

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This report has been prepared pursuant to Section 305(b) of the Federal Water Pollution Control Act of 1972 (PL 92-500), as amended by the Clean Water Act of 1977 (PL 95-217). This biennial report presents an assessment of Kentucky's water quality conditions and trends for the period January 1, 1982 through December 31, 1983. Also discussed are special water quality problems and the status of the state water management program.

Water Quality Assessment

The stream water quality in Kentucky's 1984 report is based on rivers and streams shown on the U.S. Geological Survey's Hydrologic Unit Map of the state. Of the 19,000 miles displayed on this map, approximately 10,500 miles (55 percent) were assessed for the reporting period.

Based on this assessment, the water quality in Kentucky's rivers and streams during 1982-83 was generally fair. Approximately 44 percent of the total miles assessed experienced some degree of use impairment. Uses were not supported in 776 miles (7.4 percent). Of the known causes of use impairment statewide, 57 percent was due to nonpoint sources, 24 percent to municipal sources, 16 percent to acid mine drainage, and 3 percent to industrial sources.

As a result of the water quality ranking of the thirty-four hydrologic units composing most of the state, the highest priority watersheds in terms of water quality degradation are the Tradewater River basin, the Salt River basin excluding the Rolling Fork, South Fork of the Licking River basin, and the Upper Cumberland River basin above the Rockcastle River. The Tradewater River basin's major impacts are acid mine drainage and sedimentation. Major impacts to the Salt River basin are nonpoint agricultural and urban runoff followed closely in significance by municipal and industrial point sources. The South Fork of the Licking River basin's major impacts are due to municipal discharges and nonpoint source agricultural runoff. The major impact in the Upper Cumberland is sedimentation resulting from mining activities, with localized impacts from municipal discharges. Water quality impairment was exacerbated in some of these watersheds during 1982-83 by the persistence of extremely low flows.

Problem water quality parameters noted at fixed trend monitoring stations throughout the state are generally related to the impacts which occur in the various basins. Nutrients, such as total phosphorus and nitrate and nitrite - nitrogen are related to agricultural activities and, to a lesser extent, discharge of domestic wastewater. Fecal coliform bacteria violations are caused by improper wastewater treatment plant operation, faulty septic tank systems and agricultural runoff. Land disturbances, either from agricultural activities or mining operations, increase the amount of suspended solids in streams, as well as levels of metals such as copper, iron and zinc. Sediments from most areas of the state contain elevated levels of chlordane, reflecting its widespread use as a broad spectrum-insecticide.

The assessment of lake conditions is based on the 90 lakes which have been surveyed by Kentucky for trophic status and restoration needs. The surveys were funded by a cooperative agreement award to the state through the Clean Lakes Program which is administered by the U.S. Environmental Protection Agency. Based on this assessment, the water quality in Kentucky's lakes during 1982-83 was generally good.

The lakes which were assessed have a total area of 358,214 acres. Of the 90 lakes in the classification survey, forty-five (50%) were eutrophic, twenty-six (29%) were mesotrophic, and seventeen (19%) were oligotrophic. Two of the lakes were hypereutrophic. When total surface acres of lakes are considered, the greatest percentage of the surface waters inventoried were mesotrophic or oligotrophic. Out of the total acres inventoried, 51 percent were mesotrophic, 28 percent were oligotrophic, 21 percent were eutrophic, and less than one percent were hypereutrophic.

Forty-one of the 90 lakes which were assessed do not fully support their designated uses. However, this number only represents nine percent of the total lake resource by surface area. The highest priority problem lakes in the state are McNeely, Carpenter, Corbin, Loch Mary, and Sympson. The greatest percentage of non-attainment of designated uses is caused by natural conditions. This is due to hypolimnetic iron and manganese releases from impoundments used by downstream communities as domestic water supply sources. Surface mining is the second greatest contributor to lake uses not being fully supported.

There have been no trends towards improvement or for that matter, further degradation of lakes in the past two years. Toxics are not considered to adversely affect any of the lakes which were assessed.

Groundwater accounts for over 13 percent of the total water use for public supplies and 90 percent for rural domestic supplies. The importance of this resource is underscored in the rural areas since nearly all the drinking water is derived from groundwater. Unfortunately, no single state agency has responsibility for comprehensive groundwater management since this resource is a component addressed in many solid and hazardous waste, mining, and surface water acts. As a result, protection efforts are difficult.

During the past couple of years, a number of groundwater contamination incidents have occurred in the Commonwealth. Portions of the alluvial aquifer in Louisville have been contaminated by high nitrate and bacteria levels from septic tanks and seepage pits. Water wells in Magoffin County have been polluted by oil brines. Volatile organics have been detected in the karstic aquifers of the Bowling Green area. A major hepatitis outbreak has occurred throughout Knott, Floyd and Meade counties primarily due to faulty personal waste disposal and septic systems. Mining activities are the alleged source of well contamination throughout the Eastern Coalfield region.

Special Concerns/Remaining Problems

The Cabinet has received numerous reports concerning detrimental effects on the environment and adverse impacts on the citizens of Kentucky as a result of the improper disposal of wastewater from oil and gas production facilities. These reports, along with expressions of concern about the problem, have been generated by wildlife and environmental agencies as well as the private sector.

The area of direct impact from produced water discharges includes the Licking River Basin, the Upper Cumberland River Basin, the Kentucky River Basin, and the Green River Basin. The entire population of Kentucky is indirectly affected by the adverse impacts on the natural resources of the Commonwealth. These resources include stream quality, aquatic habitats, national forest areas, and the productive capabilities of land.

The status of acid mine drainage impacts on the streams of Kentucky has remained essentially unchanged over the past two years. It will remain a continuing concern because most of the drainage comes from abandoned mine lands.

During 1982-83, 64 fish kills attributed to pollution were reported, affecting approximately 100 miles of streams.

Water Pollution Control Programs

Effective October 1, 1983, EPA delegated the responsibility of NPDES to the state. Kentucky inherited a backlog of nearly 1700 expired or unissued permits, most of these consisting of minor coal mining facilities. A high priority task will be to efficiently reduce this backlog while maintaining water quality goals and objectives.

The Construction Grants Program has resulted in the construction of $183 million in wastewater projects which became operational during 1982-83. Thirty municipal wastewater projects were completed with an additional 39 projects in various stages of construction. Kentucky has several concerns relative to the issue of Construction Grants funding for wastewater treatment facilities.

During 1982-83, enforcement activities resulted in 86 legally enforceable compliance orders and the assessment of $113,000 in civil penalties.

Nonpoint sources of water pollution resulting from agriculture, forestry, construction, and mining land disturbances continue unabated in Kentucky. These pollution sources are responsible for use impairment and habitat modification of Kentucky's streams, lakes and wetlands. In many cases documented proof has been gathered showing the serious water quality implications of unabated sediment, nutrient, pesticide, and acid mine drainage pollutants. Kentucky's nonpoint source assessment was completed in April, 1984. The purpose of the assessment was to determine the extent and severity of agriculture, silviculture, mining, and construction caused sediment, nutrient, and/or pesticide-related water pollution in Kentucky.

A total of 54 primary ambient monitoring stations were operated in Kentucky during the reporting period which characterized approximately 1350 miles of water (excluding the Ohio River main stem). Biological monitoring was conducted at ten of these locations in support of EPA's Basic Water Monitoring Program. During 1982-83 twenty-two intensive surveys were conducted in high priority water quality-limited stream segments for the purpose of assessing use attainability. The results of these studies form the basis for recommended changes in Kentucky's stream use classifications.

BACKGROUND

BACKGROUND

This report was prepared to fulfill the requirements of Section 305(b) of the Federal Water Pollution Control Act of 1972 (Public Law 92-500) as amended by the Clean Water Act of 1977 (Public Law 95-217). Section 305(b) requires that states submit a report to the U.S. Environmental Protection Agency (EPA) every two years which addresses current water quality conditions in their waters. Other items to be addressed in the report include an assessment of the degree to which nonpoint sources of pollutants affect water quality, an assessment of the extent to which a state's waters meet the fishable/swimmable goals of the Act, and recommendations on additional actions necessary to achieve the water quality objectives of the Act. The U.S. Environmental Protection Agency uses the report from the states to apprise Congress of the current water quality of the Nation's waters and recommends actions which are necessary to achieve improvements in water quality. States use the reports to provide information to the general public and other interested parties on water quality conditions.

This report follows, as much as possible, the guidance document provided to the states by the EPA for the 1984 report. The stream water quality in this report is based on those streams shown on the U.S. Geological Survey's Hydrologic Unit Map of Kentucky (scale 1:500,000). The assessments were based on this map's approximately 1300 streams and rivers which contain about 19,100 stream miles. Kentucky is divided into 42 cataloging units, 32 of which make up the 12 river basins assessed in this report. These drainage basins from east to west are the Big Sandy, Little Sandy, Tygarts, Licking, Kentucky, Upper Cumberland, Salt, Green, Tradewater, Lower Cumberland, Tennessee and Mississippi. The remaining 10 cataloging units compose the main stem of the Ohio River and minor tributaries. The Ohio River Valley Water Sanitation Commission (ORSANCO) compiles a report on the Ohio River which is used as a supplement to the 305(b) reports submitted by the member states of the Commission. The assessment of lake conditions is based on the 90 lakes which have been surveyed by the Divison of Water for trophic status and restoration needs. The surveys were funded by a cooperative agreement award to the state through the Clean Lakes Program which is administered by the U.S. Environmental Protection Agency. The lakes which were assessed have a total area of 358,214 acres. This includes the total acres of Barkley, Kentucky and Dale Hollow lakes which are border lakes with Tennessee.

Kentucky's population, according to the 1980 census, is 3,660,257. The state comprises an approximate area of 40,598 square miles. It has been estimated that there are approximately 40,000 miles of streams within the borders of Kentucky which ranks the state seventh in total length of streams within the contiguous United States. Kentucky has 849 miles of border rivers. The northern boundary of Kentucky is formed by the low water mark of the northern shore of the Ohio River and extends along the river from Catlettsburg in the east to the Ohio's confluence with the Mississippi River near Wickliffe in the west (a length of 664 miles). The southern boundary is formed by an extension of the Virginia-North Carolina 1780 Walker Line which extends due west to the Tennessee River. Following the acquisition of the Jackson Purchase in 1818, the 30°36' parallel was accepted as the southern boundary from the Tennessee River to the Mississippi River.

Kentucky's eastern boundary begins at the confluence of the Big Sandy River with the Ohio River at Catlettsburg and follows the main stem of the Big Sandy and Tug Fork southeasterly to Pine Mountain for a combined length of 121 miles, then follows the ridge of Pine and Cumberland mountains southwest to the Tennessee line. The western boundary follows the middle of the Mississippi River for a length of 64 miles and includes several of the islands in the Mississippi channel.

The climate of Kentucky is classified as continental temperate humid. Summers are warm and humid with an averge temperature of 76°F, while winters are moderately cold with an average temperature of 34°F. Annual precipitation averages about 45 inches but varies between 40 to 50 inches across the state. Maximum precipitation occurs during winter and spring with minimum precipitation occurring in late summer and fall.

CHAPTER I

WATER QUALITY ASSESSMENT

RIVERS AND STREAMS

Status

Water quality conditions reported for rivers and streams in Kentucky are based primarily on four categories of information; (1) primary network data, (2) intensive surveys, (3) Kentucky Department of Fish and Wildlife Resources reports, and (4) acid mine drainage impact inventory. Table 1 provides a summary of designated use support during the reporting period. The designated uses are aquatic life and recreation. The table indicates that for the 10,503.7 miles of streams assessed, approximately 44 percent experienced some degree of use impairment during 1982-83.

Table 1

Summary of Designated Use Support

Basin	Miles Assessed	Miles Supporting Use(s)	Miles Partially Supporting Uses	Miles Not Supporting Uses	Miles Not Assessed
Big Sandy	705.3	69.0	392.4	243.9	550.2
Little Sandy	154.2	34.9	119.3	0.0	206.0
Tygarts Creek	112.7	101.9	10.8	0.0	81.7
Licking	1169.9	578.7	545.1	46.1	864.2
Kentucky	2343.4	1603.2	664.8	75.4	1555.2
Upper Cumberland	1345.3	787.8	401.8	155.7	818.0
Salt	994.0	472.8	499.1	22.1	558.0
Green	2681.4	1724.2	867.7	89.5	920.5
Tradewater	382.6	131.5	111.9	139.2	132.3
Lower Cumberland	273.5	162.4	106.5	4.6	430.1
Tennessee	43.7	19.8	23.9	0.0	324.8
Mississippi	135.5	72.0	63.5	0.0	236.6
Ohio (Minor Tribs.)	162.2	90.6	71.6	0.0	1287.3
Ohio (Main Stem)			Assessment made by ORSANCO		664.5
State Total	**10,503.7**	**5,848.8**	**3,878.4**	**776.5**	**8,629.4**

Table 2 provides a summary of the relative causes of use impairment statewide from the indicated sources for the 4655 miles of waters assessed that are not fully supporting the designated uses. Due to insufficient information, relative causes were not provided for 2463 miles (52.8 percent of the total).

Table 2

Relative Causes of Use Impairment

Cause	Miles Impacted	Percent
Industrial Sources	25	0.5%
Municipal Sources	525	11.3%
Nonpoint Sources	1250	26.9%
Acid Mine Drainage	357	7.7%
Oil & Gas Production	35	0.8%
Specific Cause Not Determined	2463	52.8%
TOTAL	**4655**	**100.0%**

Hydrologic Unit Water Quality Ranking

The purpose of the hydrologic unit water quality ranking is to compare each of the U.S. Geological Survey cataloging unit watersheds in terms of overall water quality. Various sources of information and data have been combined with appropriate weighting to give a rating which ranks the watersheds from best to worst. The composite rank formula utilized is of the form:

$$RANK = a(WQI) + b(FISH) + c(SUDS) + d(AMD)$$

where: a, b, c, and d are weight constants which sum to 1.0

WQI — Water Quality Index - determined from the evaluation of primary network monitoring data.

FISH — Fish Rank - based on a modified Karr Index using Kentucky Department of Fish and Wildlife studies.

SUDS — Stream Use Designation Rank - based on professional assessment of the degree of impact determined from intensive surveys.

AMD — Acid Mine Drainage Impact - an on/off factor which reduces RANK if there are adverse impacts in a hydrologic unit.

The weight constants may be modified to evaluate the influence of the different variables and to arrive at a formula which accurately represents the relative importance and dependability of the individual ranking variables. Further refinement can be anticipated as additional data becomes available. Weight constants utilized in this application of the equation are based upon judgement and the relative abundance of information in each category. The assigned weights are: a=0.5, b=0.2, c=0.2, and d=0.1.

The following is a brief discussion of the development of each of the four ranking variables.

(1) Water Quality Index Rank (WQI)

Water quality index values were calculated for each of the 54 primary ambient monitoring stations operating during 1982-83. Station locations can be found elsewhere in this report under the monitoring program discussion. Data for the two year period was retrieved and compiled by U.S. Geological Survey hydrologic unit. Twenty-six of Kentucky's forty-two hydrologic units were evaluated in this manner.

Categories assessed in the development of the water quality index include: oxygen, pH, aesthetics, trophic nutrients, toxics, fecal coliform bacteria, and biological quality. The method for assigning point values in each of the categories is presented in Appendix A.

Transformation of the water quality index point values was done using the Statistical Analysis System (SAS) procedure RANK. The RANK procedure computes ranks for numeric variables and can also produce normal scores. There are three options for handling ties (when two or more observations in the data have the same value for the ranking variable): using the mean of the corresponding ranks for the tied values; using the lowest of the corresponding ranks for the tied values, or using the highest of the corresponding ranks. In this case, the ties received the mean of the corresponding ranks. The "percent" option was also specified, so that each rank is divided by the number of observations and then multiplied by 100 to get percentages.

The resulting water quality index rank is a number from (1/n*100) to 100, where n, is the number of observations. For watersheds where ambient monitoring data is not available the median rank of 50 was assigned. This assignment is based on the assumption that these units will have water quality approximately equal to the median value for the state.

(2) Fisheries Rank (FISH)

Ecological integrity has been described as the capacity of a system to support and maintain "a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat" within a given geographic region (Ballentine and Quarrie 1975. The Integrity of Water: A Symposium. U.S. Environmental Protection Agency). To assess the component of stream biotic integrity, a classification system was proposed by Karr (Fisheries. 6(6):21-27. 1981). This classification of biotic integrity employs twelve fish community parameters. These parameters reflect the variables of species composition and richness, and functional organization as expressed by trophic structure of the community.

River system fishery inventories of the Kentucky Department of Fish and Wildlife Resources served as the primary source of information used in the classification. These were supplemented with Kentucky Natural Resources and Environmental Protection Cabinet stream use designation and biological monitoring studies. Kentucky Nature Preserves reports, unpublished university collections, recent literature, and environmental impact statements were also used when pertinent.

In the classification system, numerical rankings are given to each parameter (i.e. 1=very poor or absent, 3=median level or average presence,

5=very good or exceptional presence). A total numerical ranking is then achieved from the summation of the individual parameter rankings. The total numerical ranking is then applied to a descriptive classification of stream biotic integrity (i.e., good, fair, poor). In the present 305(b) document, a numerical ranking of greater than 46 is considered good; a ranking of between 37 to 45 is fair; and a ranking of less than 37 is poor. This is somewhat modified from Karr's classification which included a greater number of biotic integrity types (i.e., excellent, very poor, etc). A maximum numerical ranking of 60 is possible. In the current evaluation, when two or more sites were located on the longitudinal axis of the same stream, and the classification of these sites differed, the mid-point between the sites was arbitrarily chosen as the limit of a given segment.

The sum of stream miles in each category was determined for each hydrologic cataloging unit and a simple formula was used to give each watershed a representative point value.

$$\text{Fish point value} = \frac{\text{miles of good - miles of poor}}{\text{total of good, fair and poor}}$$

The point value equation results in a number which ranges from minus one to plus one depending on the number of stream miles in each group. RANK, the SAS procedure, was then used as it was for the water quality index point values, resulting in a Fish Rank of the U.S. Geological Survey hydrological cataloging units. For watersheds where literature data was not available or insufficent, the median rank of 50 was assigned.

A total of 726 evaluations were made, characterizing 432 streams representing 10,135 miles. This evaluation permitted the identification of 46 streams or stream segments (896 miles) with poor biotic integrity. The rating of poor reflected degradation of one or more of the variables (flow regime, water quality, habitat structure, energy source) which influence the biotic integrity of aquatic communities (Karr and Dudley, Environmental Management. 5(1):55-68; 1981). Factors contributing to this observed degradation included impacts from coal mining, domestic wastewater discharges, farming operations, and stream channel modification activities.

(3) Stream Use Designation Survey Rank (SUDS)

During 1982-1983, twenty-two intensive surveys were conducted on water quality-limited stream segments for the purpose of determining use attainability. A listing of these intensive surveys can be found elsewhere in this report under the monitoring program discussion.

Based on best professional judgement of available data, use impairment was evaluated in the watersheds which have been studied. The total number of stream miles studied were grouped into three classes: unimpaired, partially impaired and impaired. As in the previous calculation, a simple formula was used to give each watershed a representative point value.

$$\text{SUDS point value} = \frac{\text{miles unimpaired - miles impaired}}{\text{total miles studied}}$$

The same ranking procedure was used while watersheds which had not been studied received the median rank of 50. In addition, the SUD value was added to the biological trend assessment for a hydrologic unit and averaged for a final value in the water quality index.

(4) Acid Mine Drainage Impact Factor (AMD)

Only a limited amount of current information was available for streams which are affected adversely by mining. As a result, a simple on/off factor was used. If there are no impacts due to mining in a watershed it receives a value of 100. Otherwise a value of zero is assigned.

Streams affected by acid mine drainage were taken from a report produced by the Division of Water in 1981 which inventoried streams in the western and eastern coalfields of the state to determine which ones were affected by coal mining activities. The streams which had a pH below 6.0 standard units were considered to be affected by AMD. Those streams which were reported as being affected by AMD and also shown on the U.S.G.S. Hydrologic Unit Map of Kentucky were assessed as being poor in quality (except for the main stem of the Tradewater River which was rated fair because pH values below 6.0 units were intermittent). A total of 357 stream miles in four hydrologic units were impaired by AMD impacts.

The resultant hydrologic unit ranking is presented in Table 3. This table also lists the percent rank assigned to the ranking variables in each of the watersheds. Further simplification was desired in developing a water quality ranking for the purpose of presentation. Rather than presenting a number which is only a relative comparison to other watersheds, it is more illustrative to develop a classification of "good, fair, or poor" for each hydrologic unit. In order to classify the ranking into natural groups, the SAS procedure CLUSTER was used to perform a cluster analysis on the composite rank (RANK) and group the watersheds as indicated. There was a sufficient data base to allow the analysis to be performed on thirty-four hydrologic units representing most of the state as shown in Figure 1.

Table 3

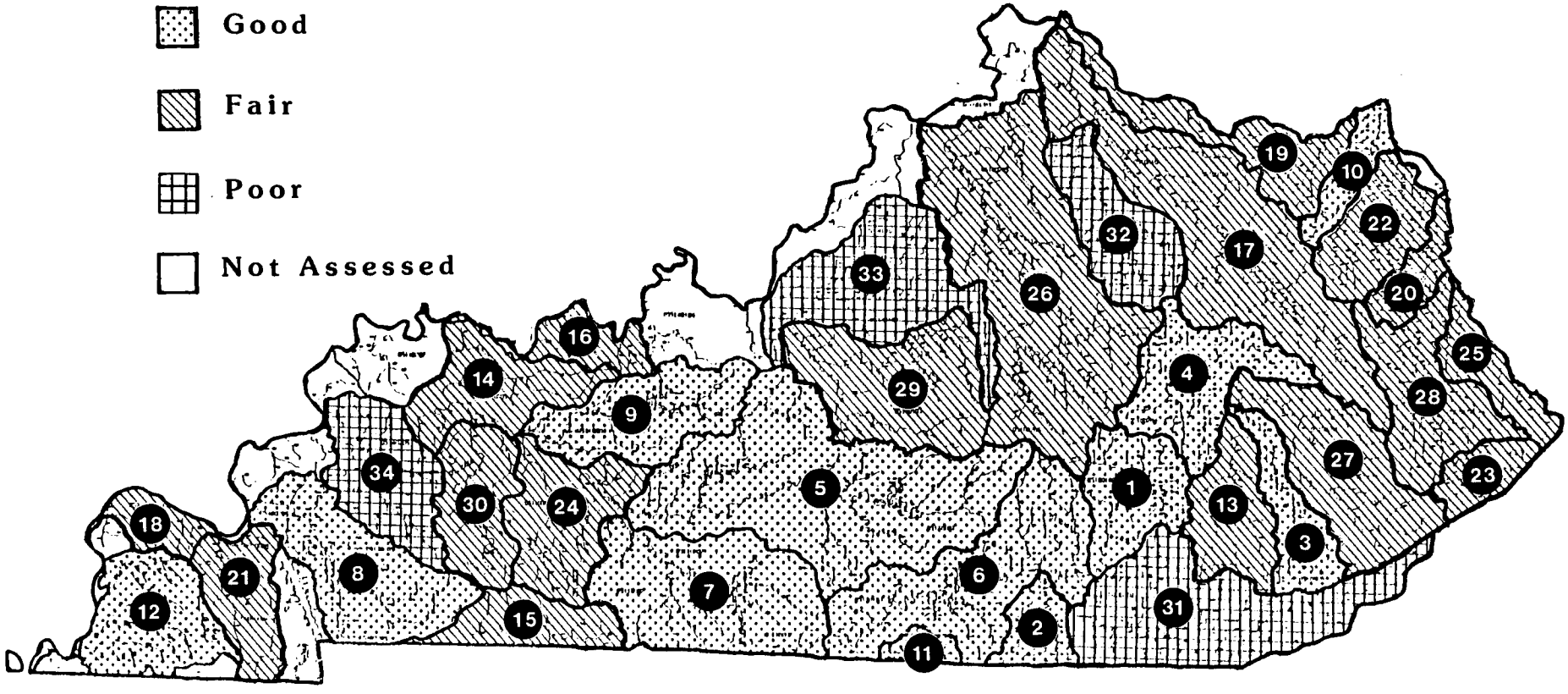
Hydrologic Unit Water Quality Rank

Hydrolgic Unit	Ident.* No.	RANK	WQI (Wt. = 0.5)	FISH (Wt. = 0.2)	SUDS (Wt. = 0.2)	AMD (Wt. = 0.1)
Good						
05130102	1	87.5	100.0	87.5	50.0	100.0
05130104	2	82.7	94.2	78.1	50.0	100.0
05100202	3	80.9	94.2	68.8	50.0	100.0
05100204	4	79.2	88.5	75.0	50.0	100.0
05110001	5	79.1	80.8	93.8	50.0	100.0
05130103	6	77.3	69.2	96.9	66.7	100.0
05110002	7	72.6	69.2	84.4	55.6	100.0
05130205	8	69.8	84.6	37.5	50.0	100.0
05110004	9	69.0	69.2	71.9	50.0	100.0
05090103	10	68.7	50.0	90.6	77.8	100.0
05130105	11	65.0	50.0	100.0	50.0	100.0
08010201	12	64.6	69.2	50.0	50.0	100.0
Fair						
05100203	13	59.3	46.2	81.3	50.0	100.0
05110005	14	57.7	69.2	15.6	50.0	100.0
05130206	15	56.9	50.0	59.4	50.0	100.0
05140201	16	56.2	50.0	56.3	50.0	100.0
05100101	17	56.2	34.6	50.0	94.4	100.0
05140206	18	55.6	50.0	53.1	50.0	100.0
05090201	19	54.4	50.0	46.9	50.0	100.0
05070204	20	52.6	57.7	18.8	50.0	100.0
06040006	21	51.2	42.3	50.0	50.0	100.0
05090104	22	50.0	50.0	25.0	50.0	100.0
05070202	23	46.2	50.0	6.3	50.0	100.0
05110003	24	46.2	38.5	40.6	94.4	0.0
05070201	25	45.6	50.0	3.1	50.0	100.0
05100205	26	45.5	26.9	65.6	44.4	100.0
05100201	27	42.1	19.2	62.5	50.0	100.0
05070203	28	38.8	53.8	9.4	50.0	0.0
05140103	29	32.6	7.7	43.8	50.0	100.0
05110006	30	32.3	30.8	34.4	50.0	0.0
Poor						
05130101	31	28.4	19.2	21.9	22.2	100.0
05100102	32	28.2	3.8	31.3	50.0	100.0
05140102	33	28.1	11.5	28.1	33.3	100.0
05140205	34	14.3	19.2	12.5	11.1	0.0

*Identification Number locates hydrologic unit on Figure 1.

Figure 1.

Hydrologic Unit Water Quality Rank



* Numbers correspond with relative ranking shown in Table 3.

As shown in Table 3, the highest priority watersheds relative to water quality impairment are the Tradewater River (05140205), Salt River (05140102), South Fork of the Licking River (05100102), and the Upper Cumberland River (05130101). These watersheds were rated poor due to physicochemical and biological conditions at the monitoring sites in each basin. A general discussion of why these basins are poorly rated is as follows:

(1) Hydrologic Unit 05140205 - Tradewater River basin.

The Tradewater River basin's major impacts are acid mine drainage and sedimentation. Minor impacts in the basin are agricultural runoff and municipal wastewater discharges. These impacts resulted in aquatic uses being impaired or partially impaired during 1982-83 in approximately 66 percent of the stream miles assessed in the basin.

(2) Hydrologic Unit 05140102 - Salt River basin excluding Rolling Fork

Major impacts to the Salt River basin are non-point agricultural and urban runoff followed closely in significance by municipal wastewater discharges throughout the basin and industrial discharges in the lower portion of the basin. Natural low flow conditions in the Salt River basin often compound these problems, resulting in less than desirable water quality. These impacts have resulted in aquatic uses being impaired or partially impaired during 1982-83 in approximately 53 percent of the stream miles assessed in the basin.

(3) Hydrologic Unit 05100102 - South Fork of Licking River basin.

The South Fork of the Licking River's major impacts are due to municipal discharges and non-point agricultural runoff. Additional impacts caused by low stream gradient, low flow, and significant water withdrawal by municipalities and agricultural operations contribute to the problems in this basin. These impacts have resulted in aquatic uses being impaired or partially impaired during 1982-83 in approximately 53 percent of the stream miles assessed in the basin.

(4) Hydrologic Unit 05130101 - Upper Cumberland River basin above Rockcastle River.

The major impact in this segment of the Upper Cumberland River basin is sedimentation resulting from mining activities. The basin also exhibits localized impacts from municipal wastewater discharges and, to a lesser degree, industrial wastewater discharges. Minor impacts are due to non-point runoff from agricultural and silviculture activities. An impact of increasing significance in the basin is the discharge from existing and developing oil and gas production facilities. These impacts resulted in aquatic uses being impaired or partially impaired during 1982-83 in approximately 64 percent of the stream miles assessed in the basin.

The comparison of the results of the hydrologic unit water quality ranking with the information in Table 1 presents one notable anomaly that should be addressed. Table 1 indicates that approximately 90 percent of the stream miles assessed in the Big Sandy River basin experienced some degree of use impairment during the period of record. Yet, none of the Big Sandy basin's four hydrologic units are represented in the ranking category of "poor". These hydrologic units (05070201-4) were ranked in the lower range of "fair". One explanation is that the majority of miles shown under the impaired use categories were derived from the Fisheries Rank Factor. Due to the dated

nature of some of the information, the Fisheries Rank Factor was given a lower weighting in the final composite watershed rank than was the primary network data (WQI Factor).

However, it should be pointed out that aquatic habitats within the Big Sandy River basin have historically been, and continue to be impaired. The major cause of impairment to aquatic habitats within the basin is coal mining operations. The land disturbance associated with mining in this rugged terrain results in significant runoff of the shallow sandy soils, which impacts aquatic life and habitats with settleable and suspended sediments, coal fines, and other aquatic pollutants. Oil and gas drilling have degraded the water quality in isolated subbasins. These continuous chronic impacts to the aquatic life and aquatic habitats have resulted in the impairment of the biological integrity in much of this basin.

Basin/Segment Information

Water quality conditions and trends are summarized by river basin and hydrologic unit in Tables 4 through 13. The water quality index ratings and trends are presented for the seven water quality indicator categories. The existence or non-existence of water quality trends were determined statistically for parameters measured at fixed ambient monitoring sites. The non-parametric trend analysis used was the Kendall tau-b correlation coefficient and a confidence limit of 95 percent as the criterion for the existence of a trend. Data for the years 1979 through 1983 were analyzed. The statistical trend analysis encompassed the following water quality categories and parameters.

1. Dissolved oxygen (D.O.)
2. pH
3. Aesthetics (suspended solids)
4. Nutrients (TP and NO_2-NO_3-N)
5. Toxics (As, Be, Cd, Cr, Cu, Fe, Ni, Se, Ag, Zn, un-ionized ammonia)

Fecal coliform bacteria were not included because the STORET data base was not complete enough to determine trends. Biological trends were determined by another method which is discussed in Appendix A. The parameters in the nutrients and toxics categories were analyzed separately and then combined in each category for an overall assessment which is shown in each table. An average trend was not determined because an average would mask the interpretation of the individual trends.

The direction of the arrows in the tables is an interpretation of whether there is an improving or decreasing trend in water quality for each of the 5 categories. An increasing trend in dissolved oxygen and pH is interpreted to be an improvement in water quality and conversely, a decreasing trend is interpreted to be a decrease in water quality. A downward trend in suspended solids (aesthetics category), toxics, and nutrients is interpreted to be an improvement in water quality. An upward trend for these categories is interpreted as a decrease in water quality. Since this was an initial effort in using this type of trend analysis, further interpretation was not attempted. Future refinement of the method will involve setting limits on parameter values which will signal whether the trend approaches a level of concern to aquatic uses.

Each table is preceded by a map which delineates the hydrologic unit boundaries within the basin (Figures 2 through 9). A more extensive discussion of river basin and hydrologic unit characteristics and conditions is provided in Appendix B.

Problem water quality parameters noted at fixed trend monitoring stations throughout the state are generally related to the impacts which occur in the various basins. Nutrients, such as total phosphorus and nitrate and nitrite - nitrogen are related to agricultural activities and, to a lesser extent, discharge of domestic wastewater. Fecal coliform bacteria violations are caused by improper wastewater treatment plant operation, faulty septic tanks and agricultural runoff. Land disturbances, either from agricultural activities or mining operations, increase the amount of suspended solids in streams, as well as levels of metals such as copper, iron and zinc. Sediments from most areas of the state contain elevated levels of chlordane, reflecting its widespread use as a broad spectrum insecticide. Basin and hydrologic unit-specific problem parameters are discussed in Appendix B.

For the current 305(b) reporting period, analytical capability and detection limits have improved significantly. As a result, problem parameters in previous reports are now suspect. These parameters, especially mercury and lead, were omitted from the basin discussions until conclusive evidence of their presence is confirmed.

Big Sandy River Basin

Includes Little Sandy and Tygarts Creek

FIGURE 2

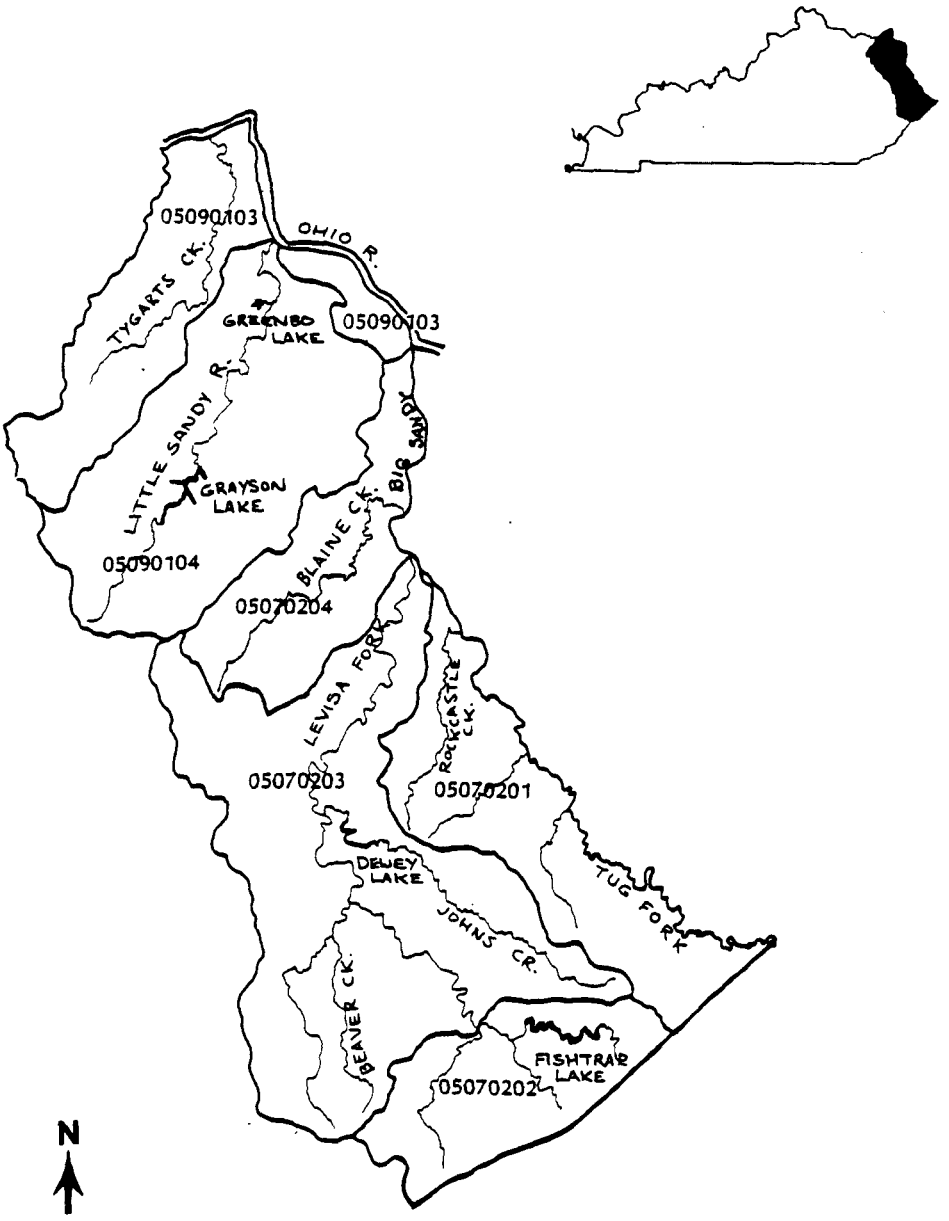


TABLE 4

BIG SANDY RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	F	G	F	P	F	F	8	605.0	Cu FC Fe
	TREND	→	→	→	→	↑	△	△				
05070201	WQI	G	G	F	G	F	P	△	F	2	186.6	Cu FC Fe
	TREND	→	↑	↑	→	↑	△	△				
05070203	WQI	G	G	G	G	F	P	F	F	3	299.5	Cu FC Fe
	TREND	→	→	→	→	↑	△	△				
05070204	WQI	G	G	F	G	F	P	F	F	3	118.9	Cu FC Fe
	TREND	→	→	→	→	↑	△	△				
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

Licking River Basin

FIGURE 3

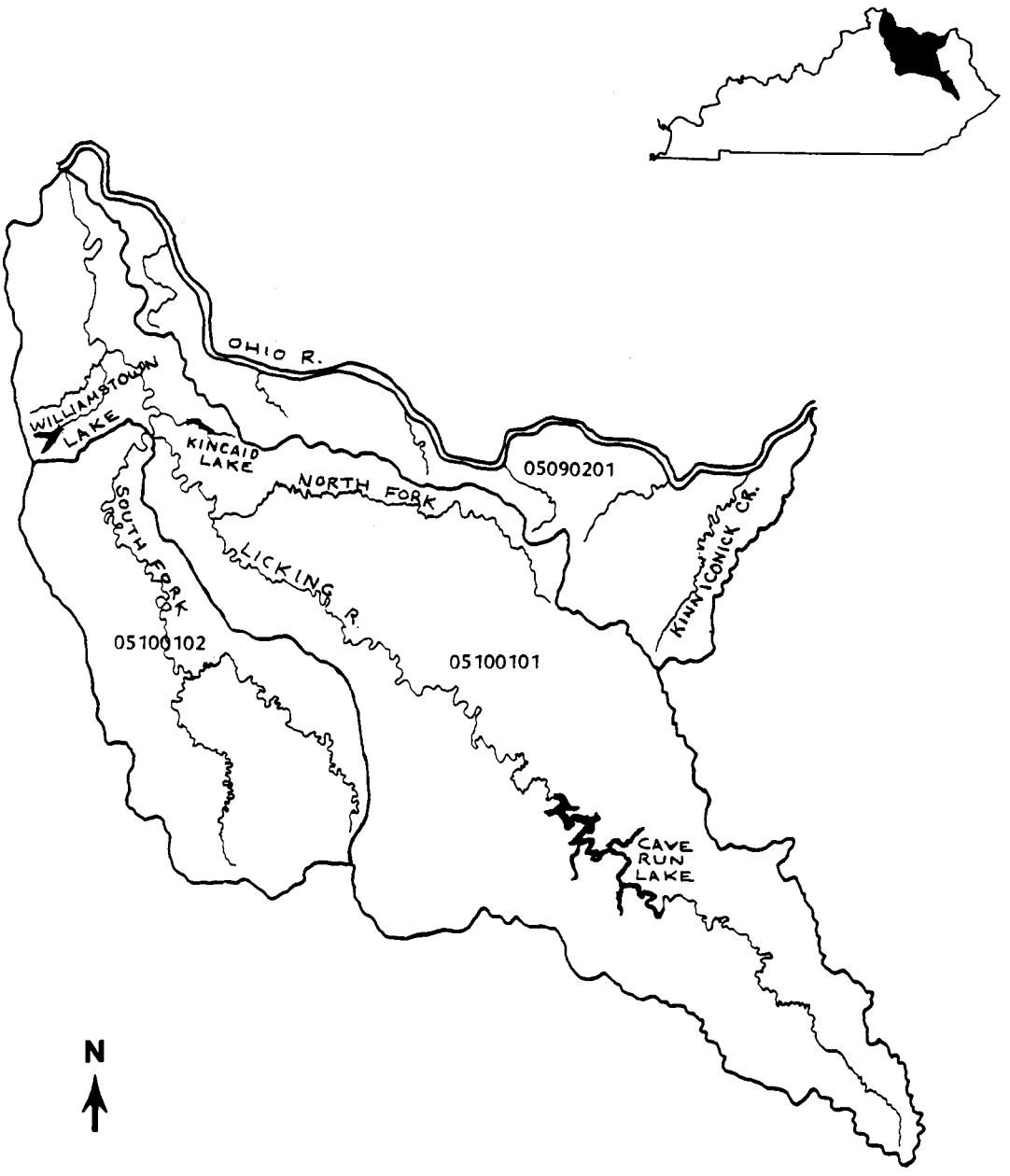


TABLE 5

LICKING RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	F	P	F	F	G	F	5	1169.9	Cu FC Fe NO_3 P
	TREND	→	→	→	→	→	△	△				
05100101	WQI	G	G	F	P	F	F	G	F	4	794.7	Cu Fe NO_3 P
	TREND	→	→	→	→	→	△	△				
05100102	WQI	△	G	△	P	F	P	△	F	1	375.2	Cu FC Fe P
	TREND	△	→	△	△	→	△	△				
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

Kentucky River Basin

FIGURE 4

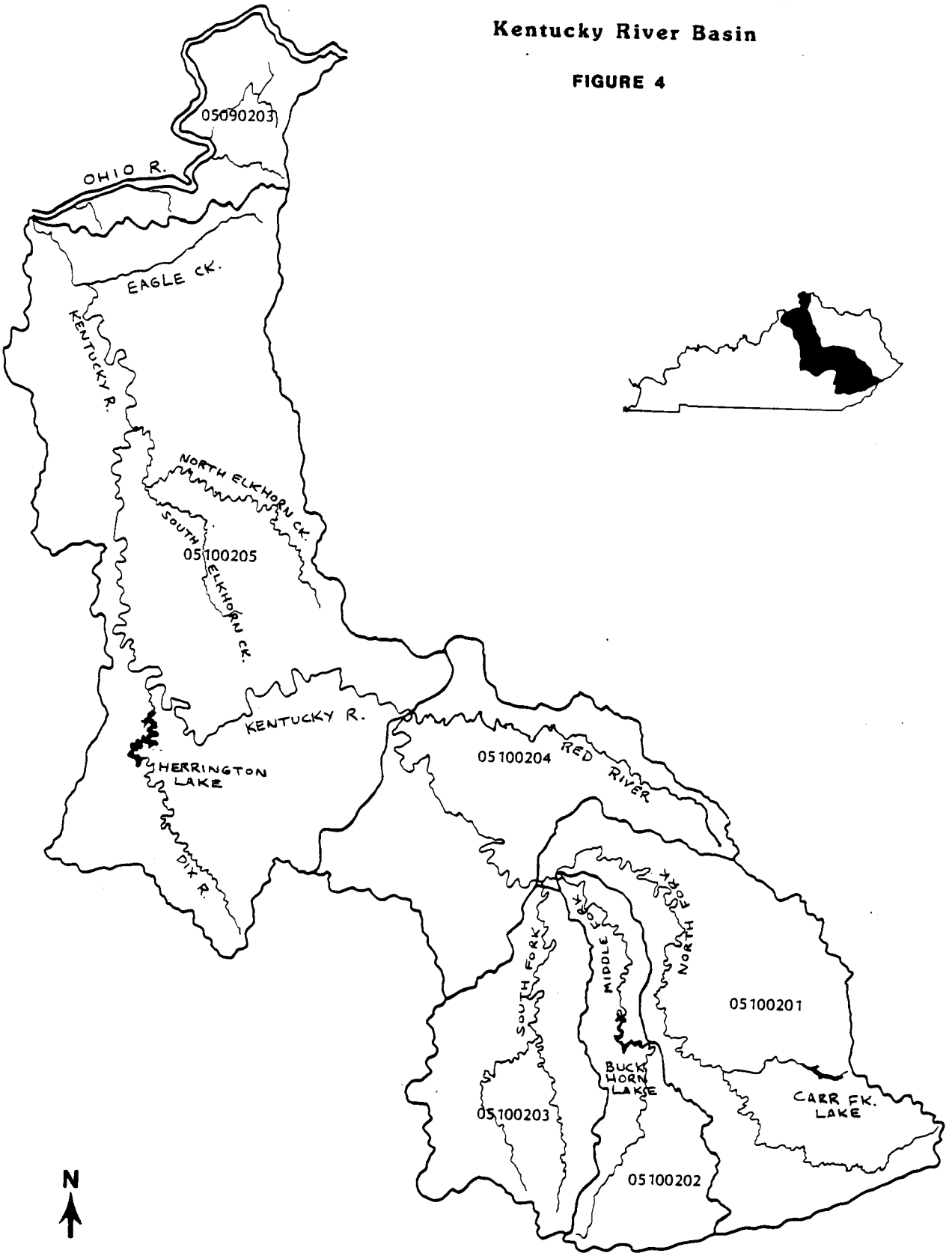


TABLE 6

KENTUCKY RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	F	F	G	F	G	F	11	2343.4	Cu FC Fe NO_3 P Zn
	TREND	→	↓	→	→	→	△	↑				
05100201	WQI	G	G	△	P	G	P	△	F	1	662.1	Cu FC Fe P Zn
	TREND	△	↓	△	↑	→	△	△				
05100202	WQI	G	G	△	G	G	G	△	G	1	151.8	Cu Fe Zn
	TREND	△	↓	△	→	→	△	△				
05100203	WQI	G	G	△	F	G	P	△	F	1	225.2	Cu FC Fe Zn
	TREND	→	↓	△	→	→	△	△				
05100204	WQI	G	G	F	G	G	F	△	G	2	346.3	
	TREND	→	→	→	→	↑	△	△				
05100205	WQI	G	G	F	P	F	F	G	F	6	958.0	Cu Fe NO_3 P
	TREND	↑	→	→	↓	↓	△	↑	↑			
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

Upper Cumberland River Basin

FIGURE 5

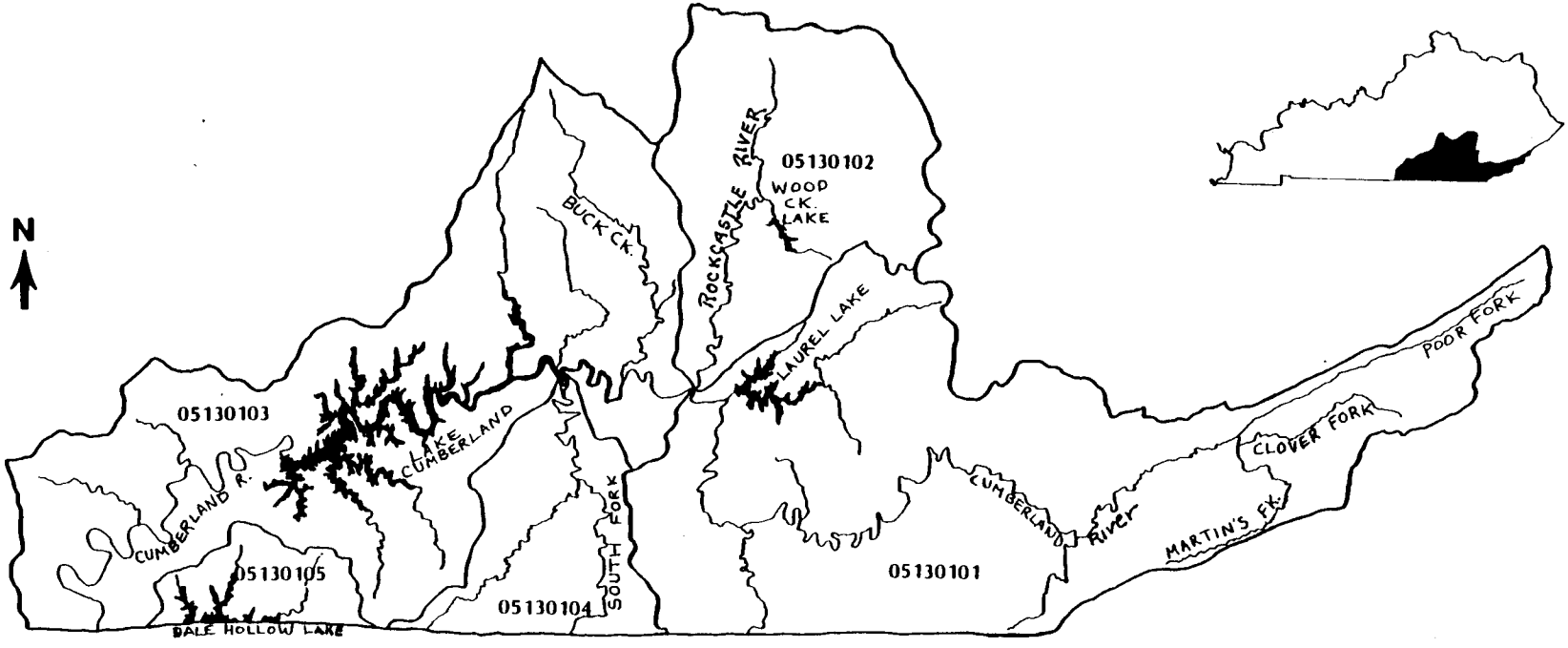


TABLE 7

UPPER CUMBERLAND RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	G	G	F	F	G	G	5	1337.5	Cu FC Fe SS
	TREND	→	→	→	→	→	△	△				
05130101	WQI	G	G	P	G	F	P	△	F	2	651.0	Cu FC SS
	TREND	→	→	↑	↓	↑	△	△				
05130102	WQI	G	G	G	G	F	G	G	G	1	234.6	
	TREND	→	↑	→	↓	↓	△	△				
05130103	WQI	G	G	G	G	F	P	△	F	1	308.0	Cu FC
	TREND	→	↑	→	→	→	△	△				
05130104	WQI	G	G	G	G	F	G	△	G	1	143.9	Cu Fe
	TREND	→	→	→	→	→	△	△				
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = IDECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

Salt River Basin

FIGURE 6

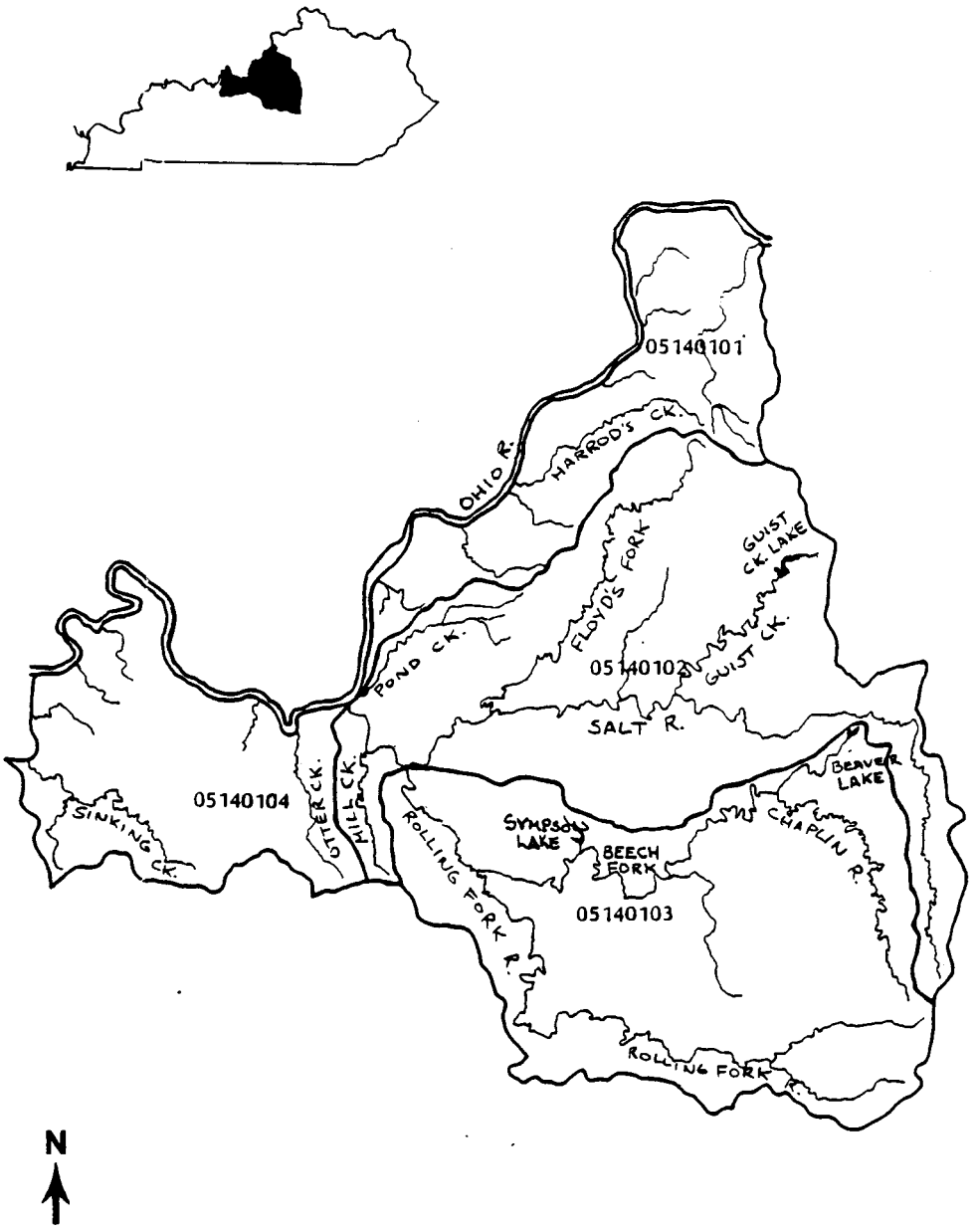


TABLE 8

SALT RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	F	P	F	F	F	F	7	994.0	Cu FC Fe P SS Zn
	TREND	→	↑	↑	↑	→	△	→				
05140102	WQI	G	G	F	P	F	F	F	F	5	405.8	Cu Fe P SS Zn
	TREND	→	→	↑	→	↑	△	→				
05140103	WQI	G	G	P	P	G	P	△	F	2	588.2	Cu FC Fe P SS Zn
	TREND	△	↑	△	↑	↓	△	△				
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

Green River Basin

FIGURE 7

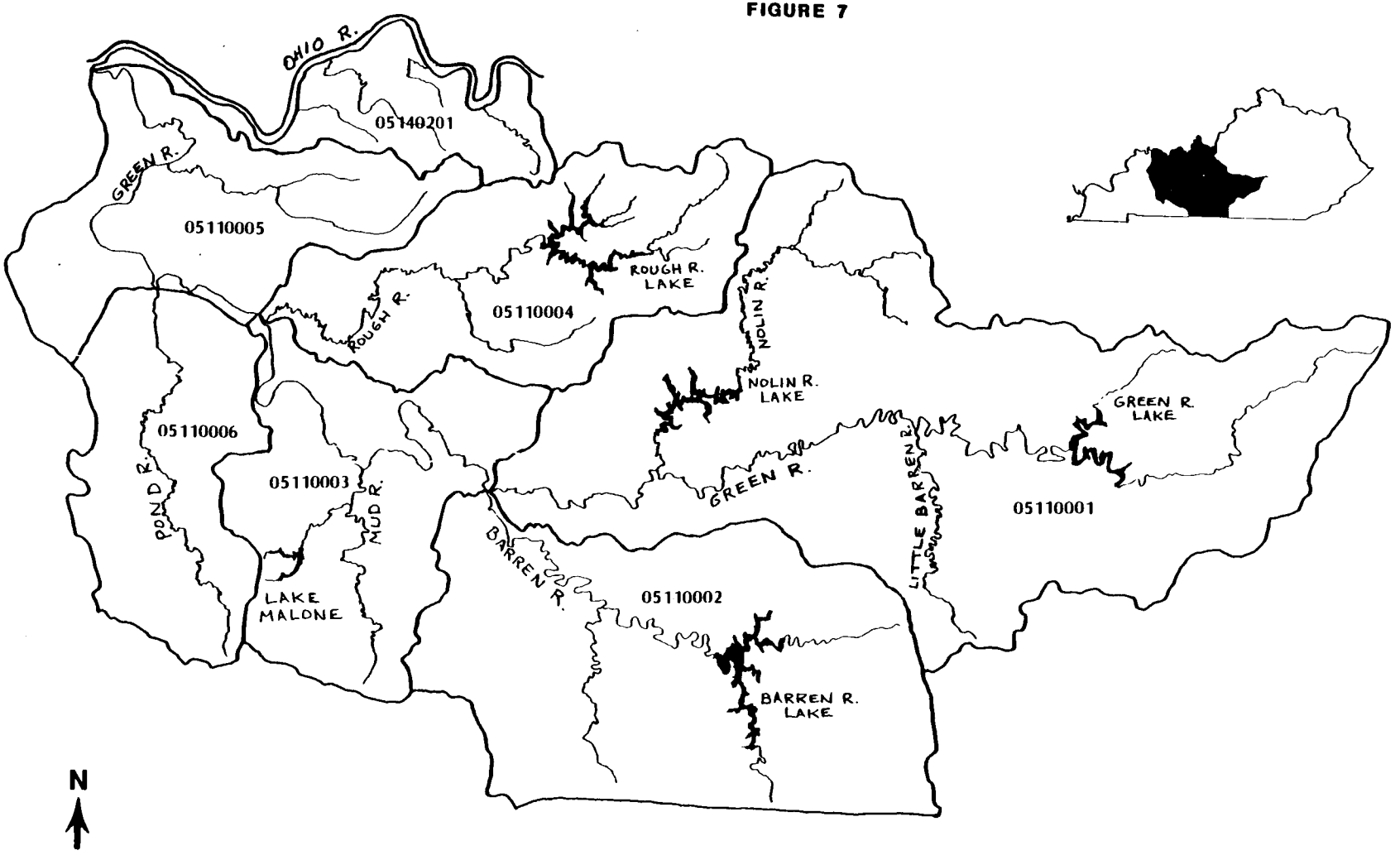


TABLE 9

GREEN RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	F	F	F	F	F	F	12	2681.4	Cu Fe NO_3 Zn
	TREND	→	→	→	→	↑	△	△				
05110001	WQI	G	G	G	F	G	P	G	G	4	892.7	Cu NO_3
	TREND	→	→	→	→	↑	△	△				
05110002	WQI	G	G	F	F	G	F	△	F	1	516.4	Cu NO_3
	TREND	→	↑	→	→	↑	△	△				
05110003	WQI	G	G	F	P	F	F	△	F	2	442.7	Cu NO_3
	TREND	→	↑	→	↑	→	△	△				
05110004	WQI	G	G	F	F	G	F	△	F	1	371.2	Cu Fe NO_3 Zn
	TREND	→	→	→	→	↓	△	△				
05110005	WQI	G	G	G	F	F	G	△	F	2	200.9	Cu Fe NO_3
	TREND	△	↓	→	→	↑	△	△				
05110006	WQI	G	G	F	P	F	F	F	F	2	257.5	Cu Fe NO_3
	TREND	→	↑	→	→	↑	△	△				

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

Lower Cumberland and Tradewater River Basins

FIGURE 8

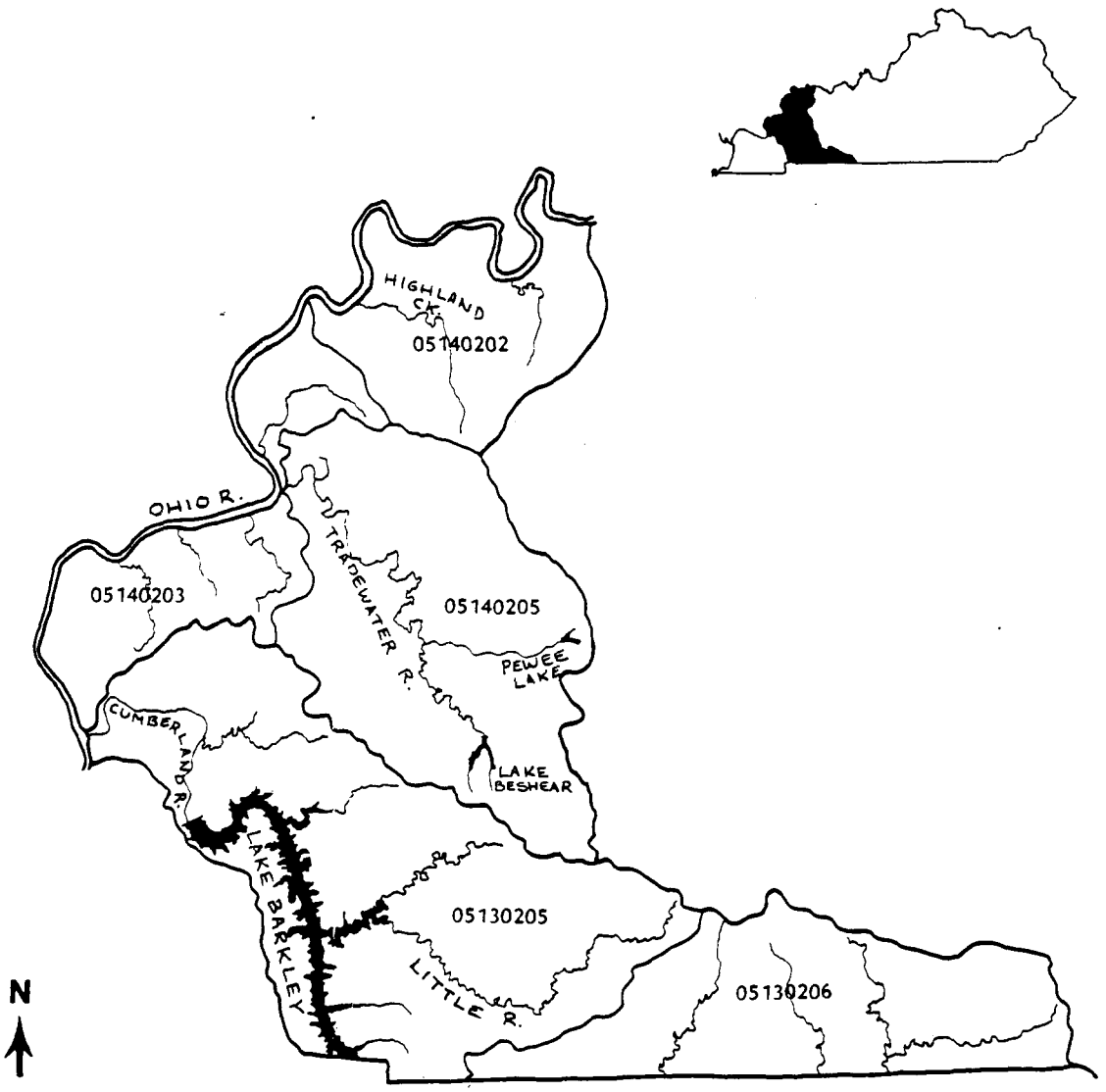


TABLE 10

TRADEWATER RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	△	F	F	P	△	F	1	382.6	Cu FC Fe
	TREND	△	→	→	→	→	△	△				
05140205	WQI	G	G	△	F	F	P	△	F	1	382.6	Cu FC Fe
	TREND	△	→	→	→	→	△	△				
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

TABLE 11

LOWER CUMBERLAND RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	G	G	△	△	△	G	2	109.3	NO_3
	TREND	△	↓	→	↑	↑	△	△				
05130205	WQI	G	G	G	G	△	△	△	G	2	109.3	NO_3
	TREND	△	↓	→	↑	↑	△	△				
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = INCREASE IN CONCENTRATION(S)
→ = NO DETECTABLE TREND
↓ = DECREASE IN CONCENTRATION(S)
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

Tennessee and Mississippi River Basins

FIGURE 9

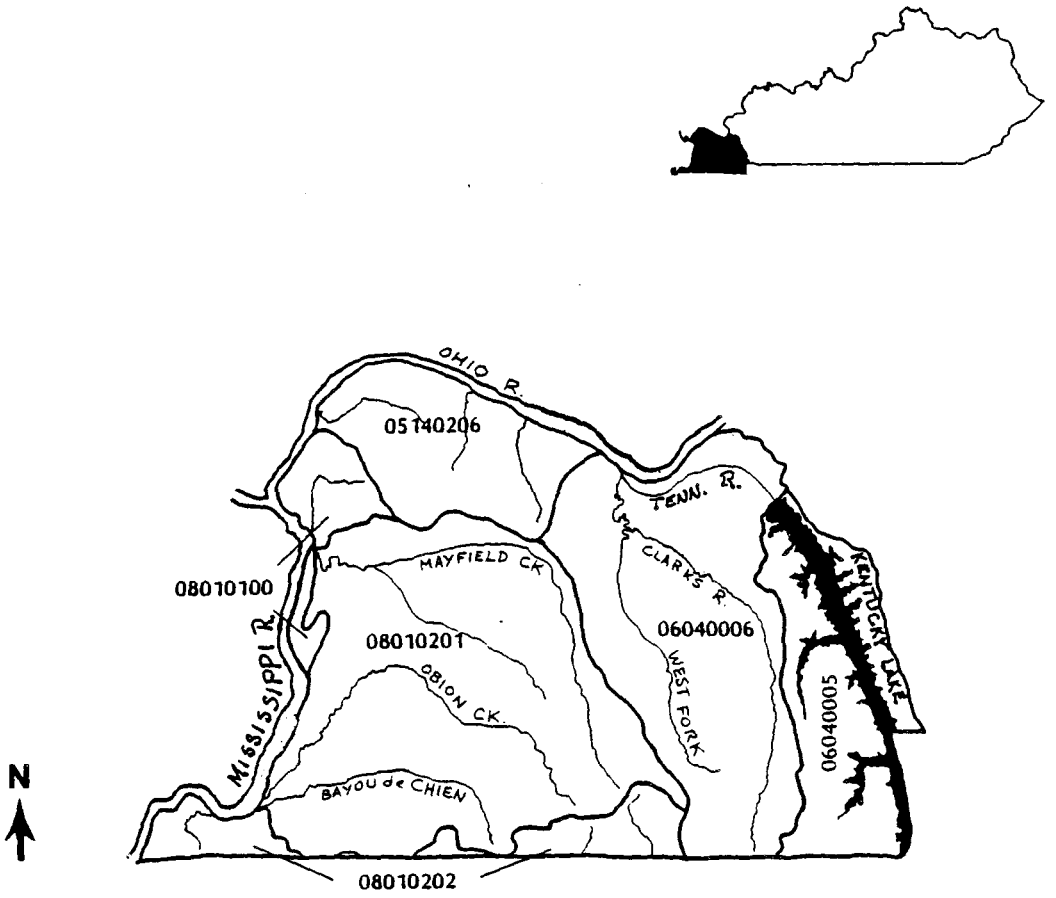


TABLE 12

TENNESSEE RIVER BASIN												
HYDROLOGIC UNIT	B2-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	F	G	F	F	F	△	F	2	43.7	
	TREND	△	↓	→	↑	↑	△	△				
06040006	WQI	G	F	G	F	F	F	△	F	2	43.7	
	TREND	△	↓	→	↑	↑	△	△				
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

TABLE 13

MISSISSIPPI RIVER BASIN												
HYDROLOGIC UNIT	82-83	D.O.	PH	AESTH.	NUTR.	TOXICS	BACT.	BIOL.	AVG.	NO. OF STATIONS	MILES ASSESSED	PROBLEM PARAMETERS
BASIN SUMMARY	WQI	G	G	△	F	G	F	△	F	1	135.5	Cu Fe
	TREND	△	→	△	→	↑	△	△				
08010201	WQI	G	G	△	F	G	F	△	F	1	135.5	Cu Fe
	TREND	△	→	△	→	↑	△	△				
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											
	WQI											
	TREND											

WATER QUALITY INDEX (WQI):

G = GOOD
F = FAIR
P = POOR
△ = UNKNOWN

TREND:

↑ = IMPROVING QUALITY
→ = NO DETECTABLE TREND
↓ = DECREASING QUALITY
△ = UNKNOWN

PROBLEM PARAMETERS

SS = Suspended Solids
FC = Fecal Coliform Bacteria
NO_3 = Nitrates
P = Total Phosphorus
Cu = Copper
Fe = Iron
Zn = Zinc

LAKES

The Natural Resources and Environmental Protection Cabinet was awarded a two year federal grant through the Clean Lakes Program to trophically classify Kentucky's public lakes and determine their need for restoration. The grant was awarded in 1981. An extension to that grant enabled the Cabinet to survey additional lakes in 1983. The three year project resulted in the trophic classification of 90 lakes. The 1980-1981 Kentucky Report to Congress on Water Quality discussed 28 of these lakes. The current report summarizes the condition of all 90 lakes which were in the lake classification program. The format has been changed from the previous report to include information that was in the U.S. Environmental Protection Agency's guidance to states for the 1984 Report to Congress.

The lake classification project assessed lake conditions by the use of field surveys conducted by the Division of Water and by the use of current survey data from other agencies. The lakes were grouped into two categories generally based on size. Lakes categorized as "major" are the 15 lakes operated by the U.S. Army Corps of Engineers (COE), Kentucky Lake which is managed by the Tennessee Valley Authority (TVA) and Herrington Lake which is operated by Kentucky Utilities. These are generally the largest lakes in the Commonwealth and constitute the largest percentage of lake surface area surveyed. The second category of lakes are designated as "minor" and are those lakes which were surveyed by the Division of Water. The general location of the lakes in the classification program are listed in Appendix C. The larger lakes are shown on the river basin maps included in the first portion of this chapter.

Monitoring Program - State Lake Surveys

Each lake in the classification study was sampled once in the spring, summer and fall. During each of the three samplings a depth profile at the deepest site was made to record temperature, pH, conductivity, and dissolved oxygen. A submarine photometer was used to measure the depth of the euphotic zone. A composite water sample was then taken from this zone to measure chlorophyll-a, total phosphorus, total filtrable phosphorous, orthophosphate (filtrable reactive phosphorus), total Kjeldahl nitrogen, ammonia and nitrite-nitrate nitrogen. A Secchi disc measurement was also taken. Because of their configuration and size, some lakes had more than one sampling site. All sites were sampled as described above. Field observations were made during the lake visits to note any excessive development of aquatic macrophytes.

The trophic status of the lakes was determined by converting the chlorophyll-a concentrations to Carlson trophic state index (TSI) values. A mean index value was derived from all the samples from each lake and the lakes were then ranked as to trophic state.

Monitoring Program - COE and Other Agency Operated Lakes

Current and long term data from the COE operated lakes were obtained in the form of computer printouts from COE District Offices. Monthly chlorophyll-a data for the spring through fall seasons were used to determine TSI values as described above. The Division of Water sampled Herrington Lake as part of its 1983 field surveys and assigned a trophic state based on that data. TVA conducted a water quality survey of Kentucky Lake in 1982 and their spring, summer and fall chlorophyll-a data were used to assign a trophic state to the lake.

Trophic Status

A summarization of Tables 15 and 16 indicates that of the 90 lakes in the classification survey, forty-five (50%) were eutrophic, twenty six (29%) were mesotrophic and seventeen (19%) were oligotrophic. Two of the 90 lakes (2%) were hypereutrophic. When total surface acres of lakes are considered, the greatest percentage of the surface waters inventoried were mesotrophic or oligotrophic. Out of the total 358,214 acres inventoried, 184,446 acres (51%) were classified as mesotrophic, 98,564 acres (28%) were oligotrophic, 75,079 acres (21%) were eutrophic, and 105 acres (less than 1%) were hypereutrophic.

When comparing major and minor lakes, the tables show that of the 17 major lakes, 10 are oligotrophic, 5 are mesotrophic and 2 are eutrophic. Two of these lakes exhibit trophic gradients (Barren River and Laurel River) and Kentucky Lake has two eutrophic embayments. In contrast the majority of minor lakes were eutrophic. Of the total number of 73 minor lakes, 43 were eutrophic (59%), 21 were mesotrophic (29%), 7 were oligotrophic (19%), and two were hypereutrophic (3%).

Two new lakes were created since the last 305(b) report was prepared. Taylorsville Lake (3050 acres) was created by an impoundment of the Salt River and Paintsville Lake (1139 acres) is an impoundment on Paint Creek. Their status will be discussed in the next 305(b) report.

Use Impairments

Tables 17 and 18 list the lakes in the classification survey according to whether their designated uses are not supported or are partially supported. The designated uses are domestic water supply (where applicable), fishing and recreation (primary and/or secondary contact). The tables also indicate the criteria by which non-support or partial support was judged and the causes for the support not being achieved. The causes in Table 18 is labelled as "probable" because in some cases, best professional judgement had to be used in making the assessments. Forty-one of the 90 lakes which were assessed do not fully support their designated uses. Table 14 summarizes the acres of lakes which support, partially support or do not support designated uses. Ninety-one percent of the total acres assessed supported designated uses while only nine percent did not fully support designated uses.

Table 14

Support of Designated Uses In Lakes

	Total Acres Assessed	Acres Supporting Designated Use(s)	Acres Partially Supporting Designated Use(s)	Acres Not Supporting Designated Use(s)
Major Lakes	348,569	320,366	28,203	0
Minor Lakes	9,645	4,924	4,148	573
State Total	358,214	325,290	32,351	573

Table 15

Major Lake Trophic State Rankings

By Carlson TSI(Chl-a) Values

Lake	TSI (Chl-a)*		Acres
	Eutrophic		
Barkley	58		57,920
Herrington	56		2,940
	Mesotrophic		
Kentucky	48		154,800
West Sandy Creek Embayment	64	(Eutrophic)	1,020
Big Sandy Creek Embayment	59	(Eutrophic)	4,480
Rough River	45		5,100
Nolin	44		5,790
Green River	43		8,210
Barren River	43		7,205
Beaver Creek Arm	60	(Eutrophic)	1,565
Skaggs Creek Arm	52	(Eutrophic)	1,230
	Oligotrophic		
Martins Fork	38		334
Cumberland	37		50,250
Grayson	37		1,512
Carr Fork	36		710
Buckhorn	36		1,230
Cave Run	35		8,270
Dewey	34		1,100
Laurel River	34		4,990
Midlake-Laurel Arm	47	(Mesotrophic)	754
Headwaters-Laurel Arm	58	(Eutrophic)	316
Dale Hollow	33		27,700
Fishtrap	32		1,143

*Scale: 0-40 Oligotrophic (nutrient poor, little algal biomass)
41-50 Mesotrophic (slightly nutrient rich, moderate amount of algal biomass)
51-69 Eutrophic (nutrient rich, large amount of algal biomass)
70-100 Hypereutrophic (very high nutrient concentrations and algal biomass)

Table 16

Minor Lake Trophic State Rankings

By Carlson TSI(Chl-a) Values

Lake	TSI (Chl-a)	Acres
	Hypereutrophic	
Reformatory	72	54
McNeely	70	51
	Eutrophic	
Wilgreen	68	169
Briggs	67	18
Carpenter	66	64
Marion County	65	21
Kingfisher	65	30
Bullock Pen	64	134
Kincaid	64	183
Guist Creek	64	317
Flat	64	38
Willisburg	62	126
Washburn	62	26
Honker	61	190
Boltz	61	92
Mauzy	61	84
Elmer Davis	60	149
Energy	60	370
Turner	60	61
Shanty Hollow	59	135
Greenbriar	59	66
Scenic	59	18
Sand Lick Creek	59	74
A.J. Jolly	58	204
Beaver	58	158
Grapevine	58	50
Corinth	57	96
Chenoa	57	37
Spurlington	57	36
Jericho	57	137
Spa	56	240
Hematite	56	90
Corbin	55	139
Morris	55	170
Liberty	55	79

Table 16 (continued)

Lake	TSI (Chl-a)	Acres
Malone	54	826
Moffit	54	49
General Butler	54	29
Shelby	53	17
Carnico	53	114
Williamstown	52	300
Linville	52	273
Long Run	52	27
Campbellsville City	51	63
Mill Creek (Monroe County)	51	109
	Mesotrophic	
Luzerne	50	55
Salem	50	99
Pennyrile	50	47
Peewee	49	360
Caneyville	49	75
Beshear	48	760
Fishpond	48	32
Freeman	48	160
Doe Run	48	51
Loch Mary	47	135
George	47	53
Blythe	47	89
Metcalfe County	47	22
Mill Creek (Powell County)	46	41
Bert Combs	46	36
Smokey Valley	45	36
Laurel Creek	45	42
Sympson	44	184
Pan Bowl	43	98
Greenbo	41	181
Lewisburg	41	51
	Oligotrophic	
Tyner	40	87
Campton	40	26
Stanford Reservoir	40	43
Cranks Creek	38	219
Wood Creek	35	672
Providence City	35	35
Cannon Creek	33	243

*Scale: 0-40 Oligotrophic; 41-50 Mesotrophic; 51-69 Eutrophic; 70-100 Hypereutrophic

Table 17
Lakes Not Supporting Designated Uses

Lake	Use Not Supported	Criteria	Cause
McNeely	Fishing, Secondary contact recreation	Nuisance algal blooms; Excessive duckweed growth; Severe oxygen depletion in hypolimnion; Dissolved oxygen less than 5 mg/l in epilimnion	Nutrient inflows from package sewage treatment plants
Carpenter	Fishing, Secondary contact recreation	Excessive macrophyte development	Shallow lake basin
Corbin	Domestic water supply; Fishing	Taste and odor complaints; Nuisance algal blooms	Taste and odor producing algae; Nutrients from point and nonpoint sources
Loch Mary	Domestic water supply	Elevated treatment costs due to hardness and manganesemine	Acid mine drainage from abandoned lands
Sympson	Domestic water supply	Taste and odor complaints	Taste and odor producing algae

Table 18
Lakes Partially Supporting Designated Uses

Lake	Use Partially Supported	Criteria	Probable Cause
Major Lakes			
Rough River	Domestic water supply	Occassional manganese treatment problems	Mn release from anoxic hypolimnion.
Martins Fork	Recreation, fishing	Sedimentation/turbidity	Surface mining.
Carr Fork	Recreation, fishing	Sedimentation/turbidity	Surface mining.
Barren River	Downstream domestic water supply	Occassional Fe and Mn treatment problems	Hypolimnetic releases.
Buckhorn	Recreation, fishing	Sedimentation/turbidity	Surface mining.
Cave Run	Downstream domestic water supply	Seasonal Fe and Mn treatment problems	Hypolimnetic releases.
Dewey	Recreation, fishing	Sedimentation/turbidity	Surface mining.
Fishtrap	Recreation, fishing	Sedimentation/turbidity	Surface mining.
Laurel River (headwaters)	Recreation, fishing	Algal blooms	Nutrients from point and nonpoint sources.
Minor Lakes			
Reformatory	Fishing	Severe hypolimnetic oxygen depletion, Dissolved oxygen less than 5mg/l in epilimnion	Nutrients from livestock operations.
Wilgreen	Recreation, fishing	Excessive algal blooms, Severe hypolimnetic oxygen depletion	Nutrients from septic tank drainage.
Briggs	Recreation, fishing	Excessive algal blooms, Dissolved oxygen less than 5 mg/l in epilimnion	Lake fertilization practices.
Marion County	Recreation, fishing	Excessive algal blooms	Lake fertilization practices.
Kingfisher	Recreation, fishing	Excessive algal blooms	Lake fertilization practices.
Kincaid	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Lake fertilization practices.

Table 18 (continued)

Lake	Use Partially Supported	Criteria	Probable Cause
Guist Creek	Domestic water supply	Taste and odor complaints	Taste and odor producing algae.
Willisburg	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from non-point sources.
Shanty Hollow	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Lake fertilization practices.
Scenic	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from natural sources.
A. J. Jolly	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from non-point sources.
Beaver	Fishing	Localized excessive macrophyte and filamentous algal growth	Shallow lake basin.
Hematite	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from natural sources.
Morris	Domestic water supply	Occassional taste and odor complaints	Taste and odor producing algae.
Liberty	Domestic water supply	Mn and Fe treatment problems during lake overturn	Releases from anoxic hypolimnion.
Malone	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Lake fertilization practices.
Moffit	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from natural sources.
General Butler	Recreation, fishing	Localized excessive macrophyte growth	Shallow lake basin.
Shelby	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from non-point sources.
Williamstown	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from non-point sources.

Table 18 (continued)

Lake	Use Partially Supported	Criteria	Probable Cause
Campbellsville City	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from non-point sources.
Salem	Fishing, recreation	Localized excessive macrophyte growth	Shallow lake basin.
Caneyville	Domestic water supply; Fishing and recreation	Taste and odor complaints, Localized excessive macroscopic algal growth	Taste and odor producing algae; Shallow lake basin.
Beshear	Fishing	Dissolved oxygen less than 5 mg/l in epilimnion	Nutrients from natural sources.
Metcalfe County	Fishing, recreation	Localized excessive macrophyte growth	Shallow lake basin.
Laurel Creek	Domestic water supply	Taste and odor complaints	Taste and odor producing algae.
Lewisburg	Fishing	Localized excessive macrophyte growth	Shallow lake basin.
Stanford Reservoir	Domestic water supply	Taste and odor complaints	Taste and odor producing algae.

Table 19 indicates the sources responsible for non-attainment of uses and the percent contribution of each source.

The greatest percentage of non-attainment of designated uses is caused by natural conditions. This is largely due to hypolimnetic iron and manganese releases from impoundments used by downstream communities as domestic water supply sources. Surface mining is the second greatest contributor to lake uses not being fully supported. Turbidity during run-off events from surface mining activities creates a disincentive for fishing and recreation uses.

There have been no trends towards improvement, or for that matter, further degradation of lakes in the past two years. The status of Kentucky's lakes has remained the same, i.e. water quality has been maintained since the last report. Toxics are not considered to adversely affect any of the lakes which were assessed.

Table 19

Causes of Non-Support of Designated Uses

Source	Number of Lakes Affected	Acres	% Contribution (by Acres)
Municipal	4	675	2
Non-Point	7	948	3
Natural Conditions	19	25,436	77
Surface Mining	5	4,517	14
Acid Mine Drainage	1	135	0.5
Lake Fertilization	6	1,213	3.5
TOTALS	42	32,924	100.0

Future Improvements

None of the lakes which are listed in this report as not supporting particular uses or as partially supporting uses are degraded to the extent that fishing and swimming are not possible. Lake conditions are such that these uses are considered to be impaired for the reasons given in the tables. Hazards to human health through consumption of fish or swimming in bacterial contaminated waters are not of concern. In this sense, all of the assessed 358,214 acres support a fishable/swimmable use.

Various practices can be implemented to improve the quality of the 32,924 acres that do not support or partially support listed uses (including domestic water supply). Those lakes shown to be affected by municipal nutrient sources can be improved by treatment to remove phosphorus. This is most practical for McNeely Lake through the use of Phase II Clean Lakes Program funding. Wilgreen Lake would be improved if the residential area around the lake could become part of the Richmond sewer system instead of remaining on septic tanks. Corbin and the upper end of Laurel River reservoir have less a chance of improvement because non-point sources of nutrients in their large drainage basins contribute at least 50% of their phosphorus loading.

Those lakes affected by non-point sources have the potential to be improved by implementation of agricultural best management practices. Reformatory Lake has the best potential for improvement because the main sources of nutrients are confined animal feeding lots. These can be more easily managed than the more diffuse sources in other drainage basins.

Natural conditions which cause non-support or partial support of uses are very difficult to rectify. Modifications to dam outlet structures which would provide for selective water withdrawal to mitigate hypolimnetic releases of iron and manganese affecting downstream water supplies are possible at Barren River and Cave Run, but these are very costly to construct. The COE is considering this approach at Cave Run.

Lakes used as domestic water supplies such as Rough and Liberty which experience iron and manganese treatment problems will continue to have these problems because the release of iron and manganese from lake sediments under anoxic condition is uncontrollable.

There are measures which can be taken to control excessive macrophyte development. Those lakes with this problem have the potential to be improved. Dredging of shoreline areas, and the use of aquatic screening are two methods which could be used. Lakes which are used for domestic water supply and develop algae populations that cause taste and odor problems are difficult to improve. Normally, taste and odor problems are addressed by using activated carbon or further chlorination at the water treatment plant or by using an algicide such as copper sulfate in the lake. These remedies are usually effective on a short-term basis, but do not prevent a recurrence of the problem. More research directed at controlling the species of algae that cause disagreeable taste and odor in water supplies needs to be carried out before a long-term solution to this particular problem can be found.

Scenic, Hematite, Moffitt and Beshear lakes are in undisturbed drainage basins. Their improvement in terms of higher dissolved oxygen in their epilimnetic waters during the summer is not expected to occur because this is a natural condition.

Lakes affected by surface mining activity have a potential for water quality improvement. If proper surface mining sediment management practices were implemented in their drainage basins there would be marked improvements in water quality. The past record indicates that this has not occurred. A vigorous enforcement of existing mining regulations that pertain to sediment control during mining and surface reclamation after mining needs to occur to address the problems in these lake basins. Sediment check dams have been installed at Carr Fork Lake by the COE to prevent sediment from reaching the lake. This practice may be helpful at other lakes.

Loch Mary's use as a domestic water supply source has been impaired by acid mine drainage from abandoned mine lands. Reclamation activities through the State Abandoned Land Program and the Soil Conservation Service's Rural Abandoned Mine Program were undertaken in the past 3 years and completed in August of 1983. A monitoring program was initiated to develop a baseline of water quality which could be used to indicate whether improvements had occurred. The next report will make an assessment of the lake's improvement.

The lakes which developed dissolved oxygen levels in their epilimnion below 5 mg/l at some time during the summer and were part of a lake fertilization program meant to increase fish production can be improved. The amounts of fertilizer applied to these lakes can be adjusted so that their algal productivity is lowered. This should decrease the oxygen demand in the epilimnion brought about by the decay of excess algal biomass and result in an increase of dissolved oxygen.

GROUNDWATER QUALITY

Groundwater Use In Kentucky

Approximately 5.2 percent of the total estimated water use of 4800 million gallons per day (mgd) comes from groundwater sources in Kentucky (see table 20). It must be noted however, that over 83 percent of the total water used goes toward self-supplied thermoelectric power generation with a very low percentage (3.5%) being consumed. A more realisitic appreciation of groundwater use can be observed by examining total water use for both public and rural supplies. In this regard, groundwater accounts for over 13 percent of the total water use for public supplies and 90 percent for rural domestic supplies. The importance of this resource is underscored in the rural areas since nearly all the drinking water is derived from groundwater. This is primarily because surface water supplies are either inadequate, undependable (during droughts) or too contaminated for treatment by small communities or the individual homeowner.

Table 20

State Summary of Groundwater Use for 1980[1]

User Category	Water Use (mgd)[2]	Total Groundwater Use (mgd)	Percent Groundwater of Total Water Use Within User Category	Consumptive Use (mgd)
Public Supplies	360.0	47.0	13.1	23.0
Rural Supplies				87.0
Domestic Use	60.0	54.0	90.0	
Livestock Use	39.0	1.9	4.9	
Irrigation Use	4.9	0.2	4.1	4.9
Self-Supplied Industrial Use	320.0	130.0	40.6	33.0
Self-Supplied Thermoelectric Power	4000.0	15.0	0.4	140.0
Statewide Total[3]	4800.0	250.0	5.2	290.0

1. Adapted from Solley, Chase, Mann, 1983. "Estimated Use of Water in the United States in 1980" U.S. Geological Survey Circular 1001.
2. mgd = million gallons per day
3. Does not include water withdrawn for hydroelectric power

Current State Groundwater-Related Legislation and Regulations

At this time, no one state agency has responsibility for a comprehensive groundwater management program. Groundwater is addressed as a component of many solid and hazardous waste, mining and surface water acts. As a result of this fragmentation of legislation, management and protection of this resource is difficult. Specific state acts relating to groundwater protection and/or management that the Cabinet implements include:

- Kentucky Environmental Protection Law (Kentucky Revised Statutes, Chapter 224 - Environmental Protection, 1968 as Amended).
- Kentucky Water Quality Standards (Kentucky Administrative Regulations, Title 401, Chapter 5, December 1979).
- Kentucky Water Withdrawal Law (Kentucky Revised Statutes, Chapter 151 Environmental Protection 1966 as Amended).
- Control of Water Pollution from Oil and Gas Facilities (401 Kentucky Administrative Regulations, 5:090, 1983).
- Kentucky Permanent Program Regulations for Surface Coal Mining and Reclamation Operations and Coal Exploration Operations (405 Kentucky Administrative Regulations, Chapters 7 through 24, December 1983).
- Kentucky Waste Management Regulations (401 Kentucky Administrative Regulations Chapters 34 and 35, December 1983, as Amended).
- Kentucky Mineral Conservation and Development Statutes (Kentucky Revised Statutes 353.010-353.991 (Oil and Gas Conservation).

Groundwater Monitoring Efforts

Division of Water - Water Quality Management Program

A major investigation of nonpoint source problems associated with karst aquifer systems is currently in progress in Bowling Green, which is one of the largest cities in the United States located upon a karst landscape. The aquifers of this region are generally composed of horizontal carbonate rocks and regolith deposit. Groundwater occurs primarily in solution-enlarged bedding planes and to a lesser extent in enlarged joints and faults. The extensive karst areas are more vulnerable to groundwater contamination than other geologic areas because of direct conduits provided by sinkholes, sinking streams, and major springs.

Groundwater problems have been especially noticeable in the Bowling Green area because of the combination of karst geology, urbanization-induced flashy response to storm events, and the high density of septic tanks and drain fields (with low to non-existent soil attenuation rates). All these factors contribute toward high fecal coliform, nutrient and heavy metal concentrations in the groundwater. These parameters are currently being monitored within the context of the state's 208 Water Quality Management Program (in accordance with P.L. 92-500 as amended by the Clean Water Act of 1977).

The monitoring stations are located throughout the Lost River Drainage Basin which include portions of downtown Bowling Green (septic tank effluent, faulty sanitary sewers, storm drains) and agricultural areas (row crops, livestock runoff). The stations monitor permanent and intermittent surface and subsurface streams, groundwater aquifers, and local weather conditions for future management of nonpoint source pollution within karst topography.

Flow

The average discharge for the period of record (56 years) is 2,486 cfs for the Levisa Fork at Paintsville (River Mile Index 65.2). Mean discharge for water year 1982 was below the annual average discharge (-15%). During water year 1983, the mean discharge was 12% below the annual average. The concentration effect of flow reduction during the reporting period was a contributing factor to observed increases in certain physicochemical parameters.

Hydrologic Unit 05070201 - Tug Fork

A total of 288 miles of streams draining 1,559 square miles (476 square miles in Kentucky) comprise this hydrologic unit. The major urban center (in Kentucky) is Inez (pop. 469). Two water quality monitoring stations are located in this hydrologic unit: Tug Fork at Kermit and Tug Fork at state line.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 5.2 to a maximum of 12.3 with a mean range of 8.3 to 8.6 and a median range of 8.4 to 8.5.

o pH

For the reporting period pH ranged from a minimum of 6.7 to a maximum of 8.5 with a mean range of 7.5 to 7.8 and a median range of 7.6 to 7.9. For the period of record (1979-1983) pH ranged from a minimum of 6.7 to a maximum of 8.5 with a mean range of 7.6 to 7.9 and a median range of 7.7 to 7.9.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.2 to a maximum of 48.8 with a mean range of 4.8 to 16.0 and a median range of 5.8 to 6.2. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 48.8 with a mean range of 4.3 to 9.9 and a median range of 4.0 to 4.2.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 48.8 to a maximum of 269.0 with a mean range of 107.8 to 142.8 and a median range of 107.0 to 120.6. For the period of record (1979-1983) alkalinity ranged from a minimum of 15.6 to a maximum of 269.0 with a mean range of 105.7 to 127.8 and a median range of 106.0 to 113.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 228.0 to a maximum of 922.0 with a mean range of 482.8 to 495.9 and a median range of 442.0 to 527.0. For the period of record (1979-1983) conductivity ranged from a minimum of 197.0 to a maximum of 923.0 with a mean range of 465.5 to 478.4 and a median range of 432.0 to 433.0.

The bulk of current USGS-KGS groundwater efforts is on the collection and compilation of continuously recorded and periodically measured groundwater level data from a permanent observation well network throughout the Commonwealth. Approximately one-third of these wells are in the Louisville area where rising groundwater levels are a major concern. These data reflect natural or artificial changes in groundwater storage and are published annually by the USGS as a part of "Water Resources Data" for the state.

The USGS also maintains observation wells at the Maxey Flats Radioactive Waste Burial site in Fleming County. Both water levels and radionuclides are monitored. Hydrogeologic studies of the site indicate that low-level radionuclides have moved laterally through fractured rock as much as 270 feet from the nearest burial trench.

A major baseline monitoring effort is also being proposed for the Kentucky River Basin. In addition to examining the basic resource, efforts will be directed toward the cause-effect relationship between such water impacting activities as coal extraction and oil and gas production, and ground and surface water quality and quantity. Major domestic water supply wells will be tested for certain parameters in selected areas. At this time, preliminary discussions have been carried out between KGS and other state agencies to determine the compatibility of the proposed monitoring effort with past, present and future surface water studies.

Future Groundwater Programs

Water Well Driller Certification Program

Recent legislation which will provide a new section of law creating a water well driller certification program, was passed by the 1984 Kentucky General Assembly. The bill was introduced as part of the recommendations of the Water Management Task Force, a study group created by the 1982 legislature. The features of the legislation include:

- o requiring all water well drillers of "commercially constructed wells" to be certified,
- o establishing a board of certification,
- o outlining the powers of the board,
- o defining the powers and responsibilities of the Natural Resources and Environmental Protection Cabinet related to the certification program,
- o providing minimum requirements for obtaining certification,
- o establishing penalties for violation, and
- o requiring water testing for fecal coliform and initial disinfection.

Underground Injection Control

The U.S. Environmental Protection Agency plans to implement the Underground Injection Control (UIC) program for Kentucky by May of 1984 for well classes I through V. Proposed UIC regulations were submitted to the state from EPA for their review in late 1983. The state's Department for Mines and Minerals, Division of Oil and Gas, plans to seek primacy for Class II wells, which are used to dispose of oil and gas drilling brines and to pump fluids (steam, solvents, etc.) for the enhanced recovery of petroleum products. Kentucky primacy of Class II wells, including any associated

monitoring and enforcement requirements, is not expected to take place before the winter of 1984 or spring of 1985.

Groundwater Contamination And Depletion Incidents In Kentucky

Kentucky does not have summary data on groundwater contamination problems because field investigations are generally not conducted due to limited funds, unless the condition is extremely serious. A number of groundwater contamination incidents in the Commonwealth during the past couple of years have involved various state agencies. Included as examples are six such incidents which occurred in Jefferson, Magoffin, Harlan, Warren, Knott, Floyd, and Meade counties. In addition, a short description of the depletion and contamination problem that is occurring throughout the Eastern Coalfield is also presented.

Mill Creek Area, Jefferson County

Most of Jefferson County's water supply needs are met by the Louisville Water Company (LWC). At present, the Ohio River is the sole source of raw water for the LWC which serves most of the Mill Creek area. Currently, no water utility uses the area's groundwater for public water supply. However, between 300-600 Mill Creek residents depend upon private water wells (groundwater) for domestic use due to the absence of nearby water mains.

The 1974 Water Quality Management Plan (201 Plan) for Metropolitan Louisville recommended that the Mill Creek area in SE Jefferson County be served by a regional sewerage system. The system would relieve almost all (20,000) existing septic tank-seepage pit systems and 18 of the 26 package wastewater treatment plants.

In the early 1980's, EPA prepared an Environmental Impact Statement (EIS) of the 201 study area. The EIS groundwater assessment involved an evaluation of area groundwater quality and concluded that because of some high nitrate and bacteria levels, area groundwater was not suitable as an untreated drinking water source. The source of the contamination is presumed to originate from the faulty septic systems and package treatment plants. It is expected that the contamination conditions would persist for several years, regardless of which sewering alternative is selected, due to the time necessary to construct facilities.

Because of the existing questionable suitability of the aquifer as an untreated drinking water source, EPA encourages local agencies to extend public water service to those Mill Creek residences not now served. In the cases where service cannot be extended, a groundwater quality monitoring program could include special emphasis on monitoring areas that would rely on groundwater for private water supply. Under any circumstances, private water supply users have been encouraged by EPA to disinfect area groundwater prior to consumption; families with infants have been instructed to contact the Health Department to determine if nitrates are a concern in their water.

Magoffin County

Water wells at about 200 households in the northeastern third of Magoffin County have been polluted by oil brines since oil-drilling increased in June of 1980. About 500 other households in rural portions of the county already had water-quality problems prior to the current oil boom according to Donald Crownover, Chairperson of the Salyersville Water Commission.

The most likely source of the pollution, according to some experts, is brine runoff into local springs. Oil recovered in the eastern Kentucky oil fields usually is mixed with brine water from oil-bearing strata below. Oil companies separate the oil from the brine and often place the brine into open evaporation pits. Unfortunately, precipitation and runoff exceed evaporation in the state, resulting in overflow into surface and groundwaters. Brine may also be absorbed by highly permeable soil and enter the water supply.

Salyersville, which provides 750 households with treated water, agreed to make 800 gallons of water a day available for distribution to affected rural residents. Governor Brown authorized the use of state disaster funds and members of the Kentucky National Guard to distribute the water if the weather made travel difficult during the winter of 1982-1983. The Division of Water expects that in the future, the newly promulgated Oil and Gas regulations will significantly reduce incidents of this nature.

Bowling Green, Warren County

In addition to the nonpoint source problems associated with karst topography described elsewhere in this section, there have been a number of other groundwater contamination incidents in the Bowling Green-Warren County area. One nonpoint source contaminant of great concern is gasoline from leaking storage tanks. On more than one occasion, gasoline fumes have seeped into area residential basements forcing occupants to evacuate. Combustible fumes were suspected of causing the simultaneous explosion of two area houses a number of years ago. Unfortunately, a heavy petroleum smell is becoming more commonplace throughout the cave system especially downgradient from the industrial park area. More recently, residents in the vicinity of a nearby cave entrance complained of fumes being sucked into their apartment by their air conditioning units.

Point source pollution, however, is also a severe problem. A high density of waste generators exists in the Bowling Green area with a great diversity of wastes produced. There are approximately 40 area industries and their associated potential contaminants include everything from domestic wastes to heavy metals to complex synthetic organic compounds. Some industries have their own treatment facilities and others rely on commercial waste haulers to truck by-products (sludge, spent solvents, etc.) off the site. Unfortunately, because of containment leakage, sloppy practices (spillage) and/or intentional discharge into sinkholes, some groundwater contamination by industrial by-products has occurred.

Typical contaminants previously detected in grab samples from the subterranean waters in the area include substances such as total cyanide, lead, cadmium, chromium, copper, iron, nickel, zinc, and arsenic. Detectable levels have been in the range of 0.001-0.10 mg/l. Determining the magnitude of contamination is difficult because some natural deposits of the above substances appear to exist in the Bowling Green drainage basin. Conversely, volatile organics have been detected at levels between 1-100 ug/l. These include compounds such as benzene, xylene, methylene chloride, 1,2-dichloroethane, carbon tetrachloride, bromodichloromethane, and 1,1,2-trichloroethylene which are known carcinogens. Locating specific sources of these contaminants has been difficult because of the nature of the underground streams and karst geology in the Bowling Green area.

The Division of Water expects that some of the objectives of the groundwater monitoring efforts conducted as part of the state's 208 Water Quality Management Program (described previously in this section) will provide at least some solutions to this problem. In particular, applicable objectives include a determination of the:

1. locations, pathways or conduits of major underground streams;
2. effectiveness of natural cleansing of underground streams as compared to surface waters in terms of absorption, filtration, time-related decay or natural die-off, oxygenaton and dilution;
3. relationship between volume, velocity, stream morphology, and pollutant assimilative capacity of underground streams;
4. quality and interrelationships between water in storage (slow moving water) in limestone as compared to water in rapid transit (underground streams) in terms of pollution and use impairment of the entire aquifer within the study area;
5. extent to which minimum criteria associated with use classifications for surface waters might differ from criteria for subterranean waters due to significantly different environmental conditions; and
6. quantitative level of pollution that can be allowed without corresponding use impairment.

Knott-Floyd County

In 1983, a major outbreak of hepatitis-A occurred throughout Knott county and in scattered portions of Floyd county. Over 146 cases were documented with 50 percent of the victims infected between July and August.

Contaminated drinking water supplies were considered the suspected carrier. A common contamination source was ruled out since the cases were geographically widespread and most of the victims were on private (and separate) water supply systems. When 50 out of the 146 cases were sampled, it was discovered that only 10 of the victims obtained their drinking water from community supplies, 30 had drilled wells, three received their water from springs, three from streams, three from coalbanks, and one from other sources. A large number of private wells were also contaminated with fecal and total coliform. Twenty out of twenty-six wells had total coliform levels greater than the allowable state standards while four out of fifteen wells exceeded the standard for fecal coliform.

Due to the diversity of the water supply and geographic distribution, the exact cause of the outbreak was not pinpointed. However, at least part of the transmission was suspected to result from the improper disposal of human wastes (via pit toilets, faulty septic tanks and drain fields) and subsequent migration into streams and groundwater. A countywide "Boil Water Order" was imposed but since it could not be enforced, its effect on reducing the number of outbreaks could not be determined. Fortunately, the number of outbreaks have since diminished to pre-epidemic levels.

Meade County

From December 1982 through March 1983, a hepatitis-A outbreak occurred in the county resulting in one fatality and over 110 victims. Dye trace studies indicated that underground caverns which flowed to Buttermilk Falls Spring, a local source of drinking water, were flushed of contaminants during high rainfall events. Speculation as to the source of the virus includes local landfills and septic tank discharge from the deceased

victim's home and other area residences (fecal coliform levels were also above standards in some cases). Basically, the outbreaks occurred in rural areas where sewage disposal practices are inadequate and municipal (or treated) water supplies are unavailable.

Naturally high levels of flouride have also been detected in the Meade County communities of Flaherty (1.8 mg/l) and Ekron (1.4 mg/l). Both levels are below the state standards and except for some incidents of slightly mottled teeth, no health problems have been reported. Although water quality will be periodically monitored, no further activity is expected by appropriate local and state agencies unless fluoride levels increase.

Eastern Coalfield

Over the past few years, both the water quality and quantity has significantly changed throughout the Eastern Coalfield region. According to a local water well driller, the water table in this area has definitely dropped over the past ten years (some places averaging up to one foot per year) due primarily to mining activities, and to a lesser degree to decreasing precipitation and structural shifting resulting from earth tremors. Many shallow area wells (60-80') are contaminated with fecal coliform, high iron concentrations and "blackwater". Some of the recent pollution incidents are probably due to the greater level of detection resulting from increased and comprehensive water quality monitoring. While many of these contaminated wells are old wells that need to be re-cased, most contamination results from faulty private septic systems and/or recent mining activities such as blasting or deep mine "robbing." In particular, both the surface and groundwater quality is considered extremely poor in the Evarts, Cranks Creek and Black Mountain areas where mining is heaviest. As a result of these conditions and, pollution-depletion incidents, area wells are reportedly drilled much deeper to reach higher quality water aquifers.

In October of 1982, Governor Brown declared a state of emergency in Harlan County due to an extreme water shortage and water contamination in the Cloverfork area. Officials from the State Human Resources Cabinet reported that more than 30 wells in this area had been identified as dry or the water determined to be "unfit for human consumption." The alleged source of this contamination is from nearby coal mining activities (blasting). The Kentucky National Guard began providing drinking water for the families involved.

Technical Problems In Groundwater Management

The growing groundwater contamination and depletion problem in Kentucky is a major concern of many state environmental agencies. This issue is especially poignant in light of fiscal austerity measures which make it difficult, if not impossible to hire qualified people and fund new groundwater monitoring and management programs. While state agencies have maintained some site-specific groundwater data related to those areas that the state is regulating, detailed and comprehensive knowledge of groundwater occurrence, distribution, reserves, use and recharge is limited. A few of the difficulties in delineating Kentucky's aquifer system, which is an essential first step in groundwater management, are listed along with some potential UIC-specific concerns:

- Lack of Data: Oil and gas well records generally constitute the only deep hole data in Kentucky. Unfortunately drillers logs are not detailed for the more shallow units encountered and, although law requires the reporting of fresh water, its occurrence is not accurately determined during the drilling process. In KGS special publication 10, Series XI, (Geologic Cross Sections and Columnar Sections for Kentucky) it was necessary to have multicounty cross sections because sufficient geologic information was not available for more detailed work.

- Freshwater Occurrence below Saline Water: In many counties well records indicate that fresh water may be encountered beneath saline water. This occurrence has been reported in McCreary, Whitely, Russell, Lawrence, Greenup, Estill, Lee, Jackson, Owsley, Laurel, Knox, Clay and Leslie counties. As an example, KGS Information Circular 12, Series X, reports fresh water at 1100 ft in the New Cypress Oil Pool.

- Fault Zones: Little documented information is available on the influence of fault zones on the distribution of fresh and saline waters. In some instances faults are thought to transmit fresh water to depth but other cases point to an upwelling of saline waters along fault zones.

- Karst Topography: The presence of limestone in more than 50 percent of the state, such as the Mississippian Plateau and Blue Grass provinces, creates irregular groundwater movement in karst (sinkhole) terrain. Little is known about fresh water balances much less the nature of saline water movement from depth.

- Mountain Topography: Steep elevations in eastern Kentucky restrict the spatial distribution of regional aquifers.

- Aquifer Interconnections: Exploratory oil and gas drilling and production since the turn of the century has interconnected aquifer systems in the state's oil and gas fields. Unfortunately, drilling records are few and incomplete.

- Chemical Reactions: Nothing is known about the chemical reaction between injected waste and water residing in the injection zones.

- Radius of Influence: Little is known about the radius of influence a particular injection well might have because little data is available on the hydraulic properties of aquifers that have the potential to be used as an injection zone.

WETLANDS

Wetlands are defined as areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. The importance of these lands is just being fully understood. Their value lies in several aspects, which when taken either partially or as a whole, often exceeds the apparent economic value of the land itself. Wetlands are among the most productive of all ecosystems. They are vital for the existence of many species of fish, wildlife, and plants. A summary of primary values includes: (1) natural moderation of floods, (2) erosion control, (3) water quality enhancement, (4) groundwater recharge, (5) fish and wildlife habitat, (6) recreation, (7) education and scientific research, (8) aesthetic and open space and (9) food and fiber productivity.

Little research has been conducted on Kentucky wetlands. The Commonwealth's first estimates of wetland acreage came in the early 1950's. This work by the U. S. Fish and Wildlife Service was not field checked and its purpose was limited to locating waterfowl habitat (as specified from U. S. Fish and Wildlife's Circular 39). Using aerial photos, they estimated a total of 273,000 acres were wetland in Kentucky. In 1977, the Ohio River Basin Commission (ORBC), Fish and Wildlife Work Group, in cooperation with the Kentucky Department of Fish and Wildlife Resources, released a report on wetlands along the Ohio River and its tributaries in Kentucky. Their work, which was field checked, revealed 73,000 remaining wetland acres for this area. In 1983, the U. S. Fish and Wildlife Service, in cooperation with the University of Louisville, mapped 113,370 wetland acres along the Green and Tradewater rivers (both tributaries to the Ohio River) in the western Kentucky coalfield. This increase in wetland acreage is most likely due to professional judgement of what constitutes a wetland and differing methodologies. The ORBC study apparently failed to list many of the smaller (under 1000 acres) wetlands and riparian zones mapped by U. S. Fish and Wildlife.

The U. S. Fish and Wildlife Service (1979) documented wetland losses along the Mississippi Alluvial Plain. Kentucky has four counties in the Mississippi Valley which in 1957 accounted for 54,000 acres of wetlands. According to the report, by 1977 the total wetlands of these counties dropped to 34,000 acres, a 37 percent reduction in 20 years. Of the estimated 273,000 wetland acres in Kentucky, in the early 1950's, only 147,370 acres (54%) remain along the Ohio and Mississippi rivers and their tributaries.

There has been no extensive inventory on a statewide basis of Kentucky wetlands. From the limited sources mentioned above, wetlands in Kentucky can be very generally classed into the following categories by utilizing the most recent (1979) U. S. Fish and Wildlife Service classification system.

The majority of Kentucky's wetlands fall into the Palustrine System. Areas lying shoreward of rivers and lakes, including floodplains, oxbows, ponds, marshes, and swamps, are members of this category. The broad alluvial floodplains of the Ohio and Mississippi rivers and their tributaries in western Kentucky comprise the vast majority of Kentucky wetlands. Small ponds are common throughout the state and their area is difficult to assess. They are, however, very important and have value as ecological epicenters. The Riverine System includes all wetlands and deepwater habitats contained within a channel that experiences continuous or periodic moving water or connects two bodies of standing water. While wetlands of this type are not extensive, they do provide unique habitat for many rare or endangered species and are very important ecologically. Lacustrine Systems in Kentucky are limited to man-made lakes, their shorelines, and spillways. The Lacustrine Systems are the least ecologically significant of the Kentucky wetlands.

The major threat to Kentucky wetlands is their destruction due to competing land use activities and poor land management practices. Both coal mining and agricultural practices are depleting this unique habitat. Strip mining operations in the western Kentucky coalfield are either totally destroying, by actually stripping coal from wetland areas, or drastically altering, by siltation and acid mine drainage, much of Kentucky's wetlands. The 1983 U. S. Fish and Wildlife Service study in the western Kentucky coalfield, determined that 515 stream miles were affected by acid mine drainage. Problem parameters degrading water quality included manganese, sulfate, aluminum, conductivity, turbidity, dissolved oxygen, pH, and iron. They concluded that nearly all of the wetlands in the coalfield have been adversely impacted by coal mining practices.

Logging and agricultural practices such as channelizing, tile draining, burning, and otherwise altering the water regime to render the land tillable are rapidly depleting wetland ecosystems. Other agricultural practices which cause erosion and chemical fertilizer and pesticide runoff, are also having adverse effects on the natural system.

To a lesser extent and generally in localized situations, domestic and industrial sewage discharge, oil brine discharge, and urbanization are having detrimental effects on Kentucky wetlands.

At the present time there is no monitoring program for Kentucky wetlands. A monitoring program is needed and would be an invaluable tool toward good wetland management. To initiate a monitoring program, an intensive survey and classification of Kentucky's wetlands is needed. The survey would yield considerable useful quantitative and qualitative baseline data. From this data, continual ambient monitoring of strategic wetland areas could be established to show losses of wetland acreage and trends in chemical and biological parameters. Knowledge of these parametric trends could then be used to make sound managerial decisions. Other needs of Kentucky wetlands are an increased public awareness of the value of these ecosystems; acquisition and protection of strategic wetlands; and regulations requiring permits and mitigation funds for altering wetland systems.

CHAPTER II

SPECIAL CONCERNS / REMAINING PROBLEMS

OIL AND GAS PRODUCTION POLLUTION

Oil and/or gas is produced in sixty-three Kentucky counties, but most production occurs in only a few counties. A cluster of eight counties in western Kentucky accounts for almost 65 percent of the state's oil production. Seven counties in eastern Kentucky account for another 26 percent. Natural gas is produced in thirty-one of Kentucky's counties, but eight counties produce about 90 percent of the total. Approximately 97 percent of the state's natural gas production occurs in eastern Kentucky.

In 1981, Kentucky's crude oil production was about 17,900 barrels per day which represented about 0.21 percent of the nation's total production. Production of natural gas in Kentucky was about sixty-three billion cubic feet in 1981, or 0.33 percent of the national output. The number of wells (oil, gas, dry, and service) drilled in Kentucky in 1981 was 1,780. This number represented approximately 2.2 percent of the wells drilled in the United States during 1981.

The Cabinet has defined the area of direct impact from produced water discharges to surface waters to include the Licking River Basin, the Upper Cumberland River Basin, the Kentucky River Basin, the Green River Basin and the Big Sandy River Basin. The entire population of Kentucky is indirectly affected by the adverse impacts on the natural resources of the Commonwealth. These resources include stream quality, aquatic habitats, national forest areas, and the productive capabilities of land.

The Cabinet has received numerous reports concerning detrimental effects on the environment and adverse impacts on the citizens of Kentucky as a result of the improper disposal of produced water. These reports, along with expressions of concern about the problem, have been generated by wildlife and environmental agencies as well as the private sector. The following are several examples of incidents and concerns:

- In January 1982, the Secretary of the Cabinet received a letter from the Kentucky Department of Fish and Wildlife Resources concerning a pollution problem in the South Fork of the Red River in Powell County. The letter and supporting materials documented the severe impact on the aquatic resources of the South Fork due to brine water discharge. In addition, the letter stated an opinion that impacts will continue downstream and eventually affect the biota in the main stem of the Red River.

- The National Forest Service has contacted the Cabinet concerning pollution problems encountered in forests within Kentucky due to brine discharge.

- The Kentucky Nature Preserves Commission has expressed concern over the damaging effects of brine on plant and aquatic life.

- During the fall of 1982, high sodium levels were detected in the water supplies for the towns of Clay City and Stanton. An alert was issued for persons on sodium restricted diets.

- In January, 1982, the Lexington Fayette Urban County Board of Health adopted a resolution requesting that the Cabinet and the U.S. Environmental Protection Agency take immediate steps to determine the

extent of saline and bromide contamination in the Kentucky River and its tributaries.

- In November, 1982, a public hearing was held in Magoffin County to address the problem of private well contamination. Approximately fifty concerned citizens attended. The complaints included oil and brine in well water, livestock refusing to drink, and clothes washed in well water turning brown. Later that month, Governor Brown signed Executive Order 82-995 declaring a state of emergency in Magoffin County due to the contamination of private wells by oil and brine. The Executive Order authorized the National Guard to deliver water to affected residents of the county. In addition, the Governor directed the Cabinet to develop a regulatory program for protection of the surface and subsurface waters of the Commonwealth from improper brine disposal and the Division of Disaster and Emergency Services to identify alternative sources of potable water.

The Cabinet has received additional complaints of this nature from citizens in other regions of the Commonwealth.

In January of 1984 Kentucky adopted a new regulation 401 KAR 5:090 entitled Control of Water Pollution From Oil and Gas Facilities which provides for preventing, abating, and controlling water pollution from the subject facilities. In addition, the Cabinet funded a study initiated by the University of Kentucky, School of Biological Sciences in August 1983 for the purpose of developing numerical criteria associated with Kentucky's aquatic life use classification, which may be influenced by wastewater discharges from oil and gas production activities in the state. Recommended criteria will be incorporated into Kentucky's water quality standards regulations as a component of the 1984 triennial review process.

ACID MINE DRAINAGE

The 1982 Water Quality Report to Congress devoted a special section to the problem of acid mine drainage (AMD) in Kentucky. That section pointed out that the western coalfield had the most serious problems with AMD. The Tradewater River basin and the Green River basin were the most seriously affected basins in the state. Scattered streams were also affected in the eastern coalfields but not nearly to the extent as in the western coalfields.

The status of acid mine drainage impacts on the streams of Kentucky has remained essentially unchanged over the past two years. It will remain a continuing concern because most of the drainage comes from abandoned mine lands. The state has a program to reclaim abandoned mine lands but the priority for reclamation is to first address those sites which pose an extreme danger to public health, safety, general welfare or property because of past coal mining practices. Environmental effects, such as stream water quality and aquatic habitat degradation, are considered a lower priority. When priority one sites are reclaimed, there is the possibility that reclamation funds can be used to address stream water quality. An assessment of stream improvements will be made at that time.

CONSTRUCTION GRANTS FUNDING

A recent update of financial information for Construction Grants applicants shown on Kentucky's priority list indicates a total of $1.1 billion in wastewater needs. This figure is overwhelming in comparison with Kentucky's annual construction grants allotment of $31.1 million.

In an attempt to spread available dollars over more projects, the federal funding level has been reduced to 55 percent effective October 1, 1984. Many dollars may still be obligated over the next several years at the 75 percent level due to the fact that multi-year projects initiated before October 1, 1984 can receive 75 percent funding until a project is completed. Kentucky will give serious consideration to requesting that EPA change policy so that multi-year projects are funded at 55 percent after October 1, 1984. This will allow segmented projects to be funded for the 20 year design, while the funding is maintained at 55 percent.

Many of the smaller communities in line to receive funding at the 55% level will have extreme difficulty developing the required local share. Communities with a large customer base will have less difficulty and will be in a better position to take 55 percent funding not used by smaller communities.

POLLUTION-CAUSED FISH KILLS

Fish kills are investigated by the Kentucky Department of Fish and Wildlife Resources and reported to the Division of Water.

During 1982, 27 kills attributed to pollution were reported (see Table 21). Approximately 52 miles of stream were affected resulting in an estimated kill of 98,436 fish. Of the reports containing counts of dead fish, four were light (less than 100), eight were moderate (100-1000), and five were major (more than 1000). Mining or oil drilling operations were responsible for six kills, agricultural wastes for eight kills, oil or chemical spills for seven kills and wastewater for three kills. The causes of the additional three kills were undetermined. The largest kill was caused by release of zinc cyanide from a plating operation which affected approximately 15 miles of North Elkhorn Creek in Fayette and Scott counties.

During 1983, 37 kills attributed to pollution were reported. Approximately 51 miles of stream were affected resulting in an estimated kill of 76,187 fish. Of the reports containing counts of dead fish, two were light, four were moderate, and nine were major. The causes of the kills were varied. Oil or chemical spills (14), wastes from oil drilling or mining operations (7), and wastewater (7) were the most frequent. The largest kill was caused by wastes from a hog feeding operation.

Additional information on fish kills is contained in Appendix D.

Table 21

Fish Kill Summary

		1982	1983
Severity:	Light (<100)	4	2
	Moderate (100-1,000)	8	4
	Major (>1,000)	5	9
	Unknown	10	22
	TOTAL	27	37
Cause:	Mining or Oil operation	6	7
	Agricultural operation	8	5
	Oil or Chemical spill	7	14
	Wastewater	3	7
	Unknown	3	4
	TOTAL	27	37
River Basin:	Big Sandy	2	3
	Little Sandy	0	0
	Tygarts Creek	0	0
	Licking	4	5
	Kentucky	8	13
	Salt	4	4
	Green	2	5
	Tradewater	0	0
	Upper Cumberland	4	4
	Lower Cumberland	0	0
	Tennessee	0	1
	Ohio	3	1
	Mississippi	0	1
	TOTAL	27	37
Approximate Number of Stream Miles Affected		52	51
Estimated Number of Fish Killed		98,000	76,000

CHAPTER III

WATER POLLUTION CONTROL PROGRAMS

POINT SOURCE CONTROL PROGRAM

From January 1, 1982 to September 30, 1983 Kentucky's point source permitting program (NPDES) was administered by EPA, Region IV in Atlanta, Georgia. EPA's efforts were directed towards issuing permits for major industrial and major municipal dischargers as a first priority, with minor industrial and minor municipal facilities issued as time allowed. Nearly all industrial permits contained technology-based limits (BPT/BAT) whether the discharges were into effluent-limited or water quality-limited streams. Major and minor municipal permits specified secondary treatment for discharges into effluent limited streams with stricter limits for most water quality-limited streams. During this period of time the state's Division of Water was reviewing these permits and certifying their adequacy with regard to Kentucky Water Quality Standards pursuant to Section 401 of the Clean Water Act.

Effective October 1, 1983, EPA delegated the responsiblity of NPDES to the state and the Division of Water began issuing Kentucky Pollutant Discharge Elimination System (KPDES) permits. The Division of Water inherited a backlog of nearly 1700 expired or unissued permits from EPA. A large portion of that backlog consists of minor coal mining facilities (also regulated by the state's Department for Surface Mining Reclamation and Enforcement, DSMRE). During the first quarter of 1984 the Division of Water issued a statewide General Permit for Coal Mining Discharges that will soon remove nearly two-thirds of the existing backlog. General Permit coverage is keyed to DSMRE identification numbers which enables DSMRE inspectors to determine KPDES compliance during their routine surveillance activities. For 106/305(b) reporting purposes, the Division of Water will periodically receive summaries of DSMRE compliance/enforcement activities for facilities covered by the General Permit.

Figure 10 shows how KPDES applications are processed into final discharge permits. The process by which effluent limits are generated based on water quality standards and effluent guidelines is diagramed in Figure 11.

Municipal Facilities

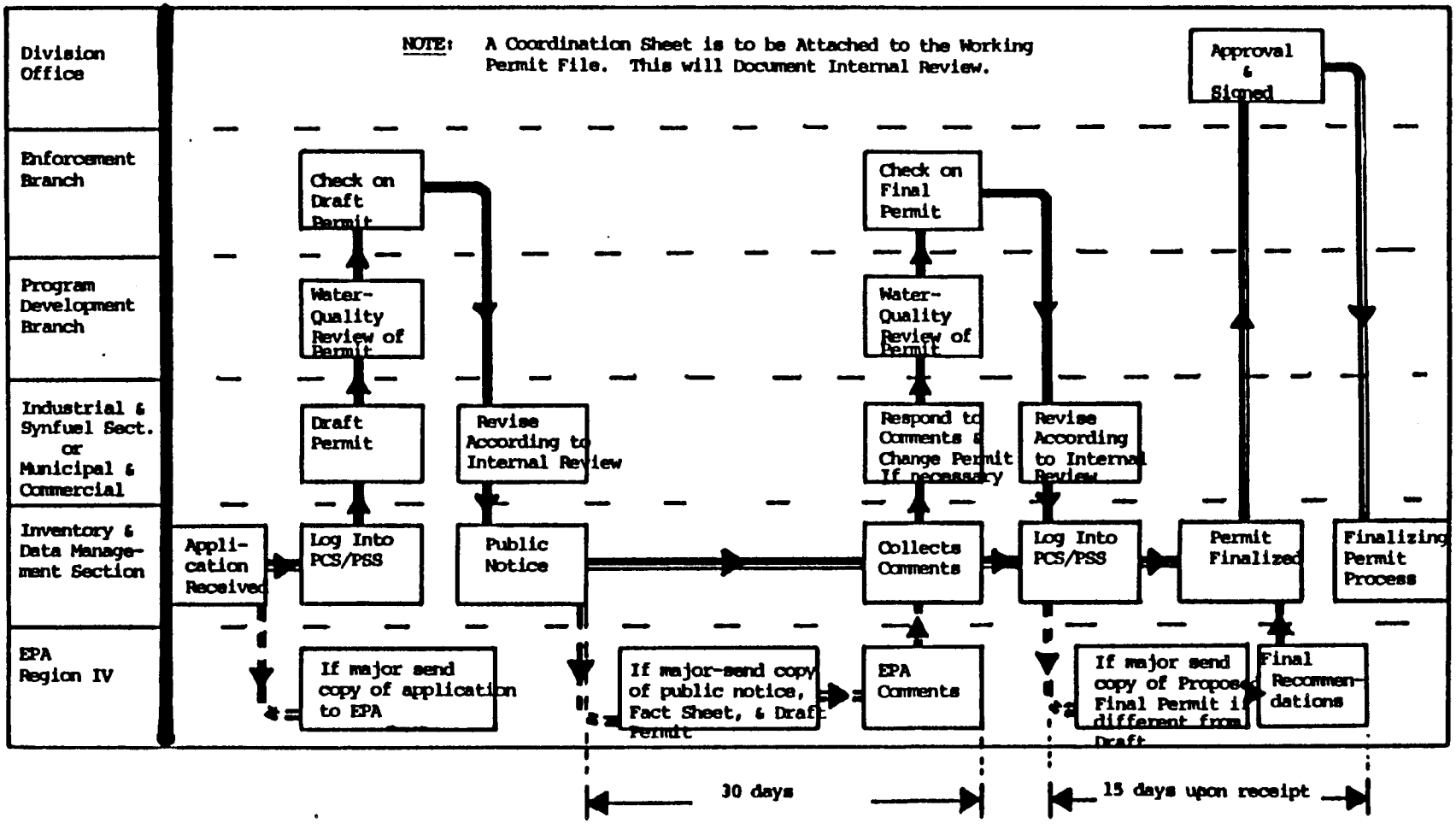
The Construction Grants Program is reponsible for managing federal grants awarded to municipalities for the construction of sewage treatment plants. Kentucky has been delegated fourteen of the twenty functions required for primary responsibility to administer the program.

The Construction Grants Program has resulted in the construction of $183 million in wastewater projects which came on line during 1982-1983. The result has been the completion of 30 wastewater projects. In addition, 39 projects are in various stages of construction. Table 22 provides a listing of projects which have been completed. These projects are located on the state map presented in figure 12. Table 23 contains a listing of projects which have been funded but are not yet completed.

A review of the discharge monitoring reports for the facilities completed during calendar year 1982 and 1983, which previously had wastewater discharges to surface waters, indicates the following:

Figure 10

KPDES PERMIT ROUTING



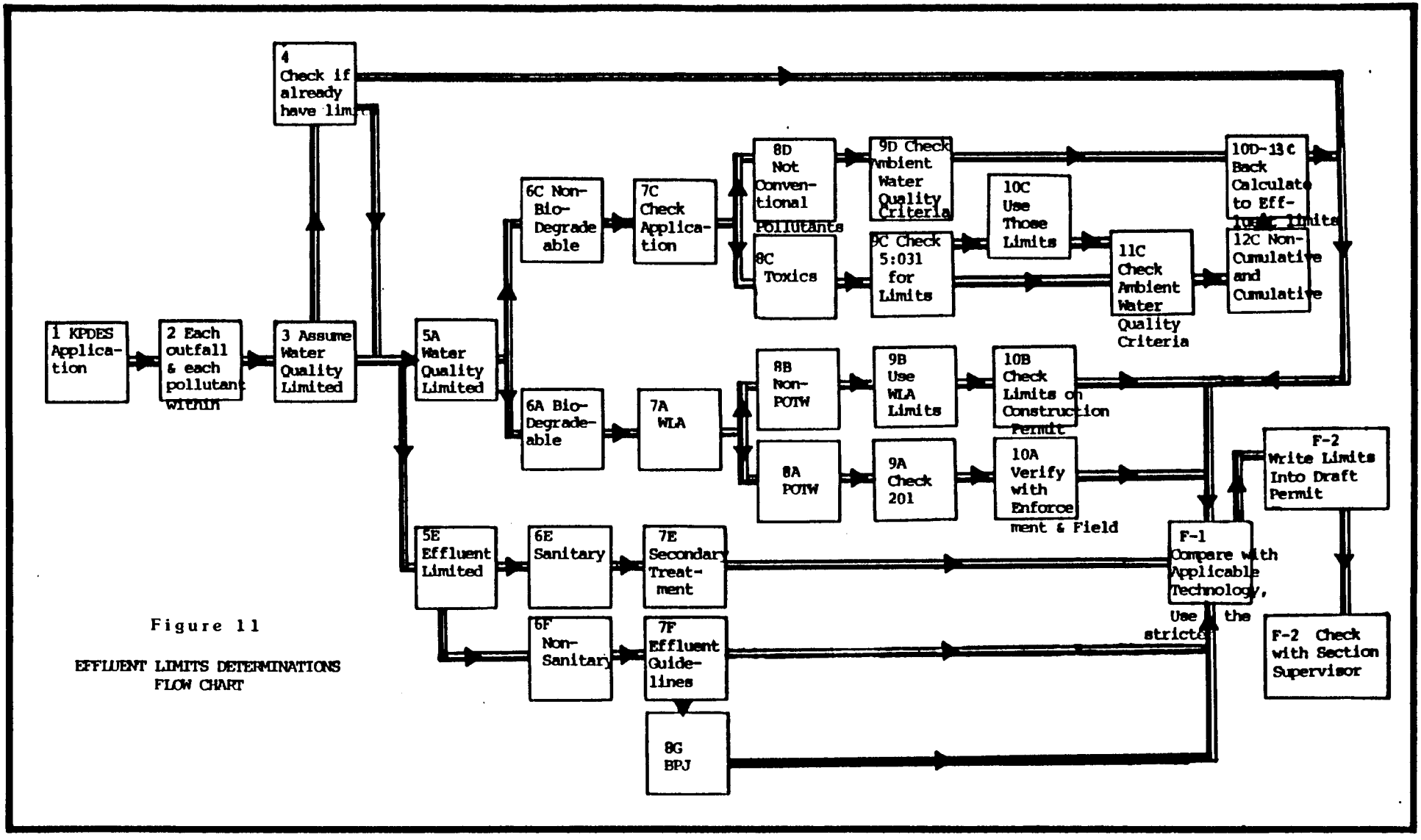


Figure 11

EFFLUENT LIMITS DETERMINATIONS
FLOW CHART

Table 22

Construction Grants Funded Projects Which Came On Line During Calendar Years 1982 and 1983

Project	Date on Line	Design Flow (mgd)	Treatment Cost* (Million Dollars)	Other Costs* (Million Dollars)
Ashland	June 1982	11.000	14.000	2.600
Bedford	Feb. 1983	0.114	0.283	1.184
Bowling Green	Nov. 1982	8.400		3.622
Caneyville	June 1983	0.110	0.482	0.983
Corbin	Apr. 1982	4.500	3.253	0.545
Crab Orchard	Jan. 1983	0.110	0.745	1.183
Crofton	Apr. 1982	0.066	1.227	0.577
Drakesboro	July 1983	0.100	0.951	0.819
Fancy Farm	Apr. 1982	0.140	0.494	0.728
Fordsville	Dec. 1983	0.110	0.974	0.705
Grnup. Env. Com.	Sept. 1982	2.050	3.970	1.140
Guthrie	Sept. 1982	0.310	1.975	1.032
Harrodsburg	Nov. 1982	2.680	8.931	0.338
Hopkinsville S	Sept. 1983	5.300	20.317	7.235
Hopkinsville N	Apr. 1982	2.880	6.178	
Jamestown	May 1982	2.500	2.642	1.951
Livermore	Apr. 1982	0.350	1.821	0.725
London	June 1982	4.000	6.793	1.357
Madisonville	June 1983	4.500	8.769	13.388
Morehead	1982	2.500	5.810	4.000
Mt. Sterling	1982	2.660	4.900	0.590
Nicholasville	May 1983	2.800	7.261	4.271
Nortonville	June 1982	0.140	1.450	0.781
Richmond (TC)	July 1983	3.750	8.765	0.964
Richmond (DC)	Sept. 1983	4.500	8.422	0.926
Salem	Dec. 1983	0.100	1.267	0.682
Shepherdsville	Feb. 1983	1.000	3.922	1.617
Simpsonville	Dec. 1982	0.120	0.357	1.182
West Point	June 1983	0.300	0.352	
Williamstown	Apr. 1982	0.533	0.836	0.802
TOTAL		67.623	127.147	55.927

*Costs shown include local share.

Figure 12

KENTUCKY MUNICIPAL CONSTRUCTION GRANTS

PROJECTS COMPLETED IN 1982-1983

1	Ashland	16	Jamestown
2	Bedford	17	Livermore
3	Bowling Green	18	London
4	Caneyville	19	Madisonville
5	Corbin	20	Mt. Sterling
6	Crab Orchard	21	Morehead
7	Croftin	22	Nicholasville
8	Drakesboro	23	Nortonville
9	Fancy Farm	24	Richmond (TC)
10	Fordsville	25	Richmond (DC)
11	Greenup	26	Salem
12	Guthrie	27	Shepherdsville
13	Harrodsburg	28	Simpsonville
14	Hopkinsville (North)	29	West Point
15	Hopkinsville (South)	30	Williamstown

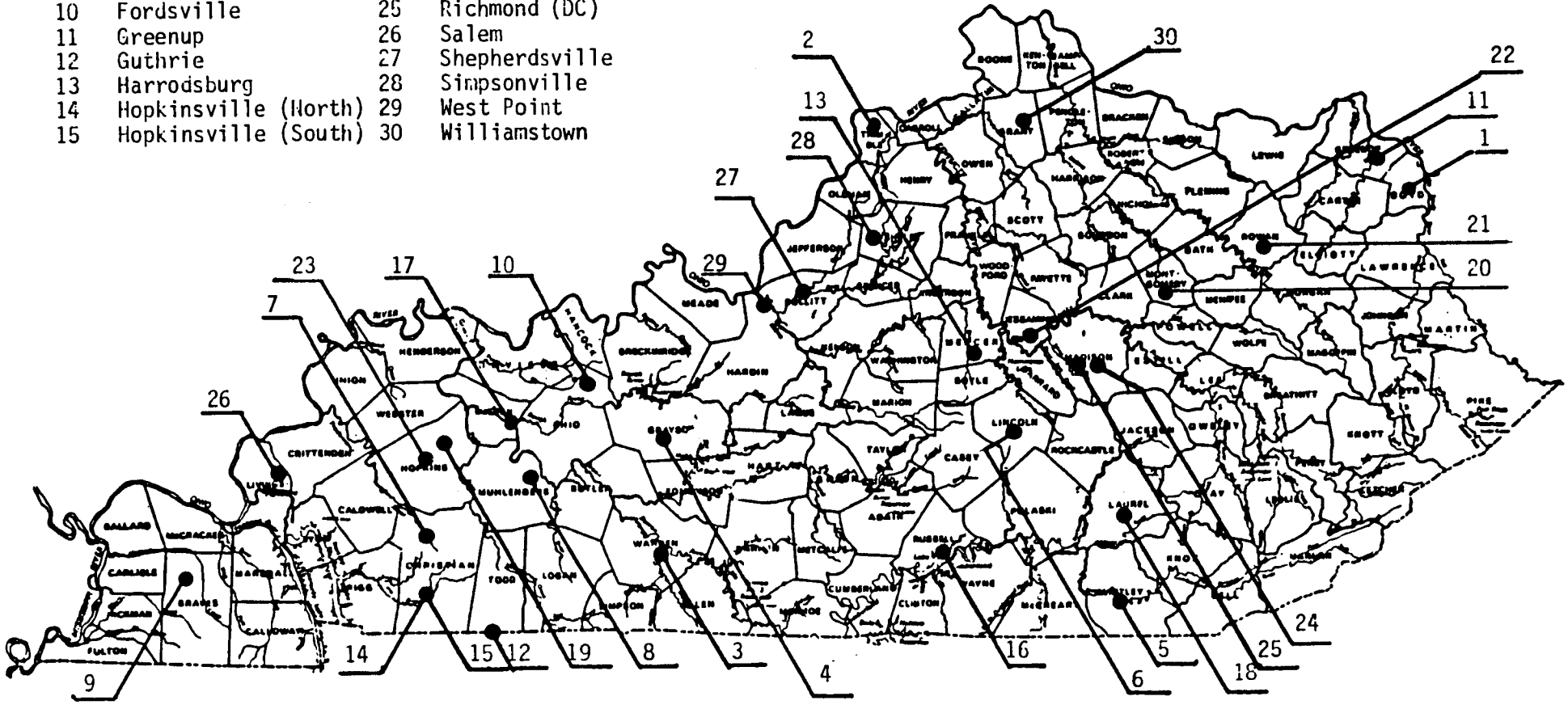


Table 23

Projects Which Have Received Construction Grants Funding But Construction Is Not Yet Completed

Project	*Type Grant	Total Cost
Alton W.D.	2/3	1,803,900
Berea	2/3	7,507,471
Berry	2/3	888,400
Bradfordsville	2/3	574,920
Carrollton	2/3	3,818,248
Centertown	2/3	1,197,875
Elizabethtown	3	17,576,675
Fleming-Neon	3	7,065,004
Flemingsburg	2/3	5,135,990
Fountain Run	2/3	657,050
Franklin	2/3	5,491,029
Georgetown	3	6,294,963
Hardinsburg	2/3	2,018,292
Hickman	2/3	870,650
Inez	2/3	3,736,776
Irvington	2/3	2,335,914
Island	2/3	1,143,548
LaCenter	2/3	556,686
LaGrange	2/3	3,180,423
Lexington - West Hickman	3	28,782,426
Midway	2/3	2,466,394
Milton	2/3	1,033,633
Monticello	2/3	5,770,694
Mt. Vernon	2/3	1,201,780
New Castle	2/3	1,583,700
Owensboro	3	8,492,722
Paintsville	2/3	3,137,668
Princeton	3	4,910,310
Radcliff	2/3	5,289,212
Russellville	3	2,143,185
Sacramento	2/3	1,612,919
Sadieville	2/3	952,600
SD #1 Shelby Co.	2/3	3,500,000
Scottsville	2/3	2,464,446
Shelbyville	3	4,322,137
Springfield	2/3	2,303,230
Stanford	2/3	1,688,545
Stanton	2/3	1,342,255
Sturgis	2/3	2,217,417

*3 Means Construction Funding
2/3 Means Design and Construction Funding

	Previous Discharge lbs/yr.	Existing Discharge lbs/yr.	Improvement lbs/yr.
BOD	5,254,694	748,645	4,506,049
TSS	3,623,068	899,478	2,723,590

Note: BOD is 5 day biochemical oxygen demand, TSS is total suspended solids.

Although significant improvements in water quality have been realized through the construction of the new wastewater treatment facilities, there are numerous needs that remain to be addressed. The 1982 Needs Survey indicated that the problems associated with the following categories of municipal discharges need to be resolved:

- o Municipal discharges causing water quality problems,
- o Municipal discharges that are causing public health hazards, and
- o Municipal discharges that do not meet minimum federal requirements.

The 1982 Needs Survey indicated that Kentucky has in excess of $835 million in wastewater treatment projects that remain to be built. Since most of these needs are based on water quality-based KPDES permit limitations, this would indicate that significant water quality problems exist in the state due to inadequately treated point sources. Additionally, in the areas of combined sewer overflow and stormwater system needs, this survey indicated that the state has in excess of $1,450 and $2,340 million, respectively, to correct these problems. These needs are overwhelming when compared to the $31.1 million in federal assistance currently allocated to Kentucky for wastewater treatment projects.

In order to continue to target federal assistance toward the most serious water quality problems, Kentucky is reviewing its Construction Grants Projects Priority List and Formula to assure that water quality and public health projects receive proper prioritization. New formula factors being added for 1985 will be reviewed at a public hearing to assure consistency in allocating projects according to their priority.

Industrial Facilities

On the subject of water quality benefits from technology-based effluent limits, the imposition of BPT/BAT-level permit limits should not have a noticeable effect on water quality because these limits are only used for effluent-limited streams. For water quality-limited streams, no data is currently available to show improvements that resulted from water quality-based permit limits due to the minimal use of these limits on industrial dischargers during 1982-1983. It is anticipated that the use of water quality-based limits on dissolved solids for oil stripper well brine discharges will lead to significant improvements in a large number of small streams in the south-central and south-eastern regions of the state.

Permit Compliance

During Federal Fiscal Year 1983 the Kentucky Division of Water began to take a stronger stand regarding enforcement. A new "Notice of Violation" was developed and a plan implemented to bring about a quicker resolution to water pollution problems. The new plan provides a more effective legal approach for bringing facilities into compliance with their permits. With the aid of data processing equipment, violations are detected sooner on self-monitoring data and enforcement action is much more

timely and effective than in previous years. In late 1983, the Division began preparing a quarterly non-compliance report on all major facilities to better track these facilities and immediately address non-compliance. The Division intends to expand this procedure to the minor municipal category in Federal Fiscal Year 1985. A new "State Municipal Strategy" was developed in early 1984 that lays the groundwork to bring all municipal facilities in the state into compliance by 1988. Implementation of this strategy will begin in June of 1984.

Enforcement

The procedure generally followed to enforce compliance with Water Quality Regulations involves identification of problem violations through on-site inspection and evaluation of self-monitoring data, informal negotiations resulting in legally enforceable compliance schedules, and civil litigation before an administative hearing officer. Most violations are resolved through informal negotiations by the Division of Water's field personnel. More severe or persistent violations are usually addressed by legally enforceable Agreed Orders negotiated by the Division's central office. When informal negotiations fail to achieve compliance, the Natural Resources and Environmental Protection Cabinet has the authority to conduct formal administrative hearings and employs a staff of attorneys for that purpose. After formal hearings, the Cabinet Secretary may execute compliance orders and assess civil penalties. It is also possible to obtain immediate relief through Franklin Circuit Court by seeking a restraining order or injunction.

During Federal Fiscal Years 1982 and 1983, enforcement activities resulted in 86 legally enforceable compliance orders and the assessment of $113,000 in civil penalties. While it is presumed that improvements in stream quality result from these activities, the Division has rarely been able to allocate the resources necessary to document improvements.

NONPOINT SOURCE CONTROL PROGRAM

Nonpoint sources (NPS) of water pollution resulting from agriculture, forestry, construction, and mining land disturbances continue to go unabated in Kentucky. These pollution sources are responsible for use impairment and habitat modification of Kentucky's streams, lakes, and wetlands. In many cases documented proof has been gathered showing the serious water quality implications of sediment, nutrient, pesticide, and acid mine drainage pollutants.

Kentucky's nonpoint source assessment was completed in April, 1984. The purpose of the assessment was to determine the extent and severity of agriculture, silviculture, mining, and construction caused sediment, nutrient, and/or pesticide-related water pollution in Kentucky. This information is summarized in Table 24.

Table 24
Severity and Extent of Nonpoint Source Contributions

Type of NPS	Extent	Severity	Primary Parameters
Urban	L	M	SS/M/T/C
Agriculture (non-irrigated)	W	M	N/OD/P/SS/T
Animal wastes	M	M	N/OD/C
Silviculture	L	I	SS/T
Mining	L[1./]	S	M/SS/T/O
Construction	L	M	SS/T

---EXTENT ---

W = widespread (50% or more of the State's waters are affected
M = moderate (25% to 50% of the State's waters are affected)
L = localized (less than 25% of the State's waters are affected)

---SEVERITY---

S = severe (des. use is impaired)
M = moderate (des. use is not precluded, partial support)
I = minor (des. use is almost always supported)

---PRIMARY PARAMETERS ---

C = coliforms
M = metals
N = nutrients
OD = oxygen demand
P = pesticides/herbicides
SS = suspended solids
T = turbidity
O = other (acid mine drainage-pH)

1./ Localized to two regions of state/in those regions problem is widespread.

Soil Erosion

Cropland

Over 46 million tons of soil erosion is produced from Kentucky cropland at an estimated rate of 9.93 tons/acre/year. Cropland in the eight county Purchase Major Land Resource Area (MLRA) is eroding at the greatest rate; 15 tons/acre/year (see Figure 13 for map of Major Land Resource Areas in Kentucky). Based on a 1982 U.S. Soil Conservation Service (SCS) study, approximately 57 percent of the state cropland needs conservation measures to reduce erosion rates to tolerable limits (usually less than 5 tons/acre/year). While erosion rates are highest in the Purchase area, the areal extent of acreage needing treatment is twice as high in the Pennyroyal and Western Coalfield MLRA. Not surprisingly, an earlier survey of district conservationists indicated that agricultural activities such as row crops were the predominant nonpoint source polluters in the state.

The SCS reported in 1975 that approximately 1.2 million acres of cropland in the Green River Basin were eroding in excess of acceptable limits. The average cropland erosion rate for the basin was 7.6 tons/acre/year or 9.7 million tons of soil erosion annually. In the Kentucky River Basin, over 302,000 acres of cropland had erosion rates exceeding acceptable limits in 1981. The average rate of erosion on cropland in the basin was estimated at 8.8 tons/acre/year. Annual tons of soil erosion exceeded 5 million. The southeastern section of the basin and part of the Outer Bluegrass region have the highest soil loss rates, ranging from 5-20 tons/acre/year depending on soil type, slope conditions, and management practices. Erosion in the Cumberland River Basin reportedly affects 2376 acres of cropland according to a 1980 SCS report. Of this total, 1109 acres are located in the Upper Cumberland subbasin and 1266 acres in the Lower Cumberland subbasin. Total annual erosion on cropland for the basin was 14,712 tons. Affected cropland acreage attributed to Kentucky included 431 acres and 480 acres in the Upper and Lower Cumberland subbasins, respectively. The difference in affected acreage was attributed to watersheds draining portions of Tennessee.

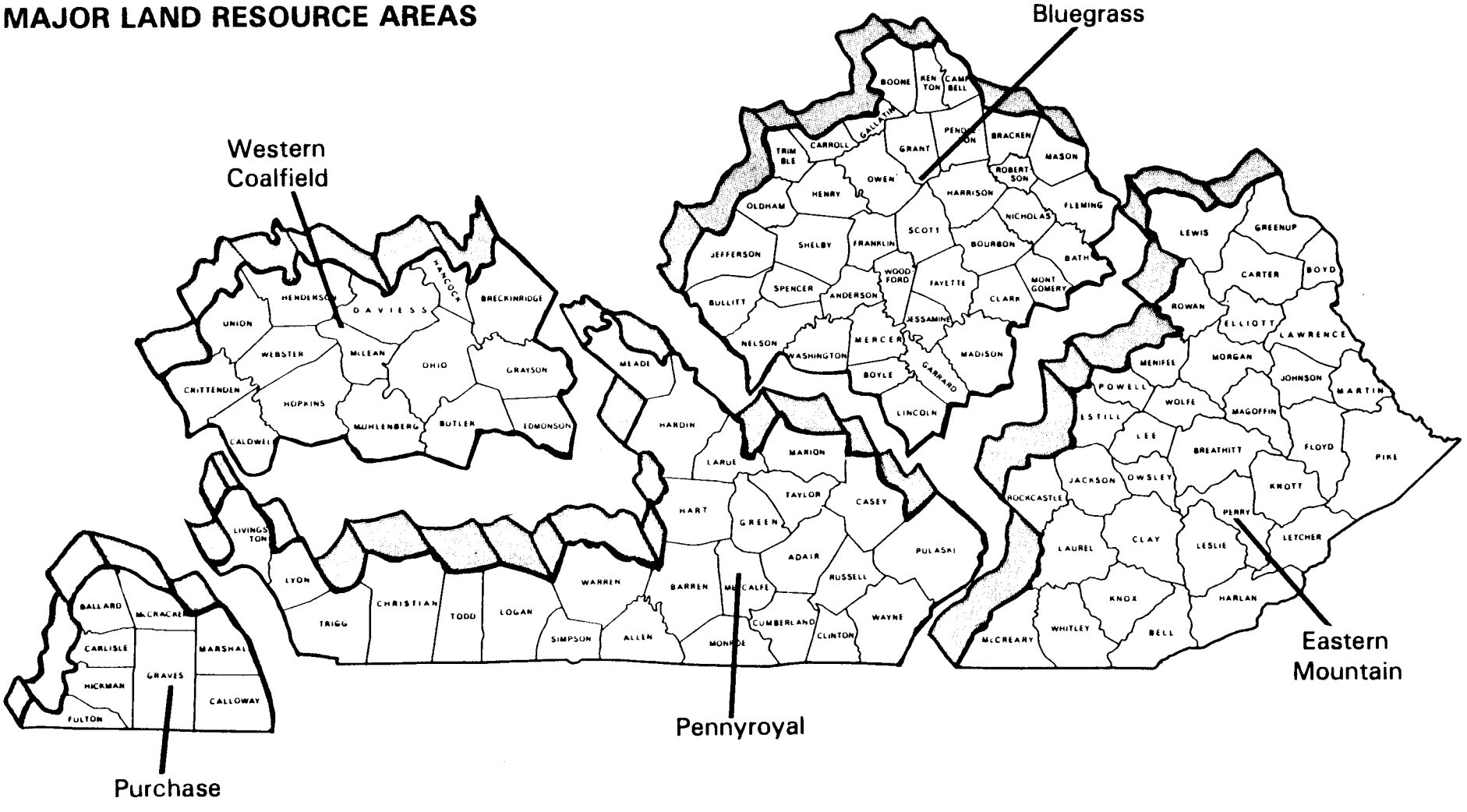
Pastureland

Erosion attributed to pastureland amounted to 36.8 million tons, or an average per acre rate of 6.42 tons/year. Pastureland requiring conservation in the state is approximately 80% of the total resource or 4.6 million acres. Regionally, most of the affected acreage is located in the Bluegrass MLRA although the Pennyroyal MLRA also accounts for a significant amount of pasture acreage requiring improved management.

Two hundred and fifty thousand (250,000) pasture acres are affected in the Green River Basin. Gently sloping uplands averaged about .5 tons/acre/year or less. Moderately sloping uplands, 8 percent or greater, average about 1.6 tons/acre/year. Steeper areas were reported to be eroding in the neighborhood of 5 tons/acre/year. Erosion prone pastureland in the Kentucky River basin amounted to approximately 275,000 acres. Erosion rates exceed 11 tons/acre/year on steeply sloped and inadequately managed pastureland. Pastureland on gentle to moderate slopes average a 3.5 ton/acre/year soil loss.

Figure 13

COMMONWEALTH OF KENTUCKY MAJOR LAND RESOURCE AREAS



Forestland

Although only 122,000 acres of Kentucky's forestland is annually disturbed by commercial logging operations, the Soil Conservation Service reported 14.8 million tons of annual soil loss, or an average of 1.6 tons/acre/year. Nearly 11.5 percent (1.2 million acres) of Kentucky's forestland, however, is reported to be affected by livestock grazing and in need of fencing to exclude domestic animals. Average soil loss from grazed forestland is estimated at 8.2 tons/acre/year.

In the Green River basin, erosion as the result of livestock grazing and timber harvesting affects approximately 202,000 and 245,000 acres, respectively. The area impacted by these two activities in the Kentucky River basin is 121,000 acres and 5,680 acres, respectively. Ninety-two percent of the woodland acreage affected by grazing is located in the lower portion of the basin and accounts for 27 percent of the total annual soil loss attributed to forestry in the basin. Annual erosion associated with haul roads and skid trails (harvest access system) represents 19 and 28 percent, respectively, of the basin's forest-related erosion.

Construction

The SCS determined in 1983 that 1839 acres being developed in 343 sites in the state were affected by homebuilding or other construction activities. Nearly all of the sites examined by the SCS were located in the highly urbanized Bluegrass MLRA or the 33 counties of the Eastern Coalfield. Half of the total soil loss was attributed to the Bluegrass MLRA. Erosion rates in the Bluegrass and Eastern Coalfield MLRAs average 95.5 and 325.9 tons/acre/year, respectively. Annual soil loss for the state ranged from 798 tons in the Western Coalfield to 125,018 tons in the Bluegrass MLRA. Half of the acres affected by construction in the Bluegrass were determined to be located in the northern Kentucky counties of Boone, Kenton, and Campbell in close proximity to Cincinnati, Ohio. Two hundred (200) acres were affected in Kentucky's fastest growing urban area, Lexington-Fayette County. Surprisingly, only 66 acres were disturbed by construction in Kentucky's largest metropolitan area, Louisville-Jefferson County.

The SCS further determined in 1983 that 2,090 acres and 972 miles of roads and railroad rights-of-way were eroding at excessive rates. This amounts to only .5 percent of the total acres and 1.4 percent of the total miles of federal and state highways, county maintained roads, or railroad easements in the state. Four hundred thirty-eight thousand (438,000) tons of annual soil loss was attributed to roadside or railroadside amounting to 210 tons/acre/year or 450 tons per mile per year. Survey results indicate that roadside and railroadside erosion is highest in terms of acres, miles, and annual tons of eroded soil in the Western Coalfield, Pennyroyal, and Eastern Coalfield MLRAs.

Acid Mine Drainage and Sedimentation from Mining Activities

Studies conducted by the Kentucky Nature Preserves Commission (KNPC) in the Commonwealth's coalfields in 1979, 1980, and 1981, concluded that a significant number of stream segments are impacted by coal mining activities. Seventy stream segments investigated by the KNPC were moderately degraded, degraded, or severely degraded. Of this amount, 49 segments were located in the Eastern Coalfield with the remaining 21 segments located in the Western Coalfield.

Thirty segments examined by the KNPC were considered to be degraded or severely degraded based on selected physicochemical and biological parameters. Stream segments denoted as being severely degraded were heavily impacted by fine sediment, silt, and/or coal deposits, elevated values for physicochemical parameters, and exhibited low aquatic diversity and equitability. Some streams were almost totally devoid of aquatic life and the biological communities observed were primarily composed of tolerant organisms. Streams denoted as degraded had moderate to high aquatic community diversity and moderate equitability, however, each site generally had some limiting factor such as siltation. Segments or wetlands in the severely degraded and degraded classifications included Clear Creek Wetland, Cypress Creek, Flat Creek Wetland, Old Channel Pond Creek, Spurlock Creek, Bear Fork, Cranks Creek, Canoe Creek, Weirs Creek Wetland, Tradewater River, Flat Lick Creek, Long Falls Creek, Muddy Creek, East Fork Little Sandy River, Rockcastle Creek, Levisa Fork, Jenny Creek, Licking River, Right Fork Beaver Creek, Troublesome Creek, Squabble Creek, Elkhorn Creek, Carr Fork, Road Fork Creek, Big Indian Creek, Marsh Creek, Clear Fork, and Laurel River.

Most of the streams studied by the KNPC and classified as degraded or severely degraded are impacted by surface and underground mining, however, in some cases, agriculture, stream channelization, and oil and gas operations were singled out as significant impacts. The single major pollutant in all cases was stream siltation, responsible for significant habitat modification in both of Kentucky's coalfields.

Acid mine drainage studies conducted by the Division of Water indicate that in the Western Coalfield, 244.1 miles of streams in the Tradewater River Basin, 271.2 stream miles of the Green River Basin, and 16.0 stream miles of the Lower Ohio River Basin are affected by acid mine drainage. In the Eastern Coalfield, 18.5 stream miles of the Kentucky River Basin, 27.3 stream miles of the Upper Cumberland River Basin, and 9.6 stream miles of the Big Sandy River Basin are affected by acid mine drainage. The water uses most susceptable to impairment are aquatic life and domestic water supply. Parameters most likely to be violated are alkalinity, pH, and total iron for aquatic life and total manganese, total sulfate, and total dissolved solids for domestic water supply.

Pesticides

Kentucky certified commercial applicators used 2.1 million pounds of pesticide active ingredients (PAI) in 1979. Nearly 60 percent of this amount was applied to Kentucky cropland. Another 15.5 percent of this total, representing the second largest category of pesticide use by commercial applicators, was applied to right-of-way sites. Kentucky private applicators used an estimated 19.9 million pounds of PAI in 1979; over nine times the amount used by certified commercial applicators. Nearly ninety-nine percent of this amount was applied to farm crops. In order of magnitude, conventional tillage corn, soybeans, and no-tillage corn accounted for most pesticide usage by Kentucky private applicators. Forest-related pesticides are not widely used in the state. Certified commercial applicators used only 412 pounds of pesticide active ingredients on forest land in 1979. Less than 10,000 acres of state and national forests in Kentucky are treated annually.

The distribution of pesticide use in Kentucky generally corresponds to the most concentrated agricultural crop production areas (e.g. Trigg, Christian, Todd counties) or urban population centers (e.g. Fayette, Jefferson, Kenton counties). Overall, the Lake Cumberland, Purchase, Pennyrile, and Green River Extension Areas rank highest in

pesticide usage applied by both commercial and private applicators. Herbicide is the pesticide used in the largest amount by private and commercial applicators in Kentucky. Sixty-seven percent and 82.8 percent of the total pounds of pesticides applied by commercial and private applicators, respectively, were weed control chemicals or herbicides.

Analysis of fish tissue by the Department indicate detectable levels of some pesticides in Kentucky's game and commercial fish species. The pesticide reported in the highest concentration with the greatest frequency is chlordane. Of all the reported pesticide concentrations, chlordane alone either approached or surpassed the U.S. Food and Drug Administration's action level of 0.30 mg/kg. At this level, the FDA will take legal action to remove adulterated products from the market.

Over little more than a two year period (1980-1983), fifteen reported spills and complaints were suspected as being caused by pesticides. Incidents ranged from isolated cases of contaminated farm ponds and private water wells, to contaminated community water supplies.

Fertilizer and Livestock Waste

According to available data, the greatest amount of commercial fertilizer is applied in the Pennyroyal region; the least amount is used in the Eastern Mountain area. Fertilizer use in the Commonwealth increased by 8.5 percent from 1976 through 1981. The Purchase region experienced greater than a 20 percent increase.

On a per acre basis, application rates are lowest in the Purchase, Western Coalfield and Bluegrass regions, and highest in the Eastern Mountains. Per acre application rates, however, are influenced by a number of factors such as the type of crop grown. Soybeans, a nitrogen-fixing legume which reduces the amount of needed fertilizer, are extensively grown in the Purchase region. In the Eastern Mountains, few soybeans are grown; corn and tobacco are more prevalent and require greater fertilization. The Purchase region has a high potential for water contamination by agricultural nutrients. This is due to the high percentage of cropland, the average soil loss (15 tons/acre/year), and the greatest annual increase in fertilizer use.

For agricultural wastes, the state trend indicates higher inventories of livestock and larger herds per farm (animal density). Eighty-six percent of the Commonwealth's beef inventory is located in the Pennyroyal, Bluegrass, and Western Coalfield physiographic regions. Seventy-eight percent of the dairy farms are located in the Pennyroyal and Bluegrass regions. Hog production is concentrated in the corn production region of Western Kentucky, particularily Union County. Poultry production is concentrated primarily in the Eastern Mountain region accounting for over 80 percent of the poultry producers in Kentucky.

Thirty million tons of animal manure are produced annually as estimated by the Natural Resources and Environmental Protection Cabinet. Beef production accounts for 58 percent of the total manure produced in Kentucky. Dairy, hog, and poultry production account for approximately 16, 8, and 1 percent, respectively, of the total manure produced. Over 2000 dairy and hog production operations require improved animal waste management systems for manure handling, storage, and disposal.

The largest stock of manure nitrogen and phosphorus are in the Pennyroyal, Bluegrass, and Western Coalfield areas. The potential for water quality degradation by livestock manure is high in these areas, especially considering the number of confined livestock facilities requiring improved manure handling systems.

Thirty-three reported fish kills resulted from livestock wastes or fertilizer contamination from 1975 through 1982. Ninety percent of these fish kills were the result of livestock manure runoff. Generally, data indicates a high correlation between the type of livestock production responsible for particular fish kills, spills or complaints, and their spatial locations in the Commonwealth. Poultry related pollution incidents are located in the Eastern Mountains; hog and dairy related incidents are located in the Bluegrass and Pennyroyal physiographic regions.

Sediment Delivery in Kentucky Watersheds

As a further indication of NPS affected watersheds, the Division of Water through the recently completed Nonpoint Source Assessment, predicted the amount of sediment delivered to water courses. This prediction was based on modeled erosion data and a Kentucky-specific sediment delivery curve. The top 100 significantly impacted watersheds were then ranked according to low, moderate, high and very high sediment delivery potential (see Appendix E) primarily because it is unrealistic to assume that the state could focus attention and resources on more than this number of watersheds. Although reliance on absolute values is not recommended, an example of a significantly impacted watershed would be a 10,000 acre drainage basin devoted primarily to row crops with an annual soil erosion rate of 10 tons per year. The predicted sediment yield, using the sediment delivery curve, would be approximately 1.6 tons per acre per year.

Generally, over half of the 42 U.S. Geological Survey hydrologic units that make-up Kentucky contain few or none of the top 100 significant sediment yield P.L. 566 watersheds. Twelve of the hydrologic units contain none of the top 100 affected watersheds; eleven hydrologic units contain only one. While significant yield watersheds are located in every region of Kentucky, they tend to be concentrated in the west-central and central regions.

The Green River Basin (hydrologic units 05110001 through 05110006) contains both the greatest number and area of significant yield watersheds. Forty-three of the top 100 watersheds are located in the Green River Basin. Within this basin, the Barren River (05110002), Rough River, (05110004), and Pond River (05110006) subbasins contain many of the significant yield P.L. 566 watersheds. All three of the watersheds ranked in the very high sediment delivery class are located in the Barren and Pond River subbasins. These include the Pond River 566 watershed which is heavily impacted by surface coal mining (80 percent of the basin's land use), and the Hungry Creek and Lick Creek P.L. 566 watersheds which are significantly affected by agricultural land uses. Additionally, Meadow Creek, Alexander Creek, and Lost Creek in hydrologic unit 05110001 have potentially high sediment delivery rates. Land use in these watersheds is predominately agriculture, however, 25-30 percent of each is in forest cover. Clifty Creek in the Rough River subbasin is also subject to potentially high sediment delivery due to agricultural land uses. Finally, Beaverdam Creek, Little Beaverdam Creek, Clay Lick Creek, Trammell Fork, Barren River, Lewis Creek, Meeting Creek, Little Clifty Creek, Fiddler's Creek, W. Fork Knoblick Creek, and Muddy Prong, are affected by moderate sedimentation relative to other Kentucky watersheds. With the exception of the Barren River P.L. 566 watershed number 070 (hydrologic unit 05110003), all of the above watersheds are affected by agricultural land uses. Although land uses in the Barren River 566 watershed were fairly evenly distributed among agriculture, forestry, and mining, surface coal mining was determined to be the primary sediment source.

The Kentucky River Basin (hydrologic units 05100201 through 05100205) contains 20 significant yield P.L. 566 watersheds, nearly half of which are concentrated in the southern end of the lower Kentucky River basin (hydrologic unit 05100205). Logan Creek and Prear's Creek in this subbasin are subject to potentially high sedimentation rates. Tate Creek, Sugar Creek, and Clark's Run in the subbasin are affected by moderate sedimentation. Land use in all of these watersheds is predominately agricultural which is believed to be the primary sediment source.

Only one watershed was affected by moderate sedimentation in each of the Big Sandy (hydrologic unit 05070203) and Licking (hydrologic unit 05100101) River Basins. Daniel Creek P.L. 566 watershed located in the Big Sandy River Basin is predominately in forest cover (59.7 percent). Agriculture, at 27.6 percent of the land use in the watershed, however, was determined to be the primary sediment source. This is despite the fact that some 12 percent of the watershed is surface mined for coal. On a smaller scale, surface coal mining of the area has contributed to sedimentation and other water quality impacts. In the Licking River Basin, Blackwater Creek is affected by moderate sedimentation, also attributed to agricultural activities.

Watersheds in the Upper and Lower Cumberland River Basins are also affected by moderate to low sedimentation. In particular, Pond Creek, Big Clifty Creek, and Smith Creek are P.L. 566 watersheds affected by moderate sedimentation in the Upper Cumberland Basin. Upper Cumberland watersheds in the low sediment delivery class include the Cumberland River and Meadow Creek P.L. 566 watersheds. In the Lower Cumberland River Basin, only Sugar Creek and Sandy Creek were affected by sedimentation in the moderate to low range when compared to other Kentucky watersheds.

Finally, certain Ohio River tributary watersheds were denoted in the high, moderate, and low sediment delivery classes. In the high sediment delivery class, Yellow Creek and the Ohio River P.L. 566 watershed number 190 were listed. Blackford Creek, Pup Creek, Stevens Creek, Ohio River P.L. 566 watershed number 140, and an unnamed tributary drained by Landing Creek were affected by moderate sedimentation. In the low sediment delivery class, Twelve Mile Creek, Snake Creek, Ohio River P.L. 566 watershed number 150, Spring Creek, Lick Run, Muddy Creek, Camp Creek, and Caney Creek were listed.

Existing and/or Recommended Control Programs

The Natural Resources and Environmental Protection Cabinet intends to utilize a non-regulatory approach for controlling nonpoint sources of pollution (primarily soil erosion and sedimentation) that occur in conjunction with the production of food and fiber, timber, and kindred products, and site preparation and building practices used in the light construction and housing industry. The portion of the plan that addresses surface mining, however, has been implemented through the regulatory authority of the Kentucky Department of Surface Mining Reclamation and Enforcement. This was made possible through Kentucky gaining primacy of the Surface Mining Reclamation Control Program and is, therefore, a regulatory program. Table 25 presents generalized information on Kentucky's existing and recommended nonpoint source pollution control programs. Although most of the state's NPS water quality program is voluntary in nature, there is a strong commitment for implementation on the part of local and state government officials, the general public, the affected industries, and numerous private and public sector associations.

Table 25

Existing and Recommended Nonpoint Source Control Programs (Costs Not Determined)

Type of NPS	Type of Control Program: Existing	Type of Control Program: Recommended
Urban	T	TR
Agriculture (non-irrigated)	TF	ETF
Animal Wastes	TF	ETF
Silviculture	T	ETF
Mining	TR	
Construction	T	ETFR

--- TYPE OF CONTROL PROGRAM ---

S = structural/public works
E = education
T = tech. assistance
F = financial incentives
R = regulation
O = other

The Cabinet, through educational programs, incentives, and increased technical assistance, intends to positively influence the adoption and acceptance of Best Management Practices (BMPs) to reduce or mitigate erosion and sedimentation. BMPs represent the least costly and most effective measures to reduce erosion and sedimentation and consequently to improve water quality. In terms of savings, it has been demonstrated that the costs associated with removing sediment and repairing a site after damage has already occurred, exceeds the cost of initially installing and maintaining BMPs. Although the costs for administering a voluntary NPS control program have not been fully determined, the cost estimates for actual BMP installation in Kentucky are staggering. Table 26 presents 1981 estimates for various BMPs according to priority NPS categories.

TABLE 26

Detailed Breakdown of Cost Needs

Source	Unit	Total Needs (20-30 yr)	Average Costs Per Unit	Estimated Installation Costs ($)[1./]
AGRICULTURE (Non-irrigated)				
Cropland				
Simple Components[2./]	Acres	1,014,000	$ 30.00	$ 30,420,000
Mod. Int. Components[2./]	Acres	221,000	145.00	32,045,000
Intense Components[2./]	Acres	99,000	485.00	48,015,000
Land Use Conversion	Acres	410,000	80.00	32,800,000
No-Tillage Systems	Acres	1,270,000	15.00	19,050,000
Drainage Systems	Acres	592,000	225.00	133,200,000
			SUBTOTAL	295,530,000
Pastureland				
Pasture Managment System	Acres	3,097,000	60.00	185,820,000
Pasture Establishment	Acres	1,032,000	73.00	75,145,631
Protection (overgrazing)	Acres	459,000	40.00	18,360,000
			SUBTOTAL	279,325,631
TOTAL AGRICULTURE (Non-irrigated)				574,855,631
ANIMAL WASTES				
Waste Management Systems	Number	2,116	15,000.00	31,740,000
TOTAL ANIMAL WASTES				31,740,000
SILVICULTURE				
Woodland Mgt. Systems	Acres	6,020,000	35.00	210,700,000
Tree Planting	Acres	1,220,000	100.00	122,000,000
Protection from Grazing	Acres	1,199,000	10.00	11,990,000
TOTAL SILVICULTURE				344,690,000

TABLE 26 (continued)

Detailed Breakdown of Cost Needs

Source	Unit	Total Needs (20-30 yr)	Average Costs Per Unit	Estimated Installation Costs ($)[1./]
MINING				
Abandoned Mine Reclamation	Acres	101,600	5,000.00	508,000,000
Reclamation Under Regulation	Acres	154,000	3,000.00	462,000,000
TOTAL MINING				**970,000,000**
CONSTRUCTION				
Construction Sites	Acres	80,000	160.00	12,800,000
Roadbanks	Miles	232,000	3,000.00	696,000,000
TOTAL CONSTRUCTION				**708,800,000**

1./ Based on statewide average 1981 installation costs/does not include education, technical planning, financial assistance, research or other essential components of voluntary programs/costs do not necessarily correspond to critical NPS problems but instead represent conservation needs throughout Kentucky.

2./ The "simple" components of this cropland management system include conservation tillage, contour farming, crop residue management, cover crop, and high level management. The "moderately" intense components include grass waterways and strip cropping in addition to the above simple components. The 'intense" cropland management system includes parallel terracing in addition to the components of the above systems.

Source: Kentucky Soil and Water Conservation Commission

MONITORING PROGRAM

An effective water monitoring program is essential for making sound pollution control decisions and for tracking water quality improvements. Specifically, Kentucky's ambient monitoring program provides monitoring data to identify priority waterbodies upon which to concentrate agency activities, to revise State water quality standards, to aid in the development of wasteload allocations, and to determine water quality trends in Kentucky surface waters. As outlined in Kentucky's current Water Quality Management Continuing Planning Process the major objectives associated with the Ambient Monitoring Program are:

1. To operate a fixed-station monitoring network meeting chemical, physical, and biological data requirements of the state program and EPA's Basic Water Monitoring Program (BWMP),

2. To conduct intensive surveys on priority waterbodies in support of stream use designations, wasteload allocation model calibration/verification, and other agency needs,

3. To store data in EPA's STORET system, a computerized water quality data base, and

4. To coordinate ambient monitoring activities with other agencies (EPA, Ohio River Valley Water Sanitation Commission, U.S. Geological Survey, U.S. Army Corps of Engineers, et al.)

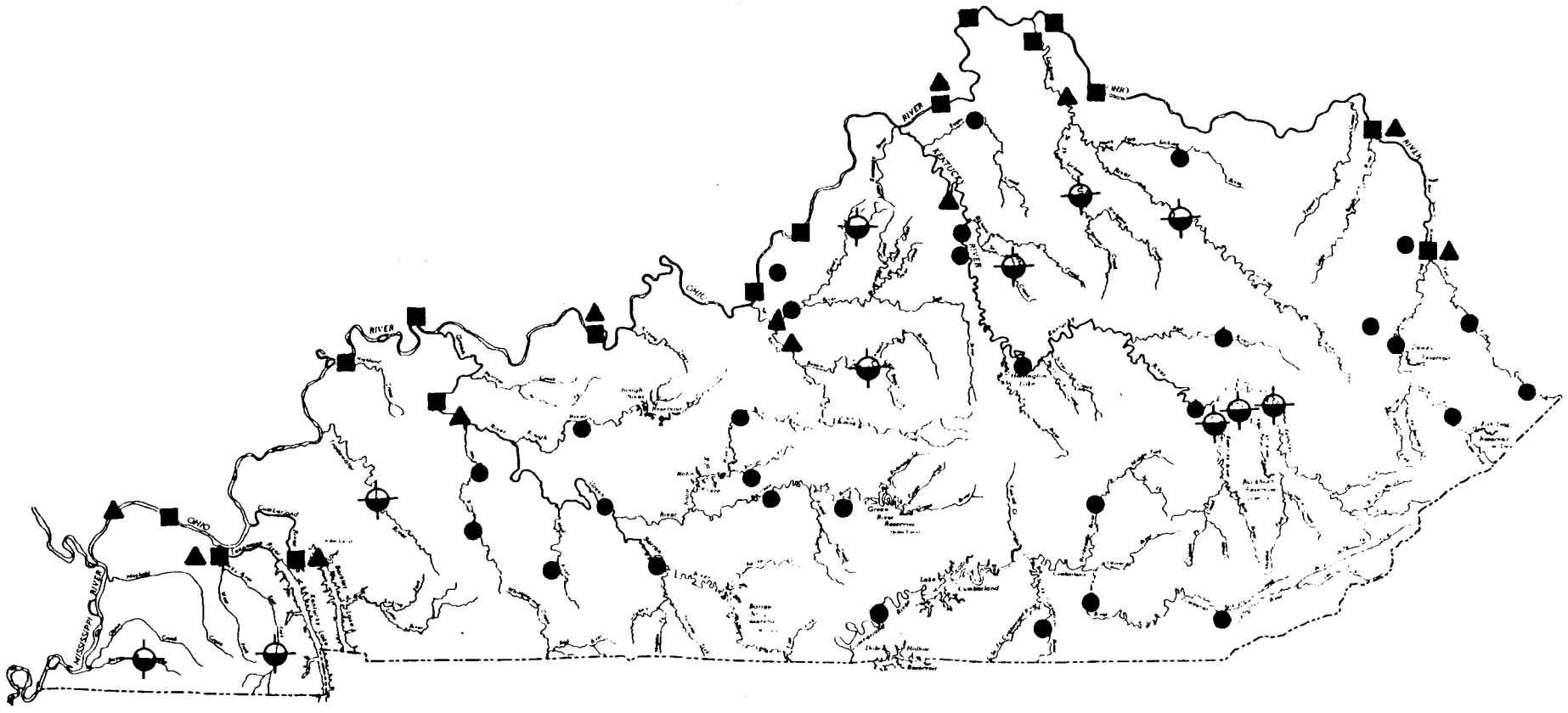
Fixed-station Monitoring Network

The location of all fixed-station primary water quality monitoring sites which were active during 1982-1983 are shown in Figure 14. Excluding the miles of the main stem of the Ohio River, data generated by this monitoring network are used to characterize approximately 1350 stream miles within the state.

For the reporting period (1982-1983), the Division of Water's physicochemical network consisted of 30 stations located in six river basins. Water samples collected monthly at each station are analyzed according to the parameter list shown in Table 27. In addition, the Division supports and uses data collected by the Ohio River Valley Water Sanitation Commission (ORSANCO) at eleven main stem Ohio River stations and five major tributary stations. The United States Geological Survey maintains the National Stream Quality Accounting Network (NASQAN) in Kentucky composed of four main stem Ohio River stations and eight major tributary stations. During 1982 the Division of Water and the U.S. Geological Survey entered into a cooperative agreement that established an additional eleven water quality monitoring stations. This agreement afforded Kentucky the opportunity to expand its primary network into areas of the state where current information is inadequate for the assessment of the effectiveness of water management programs. The terms of the agreement assure compatibility of data between the expanded network and the existing network.

Kentucky also participates in the U.S. Environmental Protection Agency's Basic Water Monitoring Program (BWMP). Kentucky's commitment to the BWMP network consists of 7 of the Division's 30 primary network stations. In addition, 9 BWMP stations on the Ohio River are maintained by ORSANCO, for a total of 16 stations in the state.

MONITORING STATIONS



- DOW Primary Network
- ORSANCO Network
- USGS NASQAN Network
- DOW/USGS Network

Figure 14

Table 27

Fixed Station Parameter Coverage

Field Data

Weather Code
Air Temp, °C
Water Temp, °C
Depth, Feet
Right Bank, %
Conductivity, umhos/cm@25 C
D.O., mg/l
pH, S.U.
Turbidity, N.T.U.
Flow, cfs

Minerals, Total

Calcium, mg/l
Magnesium, mg/l
Potassium, mg/l
Sodium, mg/l
Hardness, mg/l

Minerals, Dissolved

Calcium, mg/l
Magnesium, mg/l
Potassium, mg/l
Sodium, mg/l

Bacteria

Fecal Coliform, per 100 ml

Nutrients

NH_3-N, mg/l
NO_2 + NO_3-N, mg/l
TKN, mg/l
Total Phosphorus, mg/l

Laboratory Data

Acidity, mg/l
Alkalinity, mg/l
B.O.D., 5-day, mg/l
Chloride, mg/l
C.O.D., mg/l
Dissolved Solids, mg/l
Fluoride, mg/l
Conductivity, umhos/cm@25C
pH, S.U.
Turbidity, N.T.U.
Sulfates, dissolved mg/l
Suspended Solids, mg/l
T.O.C., mg/l

Metals, Total

Aluminum, ug/l
Arsenic, ug/l
Barium, ug/l
Beryllium, ug/l
Cadmium, ug/l
Chromium, ug/l
Copper, ug/l
Iron, ug/l
Lead, ug/l
Manganese, ug/l
Mercury, ug/l
Nickel, ug/l
Selenium, ug/l
Silver, ug/l
Zinc, ug/l

Metals, Dissolved

Aluminum, ug/l
Cadmium, ug/l
Copper, ug/l
Iron, ug/l
Lead, ug/l
Manganese, ug/l
Mercury, ug/l
Zinc, ug/l

Biological Monitoring

Kentucky has established a biological monitoring program to determine the biological integrity of the waters of the state. The objective of this monitoring effort is the development of a baseline of biological data to (1) provide information for the Environmental Protection Agency's Basic Water Monitoring Program, and (2) to aid in the determination of water quality trends. Program emphasis is presently being placed on designation of stream uses and determining degrees of use impairment. Another focal point of the program is the determination of the biological properties (toxicity) of effluents and the determination of the efficiency of pollution abatement programs.

In support of EPA's BWMP, biological data collections are conducted annually at seven primary network stations. In addition to general aquatic biological assessments, fish tissue and sediments are analyzed for metals and pesticides. Annual biological monitoring is rotated among stations in the primary network, which provides a broader basis for trend biological assessment and more efficiently utilizes limited monitoring resources.

Intensive Surveys

Kentucky continues to emphasize the use of intensive surveys to help analyze site-specific water quality problems. Information developed from intensive surveys is essential in providing a technical basis to:

1. Document the attainment/impairment of beneficial water uses,
2. Verify and justify Construction Grants decisions,
3. Address issues raised in petitions for water quality standards variances from permittees, and
4. Document water quality improvements and progress resulting from water pollution control efforts.

For the past two years intensive surveys have been used to address the appropriateness of stream use classifications on priority streams. During 1982-1983, twenty-two intensive surveys were conducted on water quality-limited stream segments which receive discharges from municipal wastewater treatment facilities applying for Construction Grants funding. A list of these stream segments and the associated municipality is presented in Table 28. A discussion of these segments appears in Appendix B.

Table 28

Intensive Surveys Conducted During 1982-1983

Stream	Basin	Municipality
Tygarts Creek	Tygarts	Olive Hill
Fleming Creek	Licking	Flemingsburg
Slate Creek	Licking	Owingsville
South Elkhorn Creek	Kentucky	Lexington
Silver Creek	Kentucky	Berea
Dix River/White Oak Creek	Kentucky	Lancaster
Floyds Fork	Salt	LaGrange, Oldham Co. Water District
Mill Creek	Salt	Radcliff
Rolling Fork	Salt	Lebanon Junction
Yellow Creek	Upper Cumberland	Middlesboro
Poor Fork Cumberland River	Upper Cumberland	Cumberland, Benham, Lynch
Roundstone Creek	Upper Cumberland	Mt. Vernon
Beaver Creek	Upper Cumberland	Monticello
Pond Creek/Caney Creek	Green	Greenville
Cypress Creek	Green	Central City
Black Lick Creek	Green	Auburn
Tradewater River	Tradewater	Dawson Springs, Providence
Craborchard Creek	Tradewater	Clay
South Fork Red River	Lower Cumberland	Adairville
Elk Fork	Lower Cumberland	Elkton
Humphrey Creek	Ohio	Kevil, LaCenter
Otter Creek	Ohio	Vine Grove

CHAPTER IV

RECOMMENDATIONS

RECOMMENDATIONS

The actions listed below are recommended for achieving further progress in meeting the goals and objectives of the Clean Water Act. Except where noted, these recommendations are primarily responsibilities of the Kentucky Division of Water, Department for Environmental Protection, Natural Resources and Environmental Protection Cabinet.

- Develop and implement water toxics monitoring and control strategies addressing toxics in both surface water and sediment. (State - U.S. EPA responsibility)

- Implement a groundwater strategy in cooperation with other state and federal agencies. Expand the existing data base in an effort to develop a more comprehensive knowledge of groundwater quality, occurrence, distribution, reserves, use and recharge.

- Improve compliance of all major KPDES facilities and implement the State Municipal Strategy to assure the construction and effective operation and maintenance of municipal facilities in the state.

- Reduce the backlog of new and expired KPDES permits that resulted from the delegation of the NPDES responsibilities in 1983.

- Implement the recommendations of Kentucky's Nonpoint Source Pollution Control Plan within existing resources by encouraging federal, state, and local organizations to institute multiple objective programs (i.e. water quality protection as well as a production orientation). These agencies include primarily the U.S. Soil Conservation Service and Forest Service; the Kentucky Soil and Water Conservation Commission and the Association of Conservation Districts; the Kentucky Divisions of Forestry, Conservation, and Abandoned Lands; and the Kentucky Department of Surface Mining Reclamation and Enforcement. Continue to seek resources independent of the above agencies to be targeted directly to implementation of the education, technical assistance, economic incentive, and continuing planning components of the plan.

- Continue to conduct monitoring activities necessary to support water quality standards decisions, construction grants and permitting programs, and 305(b) report development.

- Institute a "hands-on" training program to address problems with wastewater facilities which have adequate design capacity, but are causing pollution due to poor operator training and understanding of plant operation.

- Review the issue of Construction Grants funding for wastewater treatment facilities. Options which should be considered at a national level include: (a) variable funding according to economic conditions, such as median income in local communities; (b) continuing progress toward a loan program which creates a revolving fund account that is self-perpetuating; (c) greater amount of federal commitment for funding for the short-term as a loan program becomes finalized. Changes in funding policy will require action by Congress and EPA.

- Current policy for construction grants awarded after September 30, 1984, only provides funding for the existing needs of a community as opposed to needs for the 20 year growth forecast for the community. This approach does not necessarily take advantage of the efficiencies that exist in constructing wastewater treatment improvements to include reasonable growth expectations for the community. A change in this policy will require action by Congress and EPA.

APPENDIX

APPENDIX A

WATER QUALITY INDEX METHODOLOGY

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The rankings for the Water Quality Index (WQI) were developed utilizing data generated from monitoring activities conducted during 1982-83. Trend station data from the Division of Water primary ambient stations, joint Division of Water/U.S. Geological Survey stations, U.S. Geological Survey NASQAN stations and ORSANCO stations on tributary rivers to the Ohio River were retreived for the two year period of this report and compiled by hydrologic units within a river basin. Categories in the WQI are:

Dissolved oxygen
pH
Aesthetics (suspended solids)
Trophic nutrients (TP and NO_2 and NO_3-N)
Toxics (water quality parameters and sediment parameters)
Bacteria (fecal coliform)
Biological (algae, macroinvertebrates, fish, fish tissue parameters)

Each parameter within a category was assigned a point value according to the scheme; good=+1, Fair=0, and poor=-1. Parameters within each category were then averaged and an overall value was given to each category (-1 to +1). The categories were then summed to give a WQI value (-7 to +7) for each monitoring station.

In hydrologic units which had multiple monitoring stations, the final WQI point value was calculated as the weighted average of the individual stations. The weight variable was based on the total stream miles represented by each station. The final point values were then translated according to the scheme; good > +3, fair -3 to +3, and poor < -3.

In order to assign point values to the parameters in each category, screening criteria were developed for good, fair and poor ratings. The following list indicates the criteria used for the parameters in each WQI category with the exception of the Toxics (sediments) and Biological category.

Table A-1
Water Quality Index Screening Criteria

WQI Category	Screening Criteria		Source
Dissolved oxygen	4.0	mg/l	KSWS
pH	6-9	units	KSWS
Aesthetics (suspended (solids)	80	mg/l	NAS Blue Book* (moderate level of protection for aquatic communities)

Table A-1 continued

WQI Category	Screening Criteria	Source
Trophic Nutrients		
TP	.147 mg/l	SOTRET state-wide mean from KY ambient stations for period of record
NO_2-NO_3-N	.72 mg/l	
Toxics		
Water		
Arsenic	50 ug/l	KSWS
Beryllium	1000 ug/l	KSWS
Cadmium	12 ug/l	KSWS
Chromium	100 ug/l	KSWS
Copper	6 u/gl	EPA chronic criteria**
Iron	1000 ug/l	KSWS
Nickel	120 ug/l	EPA chronic criteria**
Selenium	35 ug/l	EPA chronic criteria**
Silver	7 ug/l	EPA acute criteria**
Zinc	47 u/gl	EPA chronic criteria**
Un-ionized Ammonia	.05 ug/l	KSWS
Bacteria (fecal coliform)	400/100 mg/l	KSWS for primary contact recreation

* Kentucky Surface Water Standards for warmwater aquatic habitat use.

** Derived from EPA Water Quality Criteria documents, October 1980. Note: The hardness value of 136 mg/l was used for determining criteria levels for metals and was based on a STORET statewide mean.

The screening criteria were then used to evaluate the available data and to arrive at good, fair and poor rankings based on the method described below:

Ranking	Method
Good	Criterion is exceeded in 0-10% of the analyses and the mean measured value is less than the screening value.
Fair	Criterion is exceeded in 11-25% of the analyses and the mean measured value is less than the screening value; or criterion is exceeded in 0-10% of analyses and mean measured value exceeds the screening value.
Poor	Criterion is exceeded in more than 25% of analyses and mean measured value is less than the screening value; or criterion is exceeded in 11-24% of analyses and mean measured value exceeds the screening criterion.

Toxics Sediments

Included in the toxics category were data from sediments collected at the trend stations (DOW primary stations & DOW/USGS) for 1982 (partial) and 1983 (all). Sediment values were compiled by station for each hydrological unit. All hydrological units were combined for each basin. Sediment data were evaluated by the following methods:

Parameters			Source of Screening Criteria
Metals			
Arsenic	Mercury	Nickel	Guidelines for the Pollutional
Cadmium	Lead	Manganese	Classification of Great Lakes
Chromium	Zinc		Harbor Sediments (U.S. EPA,
Copper	Iron		Region V, Chicago, IL, 1977)
Pesticides and PCB			
Dieldrin	Chlordane		Evaluation of Illinois
DDT	PCB		Stream Sediment Data 1974-1980

The U.S. EPA classified sediments as unpolluted (good), moderately polluted (fair), and heavily polluted (poor). The Illinois study ranked in five categories, which were combined to three categories; non-elevated and slightly elevated = Good, Elevated = Fair, Highly Elevated, and Extremely Elevated = Poor. Points were assigned as previously mentioned for the good, fair, and poor rankings (see above).

Biological Quality

This portion of the 305(b) report characterizes the aquatic biota and the water quality at selected trend stations in Kentucky. The period of data collection and frequency at these stations is limited; therefore, the characterization of the stream depends on available data, stream side habitat observations and the biologist's interpretations.

Biological monitoring of the periphyton, macroinvertebrate and fish communities and tissue residues has been conducted annually during 1982 and 1983 at a total of ten primary network stations. The various parameters used as a basis for the biological assessment are generally the following:

A. Species diversity, richness and pollution tolerance
B. Community structure
C. Biomass determination
D. Productivity
E. Tissue Residues

Periphyton quantitative sampling was accomplished by use of the Design Alliance Periphytometer. Qualitative samples were acquired by scraping selected stream substrates. Macroinvertebrate sampling consisted of deploying modified Hester-Dendy multiplate samplers for quantitative analyses. Select pickings from various stream habitats comprised the qualitative analyses. Stream size dictated the type(s) of fish collection methods. A variety of methods were used, including seining, passive netting, and electrofishing. The water quality at the biologically monitored stations is ranked as either good, fair or poor. These terms are defined as follows:

Ranking	Method
Good:	Waters that possess indigenous populations of aquatic organisms, unaltered in community structure for the available habitats with exceptional functional groupings and taxa richness. These stations most often contain species that are considered intolerant of sustained pollution.
Fair:	Waters that possess indigenous populations of aquatic organisms that show slight to moderate alterations in community structure. Taxa richness and species composition are often skewed or depressed (enough to be noted in relation to the available habitats). The community is dominated by facultative organisms and exhibit signs of stress due to pollution.
Poor:	Waters that possess indigenous populations of aquatic organisms that show moderate to severe alterations in

community structure for the available habitats. The community is dominated by tolerant and facultative organisms. Taxa richness and species composition are radically skewed and/or depressed in favor of tolerant organisms. These communities are obviously under stress from sustained pollution.

Unknown: Stations at which biological information is insufficient.

Attempts were made to determine if the aquatic communities at each of the stations were impaired, partially impaired or unimpaired during the sample period (1982-1983). However, it should be recognized that climatological conditions and loss of samplers due to vandalism have created sampling problems. On the other hand, the addition of personnel and improvement of the staff's taxonomic skills have improved data interpretation. Two stations have monitoring data spanning five years and therefore a trend analysis was possible. These factors, plus the lack of a historical data base, limits accurate trend analyses; however, these problems should be resolved with continued data collection at these locations.

Fish tissue values were ranked by station and averaged by hydrological unit and basin. The following parameters and rating criteria are based on literature review and were used for the fish tissue evaluation.

Pesticides and PCB

	Good	Fair	Poor
Aldrin	< 0.1 mg/kg	values between good and poor	> .30 mg/kg
Dieldrin	< 0.1 mg/kg	values between good and poor	> .30 mg/kg
DDT	< 1.0 mg/kg	values between good and poor	> 5.0 mg/kg
Chlordane	< 0.1 mg/kg	values between good and poor	> .30 mg/kg
PCP	ND		ND
Toxaphene	< 0.1 mg/kg	values between good and poor	> 5.0 mg/kg
PCB	< 0.5 mg/kg	values between good and poor	> 5.0 mg/kg

Good values are based on recommendations for organochlorine insecticide fish residues in the NAS Blue Book pp. 185-186.

Fair values range between good to poor rating.

Poor values are based on FDA action levels.

Metals:

	Good	Fair	Poor
Arsenic	< .5 mg/kg	values between good and poor	> 5.0 mg/kg
Cadmium	< .15 mg/kg	no value	> .15 mg/kg
Chromium	ND	ND	ND
Copper	< 10.0 mg/kg	values between good and poor	> 100.0 mg/kg
Mercury	< .5 mg/kg	values between good and poor	> 1.0 mg/kg
Lead	< 0.1 mg/kg	values between good and poor	> 5.0 mg/kg
Zinc	< 0.5 mg/kg	values between good and poor	> 5.0 mg/kg

Good

- As, Cd, and Pb values are based on U.S. Fish and Wildlife Service (USFWS) mean background levels for fish tissue. National Pesticide Monitoring Program - Luke & Schmitt, pp. 97-110. 3rd USA-USSR Symposium on Effects of Pollutants upon Aquatic Life. 1979.
- Zn and Cu values estimated as 0.10 of poor value.
- Hg value based on recommendation in NAS Blue Book pg. 174.

Fair - range of value between good and poor limits

Poor - As, Cu, Pb and Zn based on federal Canadian values for fish tissue from Tsui and McCart - "Chlorinated Hydrocarbon Residues and Heavy Metals in Several Fish Species from the Cold Lake Area in Alberta, Canada" in International Journal of Environmental and Analytical Chemistry. 1981 Vol. 10, pp. 277-285.

- Hg value derived from FDA action level.
- Cd value estimated from Kentucky background data and best professional judgement.

ND - Not determined/insufficient data for decision.

APPENDIX B

RIVER BASIN/HYDROLOGIC UNIT INFORMATION

BIG SANDY RIVER BASIN

The Big Sandy River basin lies in the rugged mountains of the Cumberland Plateau in eastern Kentucky and adjacent West Virginia and Virginia. The basin is underlain by sandstone deposits of Pennsylvanian age. There are 1,257 miles of streams in the basin depicted on the USGS hydrologic unit map. The total drainage area is 4,280 square miles, 2,885 of which are in Kentucky.

The main stem of the Big Sandy River originates at the confluence of Levisa and Tug forks at Louisa, Kentucky, and flows north 27 miles to enter the Ohio River (mile 317.1) at Catlettsburg, Kentucky. Levisa Fork flows 130 miles in Kentucky with a drainage area of 1,471 square miles. Principal tributaries of the Levisa Fork include Paint Creek, Russell Fork, Beaver Creek, and Johns Creek. Tug Fork forms the boundary between Kentucky and West Virginia for about 94 miles and has a drainage area within the state of 476 square miles. Principal tributaries to the Tug Fork within the state include Rockcastle Creek, Wolf Creek, and Big Creek. Six ambient monitoring stations are located in the basin.

The elevation of the Big Sandy River ranges from 2,400 feet above mean sea level (m.s.l.) at the head of Levisa Fork and 2,200 feet above m.s.l. at the head of Tug Fork to 498 feet above m.s.l. at its confluence with the Ohio River. The average main stem slope of the Big Sandy is 9.9 feet/mile while many of its tributaries have average slopes of over 50 feet/mile.

Steep terrain and shallow soil depths account for the limited agriculture in the basin. Localized silviculture operations occur throughout the drainage. The mainstay of the economy lies in the vast coal reserves underlying the basin. Both surface and deep mining, and to a lesser extent several small petroleum fields, provide jobs for most of the residents.

Impacts

The principal impacts to the streams in Big Sandy River basin are increased siltation and to a lesser extent increased nutrient enrichment. Acid mine drainage is limited to a few localized areas in the upper half of the drainage. The lower 12 miles of the main stem receive at least 5 industrial discharges which impact this section of the stream. Oil and gas drilling have degraded the water quality in the Blaine Creek and Johnson Creek subbasins. Other impacts are road construction, domestic sewage, urban runoff and agriculture.

The aquatic biota has been adversely affected by surface mine runoff over a large portion of the drainage. Essentially every major watershed has been impacted to some degree by surface mining. Water quality perturbations have been so extensive in some localized areas as to virtually eliminate the aquatic fauna. Two fish kills were reported for 1982 and three for 1983 in the Kentucky portion of the drainage.

Problem Parameters

Fecal coliform bacteria was the primary problem water parameter throughout the basin with copper and iron also elevated. High chlordane levels were present in sediments.

Flow

The average discharge for the period of record (56 years) is 2,486 cfs for the Levisa Fork at Paintsville (River Mile Index 65.2). Mean discharge for water year 1982 was below the annual average discharge (-15%). During water year 1983, the mean discharge was 12% below the annual average. The concentration effect of flow reduction during the reporting period was a contributing factor to observed increases in certain physicochemical parameters.

Hydrologic Unit 05070201 - Tug Fork

A total of 288 miles of streams draining 1,559 square miles (476 square miles in Kentucky) comprise this hydrologic unit. The major urban center (in Kentucky) is Inez (pop. 469). Two water quality monitoring stations are located in this hydrologic unit: Tug Fork at Kermit and Tug Fork at state line.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 5.2 to a maximum of 12.3 with a mean range of 8.3 to 8.6 and a median range of 8.4 to 8.5.

o pH

For the reporting period pH ranged from a minimum of 6.7 to a maximum of 8.5 with a mean range of 7.5 to 7.8 and a median range of 7.6 to 7.9. For the period of record (1979-1983) pH ranged from a minimum of 6.7 to a maximum of 8.5 with a mean range of 7.6 to 7.9 and a median range of 7.7 to 7.9.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.2 to a maximum of 48.8 with a mean range of 4.8 to 16.0 and a median range of 5.8 to 6.2. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 48.8 with a mean range of 4.3 to 9.9 and a median range of 4.0 to 4.2.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 48.8 to a maximum of 269.0 with a mean range of 107.8 to 142.8 and a median range of 107.0 to 120.6. For the period of record (1979-1983) alkalinity ranged from a minimum of 15.6 to a maximum of 269.0 with a mean range of 105.7 to 127.8 and a median range of 106.0 to 113.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 228.0 to a maximum of 922.0 with a mean range of 482.8 to 495.9 and a median range of 442.0 to 527.0. For the period of record (1979-1983) conductivity ranged from a minimum of 197.0 to a maximum of 923.0 with a mean range of 465.5 to 478.4 and a median range of 432.0 to 433.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 0.7 to a maximum of 90.0 with a mean range of 10.3 to 19.7 and a median range of 8.8 to 13.1. For the period of record (1979-1983) chlorides ranged from a minimum of 0.7 to a maximum of 90.0 with a mean range of 9.5 to 19.5 and a median range of 8.2 to 12.9.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 45.4 to a maximum of 204.0 with a mean range of 100.5 to 108.9 and a median range of 91.8 to 101.0. For the period of record (1979-1983) sulfates ranged from a minimum of 14.8 to a maximum of 220.0 with a mean range of 96.1 to 106.1 and a median range of 88.2 to 96.4.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.015 to a maximum of 0.645 with a mean range of 0.260 to 0.354 and a median range of 0.245 to 0.350. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 0.64 with a mean range of 0.27 to 0.34 and a median range of 0.28 to 0.36.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.020 to a maximum of 0.145 with a mean range of 0.053 to 0.075 and a median range of 0.049 to 0.075. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.015 to a maximum of 0.875 with a mean range of 0.054 to 0.090 and a median range of 0.051 to 0.068.

o Fecal Coliform

Fecal coliform standards were exceeded 65% of the time during the reporting period. The highest percentage of violations occurred at the Tug Fork at Kermit station.

Hydrologic Unit 05070202 - Levisa Fork/Greasy Creek

A total of 234 miles of streams draining 358 square miles (in Kentucky) comprise this hydrologic unit. The major urban center is Jenkins (pop. 3,271). Recreation centers include Fishtrap Lake. There are no water quality monitoring stations located in this unit.

Hydrologic Unit 05070203 - Levisa Fork

A total of 572 miles of streams draining 1,228 square miles comprise this hydrologic unit. Major urban centers include Pikeville (pop. 4,756), Prestonsburg (pop. 4,011), and Paintsville (pop. 3,815). Recreation centers include Dewey Lake and Jenny Wiley State Park. Three water quality monitoring stations are located in this hydrologic unit: Levisa Fork at Pikeville, Levisa Fork at Paintsville, and Paint Creek near the mouth.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 4.0 to a maximum of 14.0 with a mean range of 8.3 to 8.6 and a median range of 8.3 to 8.4.

o pH

For the reporting period pH ranged from a minimum of 6.4 to a maximum of 9.4 with a mean range of 7.1 to 7.5 and a median range of 7.0 to 7.4. For the period of record (1979-1983) pH ranged from a minimum of 6.4 to a maximum of 9.4 with a mean range of 7.3 to 7.5 and a median range of 7.2 to 7.5.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 0.9 to a maximum of 39.0 with a mean range of 7.1 to 8.3 and a median range of 5.0 to 5.6. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 39.0 with a mean range of 5.8 to 6.0 and a median range of 4.4 to 4.8.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 25.0 to a maximum of 125.0 with a mean range of 56.8 to 63.6 and a median range of 47.1 to 64.7. For the period of record (1979-1983) alkalinity ranged from a minimum of 17.0 to a maximum of 135.8 with a mean range of 54.1 to 61.1 and a median range of 47.6 to 62.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 174.0 to a maximum of 1120.0 with a mean range of 362.2 to 389.2 and a median range of 342.0 to 405.0. For the period of record (1979-1983) conductivity ranged from a minimum of 126.0 to a maximum of 1120.0 with a mean range of 359.3 to 375.9 and a median range of 286.0 to 377.0.

o Chlorides

For the reporting period chlorides ranged from a minimum of 3.9 to a maximum of 278.0 with a mean range of 8.7 to 60.7 and a median range of 8.3 to 37.4. For the period of record (1979-1983) chlorides ranged from a minimum of 2.3 to a maximum of 278.0 with a mean range of 8.7 to 58.0 and a median range of 7.5 to 36.1.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 13.0 to a maximum of 202.0 with a mean range of 38.4 to 110.8 and a median range of 33.1 to 113.0. For the period of record (1979-1983) sulfates ranged from a minimum of 7.8 to a maximum of 220.0 with a mean range of 38.4 to 103.4 and a median range of 33.1 to 106.1.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 0.73 with a mean range of 0.23 to 0.39 and a median range of 0.20 to 0.38. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of

0.01 to a maximum of 0.73 with a mean range of 0.21 to 0.38 and a median range of 0.20 to 0.38.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.02 to a maximum of 0.66 with a mean range of 0.05 to 0.07 and a median range of 0.04 to 0.05 mg/l. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.005 to a maximum of 0.66 with a mean range of 0.06 to 0.07 and a median range of 0.04 to 0.05.

o Fecal Coliform

Fecal coliform standards were exceeded 57% of the time during the reporting period. The highest percentage of violations occurred at the Levisa Fork at Paintsville station.

o Biological

The Levisa Fork at Paintsville station was dominated by sparse growths of filamentous green and blue-green algae as well as epipelic diatoms. Periphyton chlorophyll a values were average with regard to all BWMP stations although they exhibited large variability among replicate samplers. (Mean = 19.3 mg/m^2, Range (2.7-46.3)). Values for Ash Free Dry Weight (AFDW) were above average (4.32 g/m^2, Range (2.06-7.32)). Plankton chlorophyll a values were low (1.6 ug/l), most likely limited by turbidity. A total of 105 algal species were identified from natural substrate collections. The diatom community was dominated by epipelic (occurring on sediment) species such as Gyrosigma, Surirella, and certain Nitzschia species.

The invertebrate collections from this station were diverse. The functional groupings expressed considerable speciation. Many kinds of habitats were available to most groups common to lotic (running) waters. The most obvious influences to the benthic community are related to siltation and nutrient enrichment which also affects water quality in the stream.

No Food and Drug Administration (F.D.A.) action levels were exceeded in fish tissue at this station in 1983.

Hydrologic Unit 05070204 - Blaine Creek

A total of 162 miles of streams draining 337 square miles comprise this hydrologic unit. Major urban centers include Louisa (pop. 1,832) and Fallsburg. Three water quality monitoring stations are located in this hydrologic unit: two on the Big Sandy River at Louisa, and one on Blaine Creek at Fallsburg.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 4.4 to a maximum of 13.2 with a mean of 9.3 and a median of 8.8.

o pH

For the reporting period pH ranged from a minimum of 6.5 to a maximum of 8.0 with a mean range of 7.2 to 7.6 and a median range of 7.2 to 7.7. For the period of record (1965-1983) pH ranged from a minimum of 6.5 to a maximum of 8.1 with a mean range of 7.2 to 7.6 and a median range of 7.2 to 7.6.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.9 to a maximum of 19.5 with a mean of 5.7 and a median of 4.6. For the period of record (1979-1983) acidity ranged from a minimum of 1.9 to a maximum of 19.5 with a mean of 5.2 and a median of 4.0.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 8.0 to a maximum of 363.0 with a mean range of 44.0 to 58.0 and a median range of 28.0 to 58.0. For the period of record (1979-1983) alkalinity ranged from a minimum of 0.0 to a maximum of 363.0 with a mean range of 36.0 to 78.0 and a median range of 28.0 to 92.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 217.0 to a maximum of 4230.0 with a mean range of 390.0 to 943.0 and a median range of 351.0 to 774.0. For the period of record (1965-1983) conductivity ranged from a minimum of 125.0 to a maximum of 4230.0 with a mean range of 371.0 to 986.0 and a median range of 352.0 to 774.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 6.5 to a maximum of 991.0 with a mean range of 14.9 to 216.4 and a median range of 12.0 to 153.0. For the period of record (1965-1983) chlorides ranged from a minimum of 3.0 to a maximum of 991.0 with a mean range of 15.3 to 241.9 and a median range of 12.0 to 160.0.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 8.4 to a maximum of 44.4 with a mean of 28.5 and a median of 31.4. For the period of record (1979-1983) sulfates ranged from a minimum of 7.8 to a maximum of 44.8 with a mean of 28.0 and a median of 30.2.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.015 to a maximum of 0.655 with a mean of 0.32 and a median of 0.34. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.015 to a maximum of 0.655 with a mean of 0.314 and a median range of 0.290.

o Total phosphorus

For the reporting period total phosphorus ranged from a minimum of 0.004 to a maximum of 0.45 with a mean of 0.045 ad a median of 0.022. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.004 to a maximum of 0.45 with a mean of 0.039 and a median of 0.025.

o Fecal Coliform

Fecal coliform standards were exceeded 36% of the time during the reporting period.

o Biological

The Blaine Creek station was dominated by moderate growths of filamentous green, blue-green, and red algae, as well as pennate diatoms. Periphyton chlorophyll a values were below average (14.1 mg/m^2-Range (9.9-18.9)) as were AFDW values (2.84 g/m^2-Range (2.41-3.41)). Plankton chlorophyll a values were typical of small streams (5.1 ug/l). A total of 181 algal species were identified from natural substrate collections. The diatom community was dominated by halophilic, eutrophic, and epipelic taxa, although many typical Eastern Kentucky stream species were also present.

The invertebrate collections from this station show definite signs of stress from degraded water quality. In spite of ample variety of habitats available to the benthic organisms, the collections reflected a paucity of functional types and species diversity. The organisms collected from this location are considered to be tolerant of many environmental conditions.

No F.D.A. action levels were exceeded in fish tissue at this station in 1983.

LITTLE SANDY RIVER BASIN

The Little Sandy River basin is located in the northeastern portion of the state, lying within the Unglaciated Appalachian Plateau. The area is underlain with Pennsylvanian age sandstone deposits. The river arises near Sandy Hook, Kentucky, and flows 87 miles to its confluence with the Ohio River at Greenup, Kentucky (Ohio River mile 336.4). Principal tributaries to the Little Sandy include the Little Fork, East Fork and Big Sinking creek. The major impoundment of this area is Grayson Lake near Grayson, Kentucky. There are 360 miles of streams in the basin depicted on the USGS hydrologic unit maps, draining an area of 721 square miles.

The topography in the headwater section is generally rugged, with no flat or undulating land present. Closer to the mouth, the terrain becomes less rugged with more bottomland available for agricultural practices. Elevations range from 1,300 feet above mean sea level (m.s.l.) in the headwater region near Sandy Hook to 479 feet above m.s.l. at the river's confluence with the Ohio. Average slope for the Little Sandy is 8.3 feet/mile.

Impacts

The major impact in the Little Sandy River basin is coal mining, which contributes increased sediment loads to the receiving streams. Domestic sewage and agricultural runoff are minor impacts. Siltation resulting from coal mining operations has adversely affected the aquatic biota in the Little Sandy basin. No fish kills were reported in 1982 or 1983.

Flow

The annual average discharge for the period of record (45 years) is 475 cfs for Little Sandy at Grayson (RMI 38.05). Mean discharge for water year 1982 was below the annual average discharge (-24%). However, during water year 1983, mean discharge was only 6% below the annual average.

Hydrologic Unit 05090104 - Little Sandy River

This hydrologic unit composes the entire Little Sandy River basin. There are no water quality monitoring stations located in this unit.

TYGARTS CREEK BASIN

The Tygarts Creek basin is located in the northeastern portion of the state, lying within the Unglaciated Allegheny Plateau region of the Appalachian Plateaus Province. The bedrock in the headwaters is Pennsylvanian sandstone but as the stream flows northward it cuts into Mississippian limestone deposits. Tygarts Creek originates in southwestern Carter County, Kentucky and flows in a northeasterly direction for its 89.3 miles, where it empties into the Ohio River at South Shore, Kentucky (mile point 353.2). The principal tributary is Buffalo Creek with a drainage area of 54 square miles. The entire basin has a drainage area of 339 square miles. There are 194 stream miles in the basin depicted on the USGS hydrologic unit map.

The topography for the watershed varies from steep hillsides and narrow valleys in the headwaters to broad, wide valleys near the mouth. Elevations range from 485 feet above mean sea level (m.s.l.) at its confluence with the Ohio River to 1300 feet above m.s.l. at the source. The average slope of Tygarts Creek is 6.9 feet/mile. The average stream channel width ranges from about 30 feet in the headwater reaches to over 200 feet near the mouth.

Impacts

Municipal sewage from the city of Olive Hill is the main impact on Tygarts Creek, with some minor impacts from mining and oil drilling operations.

Tygarts Creek supports a diverse assemblage of aquatic organisms throughout the drainage. No fish kills occurred during the reporting period. There are no water quality monitoring stations located in this basin.

Flow

The annual average discharge for the period of record (26 years) is 85.9 cfs for Tygarts Creek at Olive Hill (RMI 78.0). Mean discharge for water year 1982 was below the annual average discharge (-38%). During water year 1983, mean discharge was 12% below the annual average.

Hydrologic Unit 05090103 - Tygarts Creek

Hydrologic unit 05090103 contains 194 stream miles which encompasses the entire Tygarts Creek basin. With the exception of 6.1 mi of Shultz Creek, the entire stream system has been recommended to be classified for Aquatic Life/Warmwater Aquatic Habitat use. Shultz Creek supports a "put and take" trout fishery, therefore it has been recommended for Aquatic Life/Coldwater Aquatic Habitat use. Also, the entire drainage has been recommended for Primary and Secondary Contact Recreation use. The Olive Hill Reservoir and Tygarts Creek at mile point 78.89 are recommended for Domestic Water Supply use. Stream use designation work indicated that Kentucky Surface Water Standards (KSWS) for aluminum, mercury, iron and undissociated hydrogen sulfide were violated. Historical data indicate the KSWS for pH and alkalinity were violated in a small headwater, coal mining impacted stream, which does not appear on the hydrologic unit map. The Tygarts Creek basin supports an excellent diversity of aquatic habitats and aquatic fauna. Therefore, with the exception of a two mile stream reach impacted by the Olive Hill wastewater treatment plant, the recommended stream uses are supported. This two mile reach at Olive Hill partially supports the recommended use.

LICKING RIVER BASIN

The Licking River basin is located within the eastern portion of Kentucky in two major physiographic provinces, the Allegheny Plateaus and Interior Low Plateaus. It rises in southeastern Kentucky and flows northwesterly to the confluence with the Ohio River in the Covington-Newport, Kentucky area at an elevation of 420 feet above mean sea level (m.s.l.). There are 2,034 miles of streams in the basin depicted on the USGS hydrologic unit map. Three ambient monitoring stations are located in the basin. The total drainage area is 3,700 square miles. Principal tributaries are the North Fork and South Fork of the Licking. The major impoundment of this area is Cave Run Lake near Farmers, Kentucky.

The topography of the headwaters area is characteristic of the unglaciated region of the Appalachian Plateaus. This area is dissected into narrow ridges and steep sided valleys by a network of streams. The underlying rocks are Pennsylvanian Age sandstone. Maximum elevation in the headwaters is 1,000 feet above m.s.l. Average slope for the Licking River main stem is 2.26 feet/mile.

Upon leaving the Appalachian Plateaus, the Licking flows through sections of the Interior Low Plateaus known as the Knobs and the Blue Grass. The Knobs are characterized by conical and flat-topped hills with broad valleys. The Blue grass topography ranges from an area of gently rolling hills adjacent to the Knobs, to an area highly dissected by a network of streams which have formed V-shaped valleys and narrow ridges. Mississippian and Ordovician limestones underlie most of this section.

Impacts

In the upper portion of the drainage, coal mining and gas and oil drilling operations are the major impacts. These operations contribute increased silt loads and brines to the streams. In the lower river, agricultural runoff and domestic sewage increase nutrient levels. The last few miles drain a heavily industrialized area.

The aquatic biota above Cave Run Reservoir has been impacted by coal mining and oil and gas operations; however, below the reservoir the river supports a diverse and complex group of organisms. The stability of biotic communities below the reservoir may change as oil and gas drilling increase in the drainage. Four fish kills were reported in the drainage for 1982, five occurred in 1983.

Problem Parameters

Total phosphorus was elevated throughout the basin, while fecal coliform bacteria and nitrite and nitrate-nitrogen were elevated at scattered locations. Copper was above average in the water and chlordane levels were high in sediments.

Flow

The annual average discharge for the period of record (57 years) is 4,143 cfs for the Licking River at mile point 48.0. Mean discharge for water year 1982 was below the annual average discharge (-22%). During water year 1983, mean discharge was 7% below the annual average. The concentration effect of flow reduction during the reporting period was a contributing factor to observed increases in certain physicochemical parameters.

Hydrologic Unit 051001001 - Licking River

A total of 1,439 miles of streams draining 2,780 square miles comprise this hydrologic unit. Major urban centers include Covington (pop. 49,563), Morehead (pop. 7,789), Salyersville (pop. 1,352), and West Liberty (pop. 1,381). Recreation centers include Cave Run Lake, Blue Lick State Park, Kincaid Lake, and Lake Carnico. Four water quality monitoring stations are located in this hydrologic unit: Licking River at Sherburne, North Fork Licking River near Lewisburg, Licking River at Covington, and Licking River at Butler.

Thirty nine miles (Fleming Creek drainage) of this unit have been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation uses. In addition, it has been recommended that the Fleming Creek reservoir be designated for domestic water supply use. A stream use designation study revealed a violation of Kentucky Surface Water Standards for phthalate esters, mercury and aluminum. The Fleming Creek basin is considered to support the recommended use designation because of its diverse aquatic habitat and fauna and its generally good water quality.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 4.6 to a maximum of 14.1 with a mean of 9.9 and a median of 9.8.

o pH

For the reporting period pH ranged from a minimum of 6.9 to a maximum of 8.2 with a mean range of 7.3 to 7.7 and a median range of 7.2 to 7.6. For the period of record (1979-1983) pH ranged from a minimum of 6.9 to a maximum of 8.3 with a mean range of 7.3 to 7.8 and a median range of 7.4 to 7.8.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 2.0 to a maximum of 29.0 with a mean of 10.1 and a median of 7.7. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 29.0 with a mean of 8.0 and a median of 7.4.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 39.8 to a maximum of 180.0 with a mean range of 106.0 to 128.7 and a median range of 106.0 to 138.0. For the period of record (1974-1983) alkalinity ranged from a minimum of 0.0 to a maximum of 158.0 with a mean range of 8.0 to 122.6 and a median range of 7.4 to 110.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 156.0 to a maximum of 445.0 with a mean range of 197.8 to 349.5 and a median range of 178.0 to 354.0. For the period of record (1974-1983) conductivity ranged from a minimum of 156.0 to a maximum of 503.0 with a mean range of 202.5 to 355.7 and a median range of 195.0 to 353.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged fro n a minimum of 2.9 to a maximum of 16.0 with a mean range of 7.9 to 12.1 mgl and a median range of 8.0 to 11.0. For the period of record (1974-1983) chlorides ranged from a minimum of 0.9 to a maximum of 18.1 with a mean range of 5.98 to 10.4 and a median range of 5.7 to 10.0.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 16.8 to a maximum of 65.2 with a mean of 35.3 and a median of 35.0. For the period of record (1979-1983) sulfates ranged from a minimum of 16.8 to a maximum of 65.2 with a mean of 36.3 and a median of 35.2.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.02 to a maximum of 4.05 with a mean range of 0.74 to 1.22 and a median range of 0.65 to 0.87. For the period of record (1974-1983) NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 4.05 with a mean range of 0.63 to 0.99 and a median range of 0.54 to 0.72.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.019 to a maximum of 1.79 with a mean range of 0.039 to 0.22 and a median range of 0.03 to 0.15. For the period of record (1974-1983) total phosphorus ranged from a minimum of 0.019 to a maximum of 3.3 with a mean range of 0.10 to 0.27 and a median range of 0.05 to 0.17.

o Fecal Coliform

Fecal coliform standards were exceeded 37% of the time during the reporting period.

o Biological

The North Fork Licking River station was characterized by moderate to dense growths of filamentous blue-green, green, and red algae. Pennate diatoms were speciose. The centric diatom, Skeletonema potanos dominated plankton collections. Periphyton chlorophyll a values were above average (30.2 mg/m^2, Range 15.1-47.1) while AFDW was below average (2.75 g/m^2, Range 2.23-3.21). Plankton chlorophyll a was below average (9.8 ug/l). A total of 161 algal species were identified from natural substrate collections. Planktonic green and euglenoid algae were common, suggesting nutrient enrichment, most likely from agricultural activities. The diatom community was dominated by typical stream species, as well as those associated with nutrient enrichment. The North Fork Licking River appears to be a productive stream with good water quality.

The Licking River at Sherburne station was characterized by moderate growths of filamentous green, blue-green, and red algae. Pennate diatoms were speciose. Periphyton chlorophyll a values were below average (8.3 mg/m^2, Range 5.4-10.8) as were AFDW values (1.70 g/m^2, Range 1.38-1.97). Plankton chlorophyll a values were below average (9.3 ug/l). A total of 165 algal species were identified from natural substrate collections. The diatom community was dominated by typical stream species. The Licking River appears to be a productive stream with good water quality.

The invertebrates collected from the North Fork Licking River station were diverse in relation to available habitats. Most members of the community are typical of small unimpacted streams of that area. There are no obvious alterations in the benthic community from degraded water quality. Siltation and nutrient enrichments are not detectable. The water quality at this location in relation to the benthic community is exceptional.

The invertebrates collected at the Licking River at Sherburne station were typical for the habitats and stream size. Most functional groupings were well represented. Species composition reflected ample partitioning of available habitats. The community did not reflect any obvious influences from water quality factors. Although nutrient enrichment from agricultural practices was predictable, it was not evident through the benthic community structure. The stream appears to support a diverse benthic fauna and contain good water quality.

No F.D.A. action levels were exceeded in fish tissue at these stations in 1982 or 1983.

Hydrologic Unit 05100102 - South Fork Licking River

A total of 595 miles of streams draining 927 square miles comprise this hydrologic unit. Major urban centers include Paris (pop. 7,935), Cynthiana (pop. 5,881), and Falmouth (pop. 2,482). One water quality monitoring station is located in this hydrologic unit: South Fork Licking River at Cynthiana.

o pH

For the reporting period pH ranged from a minimum of 7.4 to a maximum of 8.3 with a mean of 7.9 and a median of 7.9. For the period of record (1956-1983) pH ranged from a minimum of 7.4 to a maximum of 8.3 with a mean of 7.9 and a median of 7.9.

o Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1962-1972) alkalinity ranged from a minimum of 95.0 to a maximum of 164.0 with a mean of 131.7 and a median of 120.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 275.0 to a maximum of 920.0 with a mean of 498.0 and a median of 415.0. For the period of record (1956-1983) conductivity ranged from a minimum of 117.0 to a maximum of 920.0 with a mean of 402.7 and a median of 390.0.

- Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 4.1 to a maximum of 120.0 with a mean of 20.5 and a median of 9.1. For the period of record (1956-1983) chlorides ranged from a minimum of 2.9 to a maximum of 120.0 with a mean of 18.2 and a median of 9.6.

- Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.05 to a maximum of 4.1 with a mean of 0.59 and a median of 0.32. For the period of record (1982-1983) total phosphorus ranged from a minimum of 0.05 to a maximum of 4.1 with a mean of 0.59 and a median of 0.32.

KENTUCKY RIVER BASIN

The Kentucky River basin drains 7,033 square miles in the Cumberland Plateau and Blue Grass sections. The main stem of the Kentucky River is formed by the confluence of the North Fork, Middle Fork, and South Fork in the Beattyville, Kentucky area. Flowing northwesterly 255 miles, the river joins the Ohio River at Carrollton, Kentucky (Ohio River mile 435.6). A series of 14 U. S. Army Corps of Engineers Locks and Dams impound the river from the mouth to Beattyville. There are 3,899 miles of streams in the basin depicted on the USGS hydrologic unit map. The total drainage area is 6,966 square miles. Principal tributaries to the Kentucky River are the Red River, Dix River, Elkhorn and Eagle Creeks. Major impoundments of this basin are Herrington, Buckhorn and Carr Fork lakes.

Watershed topography varies considerably. The upper third of the drainage lies on Pennsylvanian sandstone in the Cumberland Plateau. This area is characterized by deeply dissected valleys, narrow ridge tops, and steep slopes. Average slope of the tributaries in that section ranges from 3 feet/mile to 7.2 feet/mile with the main stem averaging 0.9 feet/mile. The highest elevation in the basin is Pine Mountain, 2,273 feet above mean sea level (m.s.l.).

Adjacent to the mountainous area is the Interior Low Plateaus in which the Blue Grass and Knobs sections lie. These plateaus are underlain by limestones of the Ordovician, Devonian and Silurian periods. The Knobs form a narrow crescent separating the Blue Grass from the Cumberland Plateau and are characterized by hills with steep slopes. Topography of the Blue Grass varies from gently rolling terrain, to areas highly dissected by dendritic drainage systems with V-shaped valleys and narrow ridges, to broad undulating peneplains marked by karst areas. Average slope of the tributaries in the Blue Grass ranges from 3 feet/mile to 32 feet/mile. The main stem of the Kentucky averages 0.7 feet/mile. Maximum elevation in the Blue Grass approaches 1,000 feet above m.s.l.

Impacts

The main impacts to the Kentucky River drainage are mining and agricultural practices. Demand for fossil fuels in the past decade has greatly increased surface mining within the basin, causing a further increase in siltation of downstream areas. Cultivation of the narrow floodplains in the highlands and intensive farming throughout the Knobs and Blue Grass sections contribute to nutrient and sediment loading of the drainage.

Numerous municipal wastewater treatment plant discharges affect the water quality of the streams in the basin, primarily by nutrient enrichment and oxygen depletion.

Improper oil and gas drilling operations have recently become a serious water quality problem in portions of the drainage. The South Fork of the Red River has been extensively impacted by these operations, resulting in localized elimination of the aquatic fauna. Perturbations are so severe that they have adversely affected public water supplies as far downstream on the Kentucky River as Lexington.

The aquatic biota is generally good throughout most of the basin except in some coal field tributaries that have been impacted by mining or oil drilling. Some Blue Grass streams have been impacted by municipal wastewater treatment plant effluents. There were eight fish kills reported in 1982 and 13 in 1983.

Problem Parameters

Fecal coliform bacteria, nutrients (total phosphorus and nitrite and nitrate-nitrogen) and copper were problem water parameters. Chlordane was elevated in sediments throughout the basin.

Flow

The annual average discarge for the period of record (58 years) is 309 cfs for the Kentucky River at mile point 31.0. Mean discharge for water year 1982 was slightly below the annual average discharge (-20%). During water year 1983, mean discharge was 10% below annual average. The concentration effect of flow reduction during the reporting period was a contributing factor to the observed increases in certain physiochemical parameters.

Biological

Biological collections from the mainstem of the Kentucky began in 1979. The 1983 collections included stations above and below Frankfort, which represents the farthest downstream sampling stations to date.

In past years, the biological collections have indicated the benthic communities to be diverse in structure and composition for the available habitats. The water quality factors that consistently affect those communities are siltation and nutrient enrichments. The 1983 biological collections indicate some improvements in the benthic community structures and species composition.

In spite of siltation and nutrient enrichment to the system, the main stem water quality is considered good.

Hydrologic Unit 05100201 - North Fork Kentucky River

A total of 877 miles of streams draining 1319 square miles comprise this hydrologic unit. Major urban centers include Jackson (pop. 2,651), and Hazard (pop. 5,371). Recreation centers include Carr Fork Lake, Fishpond Lake, and Pan Bowl Lake. One water quality monitoring station is located in this hydrologic unit: North Fork Kentucky River at Jackson.

o pH

For the reporting period pH ranged from a minimum of 7.4 to a maximum of 8.1 with a mean of 7.7 and a median of 7.7. For the period of record (1980-1983) pH ranged from a minimum of 7.0 to a maximum of 8.1 with a mean of 7.6 and a median of 7.7.

o Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1970-1983) alkalinity ranged from a minimum of 24.0 to a maximum of 84.0 with a mean of 55.0 and a median of 53.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 254.0 to a maximum of 782.0 with a mean of 450.0 and a median of 420.0. For the period of record (1970-1983) conductivity ranged from a minimum of 130.0 to a maximum of 782.0 with a mean of 404.0 and a median of 400.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 3.1 to a maximum of 13.0 with a mean of 6.8 and a median of 6.1. For the period of record (1970-1983) chlorides ranged from a minimum of 3.1 to a maximum of 13.0 with a mean of 7.0 and a median of 6.8.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.01 to a maximum of 2.0 with a mean of 0.22 and a median of 0.07. For the period of record (1972-1983) total phosphorus ranged from a minimum of 0.01 to a maximum of 2.0 with a mean of 0.16 and a median of 0.03.

Hydrologic Unit 05100202 - Middle Fork Kentucky River

A total of 228 miles of streams draining 559 square miles comprise this hydrologic unit. The major urban center is Hyden (pop. 488). Recreation centers include Buckhorn Lake. One water quality monitoring station is located in this hydrologic unit: Middle Fork Kentucky River at Tallega.

o pH

For the reporting period pH ranged from a minimum of 6.5 to a maximum of 8.0 with a mean of 7.4 and a median of 7.4. For the period of record (1970-1983) pH ranged from a minimum of 6.5 to a maximum of 8.0 with a mean of 7.4 and a median of 7.4.

o Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1970-1983) alkalinity ranged from a minimum of 15.0 to a maximum of 58.0 with a mean of 33.6 and a median of 30.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 120.0 to a maximum of 259.0 with a mean of 195.0 and a median of 188.0. For the period of record (1970-1983) conductivity ranged from a minimum of 100.0 to a maximum of 400.0 with a mean of 187.9 and a median of 179.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 1.8 to a maximum of 7.7 with a mean of 5.1 and a median of 5.0. For the period of record (1970-1983) chlorides ranged from a minimum of 1.8 to a maximum of 7.7 with a mean of 5.2 and a median of 5.1.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.01 to a maximum of 1.3 with a mean of 0.12 and a median of 0.025. For the period of record (1972-1983) total phosphorus ranged from a minimum of 0.01 to a maximum of 1.3 with a mean of 0.097 and a median of 0.030.

Hydrologic Unit 05100203 - South Fork Kentucky River

A total of 332 miles of streams draining 748 square miles comprise this hydrologic unit. Major urban centers include Manchester (pop. 1,838) and Booneville (pop. 191). Recreation centers include Bert Combs Lake. One water quality monitoring station is located in this hydrologic unit: South Fork Kentucky River at Booneville.

o pH

For the reporting period pH ranged from a minimum of 7.0 to a maximum of 7.6 with a mean of 7.3 and a median of 7.4. For the period of record (1980-1983) pH ranged from a minimum of 7.0 to a maximum of 8.0 with a mean of 7.35 and a median of 7.3.

o Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1966-1983) alkalinity ranged from a minimum of 16.0 to a maximum of 60.0 with a mean of 34.3 and a median of 31.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 139.0 to a maximum of 548.0 with a mean of 258.0 and a median of 205.0. For the period of record (1965-1983) conductivity ranged from a minimum of 76.0 to a maximum of 548.0 with a mean of 226.0 and a median of 200.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 0.6 to a maximum of 45.0 with a mean of 14.2 and a median of 8.2. For the period of record (1965-1983) chlorides ranged from a minimum of 0.6 to a maximum of 45.0 with a mean of 13.7 and a median of 8.3.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.01 to a maximum of 0.32 with a mean of 0.063 and a median of 0.025. For the period of record (1971-1983) total phosphorus ranged from a minimum of 0.01 to a maximum of 0.32 with a mean of 0.069 and a median of 0.030.

Hydrologic Unit 05100204 - Kentucky River from South Fork to Red River

A total of 592 miles of streams draining 1,093 square miles located in this hydrologic unit. Major urban centers include Irvine (pop. 2,889), Stanton (pop. 2,691), and Clay City (pop. 1,276). Recreation centers include Red River Gorge and Natural Bridge State Park. Two water quality monitoring stations are located in this hydrologic unit: Kentucky River at Heidelberg and Red River at Hazel Green.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 5.9 to a maximum of 13.4 with a mean of 9.9 and a median of 10.1.

o pH

For the reporting period pH ranged from a minimum of 6.6 to a maximum of 8.1 with a mean range of 7.1 to 7.4 and a median range of 7.2 to 7.4. For the period of record (1979-1983) pH ranged from a minimum of 6.5 to a maximum of 8.9 with a mean range of 7.2 to 7.4 and a median range of 7.1 to 7.4.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.2 to a maximum of 11.0 with a mean range of 4.5 to 5.4 and a median range of 4.1 to 4.8. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 11.0 with a mean range of 3.7 to 4.8 and a median range of 3.6 to 4.1.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 10.0 to a maximum of 80.8 with a mean range of 32.9 to 47.4 and a median range of 31.6 to 48.2. For the period of record (1979-1983) alkalinity ranged from a minimum of 10.0 to a maximum of 80.8 with a mean range of 31.1 to 44.9 and a median range of 26.0 to 43.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 66.0 to a maximum of 503.0 with a mean range of 111.0 to 290.0 and a median range of 108.0 to 288.0. For the period of record (1979-1983) conductivity ranged from a minimum of 56.0 to a maximum of 737.0 with a mean range of 106.5 to 271.0 and a median range of 96.0 to 268.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 1.3 to a maximum of 19.2 with a mean range of 4.9 to 8.9 and a median range of 5.1 to 8.2. For the period of record (1979-1983) chlorides ranged from a minimum of 0.6 to a maximum of 19.2 with a mean range of 4.3 to 8.2 and a median range of 3.9 to 7.4.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 11.3 to a maximum of 148.0 with a mean range of 15.9 to 74.9 and a median range of 15.0 to 68.9. For the period of record (1979-1983) sulfates ranged from a minimum of 10.0 to a maximum of 148.0 with a mean range of 17.0 to 68.5 and a median range of 14.8 to 64.7.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 0.96 with a mean range of 0.32 to 0.34 and a median range of 0.27 to 0.32. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 0.96 with a mean of 0.31 and a median of 0.31.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.008 to a maximum of 0.204 with a mean range of 0.034 to 0.047 and a median range of 0.026 to 0.030. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.005 to a maximum of 0.564 with a mean range of 0.046 to 0.067 and a median range of 0.029 to 0.035.

o Fecal Coliform

Fecal coliform standards were exceeded 25% of the time during the reporting period. The highest percentage of violations occurred at the Kentucky River at Heidelberg station.

Hydrologic Unit 05100205 - Lower Kentucky River

A total of 1,870 miles of streams draining 3,242 square miles comprise this hydrologic unit. Major urban centers include Lexington (pop. 204,165), Frankfort (pop. 25,973), Richmond (pop. 21,705), and Danville (pop. 12,942). Recreation centers include Herrington Lake and Boonesboro State Park. Five water quality monitoring stations are located in this hydrologic unit: Kentucky River at Camp Nelson, Kentucky River above Frankfort, Kentucky River below Frankfort, Eagle Creek at Glencoe, and South Elkhorn Creek at Weisenberger Mill Pool.

A total of 141 miles have been recommended for stream use designation. The South Elkhorn Creek system encompasses approximately 88 stream miles that have been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation uses. However, 60 miles of this system has impaired water quality, partially supporting designated uses (35 miles) and not supporting designated uses (25 miles). During a one time stream use designation sampling program, violations of Kentucky Surface Water Standards were observed for dissolved oxygen, un-ionized ammonia, total aluminum, total mercury, phthalate esters, and fecal coliform bacteria. In addition elevated levels for cadmium, nitrite + nitrate - nitrogen and total phosphorus were noted.

The Silver Creek basin has 53 miles of streams that have been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation use desginations. Also, two points on small tributary streams have been recommended for domestic water supply use. Violations for Kentucky Surface Water Standards were observed during stream use designation sampling for undissociated hydrogen sulfide, phthalate esters, aluminum, mercury, and fecal coliform bacteria. With the exception of the area around the Berea wastewater treatment plant (5 miles, partial support), the Silver Creek basin is considered to support the recommended designated uses.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 3.4 to a maximum of 18.0 with a mean range of 10.2 to 10.6 and a median range of 10.2 to 10.8.

o pH

For the reporting period pH ranged from a minimum of 6.8 to a maximum of 8.5 with a mean range of 7.4 to 7.6 and a median range of 7.4 to 7.7. For the period of record (1979-1983) pH ranged from a minimum of 6.8 to a maximum of 8.5 with a mean range of 7.5 to 7.8 and a median range of 7.5 to 7.8.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 0.0 to a maximum of 33.8 with a mean range of 5.9 to 10.9 and a median range of 5.0 to 8.2. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 33.8 with a mean range of 5.3 to 21.0 and a median range of 4.2 to 6.4.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 43.7 to a maximum of 208.0 with a mean range of 63.2 to 147.8 and a median range of 66.2 to 150.0. For the period of record (1979-1983) alkalinity ranged from a minimum of 8.4 to a maximum of 262.0 with a mean range of 67.9 to 151.1 and a median range of 69.4 to 150.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 185.0 to a maximum of 830.0 with a mean range of 304.4 to 592.1 and a median range of 283.0 to 570.0. For the period of record (1979-1983) conductivity ranged from a minimum of 172.0 to a maximum of 830.0 with a mean range of 301.4 to 403.5 and a median range of 292.0 to 385.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 3.3 to a maximum of 79.0 with a mean range of 9.8 to 42.0 and a median range of 7.5 to 36.0. For the period of record (1979-1983) chlorides ranged from a minimum of 1.6 to a maximum of 79.0 with a mean range of 8.4 to 20.5 and a median range of 7.4 to 16.9.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 24.9 to a maximum of 95.2 with a mean range of 46.9 to 57.8 and a median range of 42.0 to 47.0. For the period of record (1979-1983) sulfates ranged from a minimum of 20.5 to a maximum of 180.0 with a mean range of 43.1 to 58.1 and a median range of 39.0 to 48.2.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 3.55 with a mean range of 0.49 to 0.95 and a median range of 0.49 to 0.80. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.005 to a maximum of 3.55 with a mean range of 0.428 to 0.766 and a median range of 0.27 to 0.67.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.014 to a maximum of 3.9 with a mean range of 0.101 to 1.76 and a median range of 0.067 to 1.4. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.014 to a maximum of 0.69 with a mean range of 0.106 to 0.137 and a median range of 0.088 to 0.133.

o Fecal Coliform

Fecal coliform standards were exceeded 18% of the time during the reporting period. The highest percentage of violations occurred at the Kentucky River above Frankfort station.

o Biological

The Kentucky River above Frankfort station was characterized by moderate to dense growths of filamentous green and blue-green algae, as well as centric and pennate diatoms. Periphyton chlorophyll a values were below average (11.1 mg/m^2, Range 7.0-16.6) while AFDW values were average (3.87 g/m^2, Range 2.38-5.21). Plankton chlorophyll a values were below average (7.0 ug/l). A total of 125 algal species were identified from natural substrate collections. The plankton diatom community was dominated by centric diatoms characteristic of eutrophic reservoirs while the benthic diatom community consisted of pennate diatoms associated with nutrient enrichment as well as typical stream taxa.

The Kentucky River below Frankfort station was very similar to the upstream site. The algal community was characterized by moderate to dense growths of filamentous green and blue-green algae, as well as centric and pennate diatoms. Periphyton chlorophyll a values were below average (10.0 mg/m^2, Range (4.9-17.2)) while AFDW values were slightly above average (4.25 g/m^2, Range (3.00-5.59)). Plankton chlorophyll a values were above average (42.3 ug/l). The elevated plankton value may be attributable to the influence of the Frankfort WWTP, located approximately 10 miles upstream. A total of 104 algal species were identified from natural substrate collections. Diatom community structure was similar to the usptream site.

The invertebrate collections from the Kentucky River below Frankfort station were very similar to the upstream site. Species composition and functional groupings were practically identical except for a rare caddisfly, *Orotrichia*, which was also collected from the Heidelberg site (PRI 026) in previous years. The influences of nutrients, organic wastes and siltation in this stream system are difficult to detect, because the invertebrate collections contained only the functional types associated with the kinds of habitats that are present. Partitioning of those habitats is maximal which indicates water quality does not adversely affect the benthic communities occurring there. It is the lack of habitats that limits the diversity of organisms in this stream system.

The invertebrates collected from the Kentucky River above Frankfort station represented a 2 year period. The collections in both years were dominated by the caddisfly, *Cyrnellus fraternus*, an organism quite common to large rivers with sluggish to moderate flows. Those stream characteristics are also associated with the remaining members of the community. Several species are also associated with increased nutrients because of food source requirements (algae). In general, the community collected at this site is typical for streams of this magnitude.

No F.D.A. action levels were exceeded in fish tissue at these stations in 1982 or 1983.

UPPER CUMBERLAND RIVER BASIN

The Upper Cumberland River basin is located in southeastern Kentucky in the Appalachian Plateaus and Interior Low Plateaus Provinces, with the headwaters draining slopes of the Cumberland Mountains and the Pine Mountain overthrust. The river drains Pennsylvanian sandstone in the Appalachian Plateaus and Mississippian limestone deposits in the Interior Low Plateaus. The mainstem of the river is formed at the junction of Clover Fork, Martins Fork, and Poor Fork at Harlan, Kentucky. Flowing in a generally westward direction, the river cuts across the Cumberland Plateau and Pottsville Escarpment to enter the Interior Low Plateaus Province before turning south to enter Tennessee. There are four major impoundments in the basin; Cumberland, Dale Hollow, Laurel River and Martins Fork reservoirs. There are 2,161 miles of stream in the basin depicted on the USGS hydrologic unit map. Total drainage area in Kentucky is 5,077 square miles. Principal tributaries are the Big South Fork of the Cumberland River with a drainage area of 1382 square miles and the Rockcastle River with a drainage area of 763 square miles. Other major tributaries include Clear Fork, Buck Creek, and the Laurel River.

Topography of the basin varies greatly. The eastern portion lies in the steep, rugged terrain of the Cumberland Mountains. The central portion lies in the Cumberland Plateau region which is characterized by steep undulating to rolling land. The northwestern tip of the basin is located in the Knobs region, an area of large hills with steep slopes. Extreme western portions of the basin are within the Pottsville Escarpment and the eastern subsection of the Highland Rim, which are generally upland plains with low relief and karst topography.

Average slope of the streams throughout the basin is 14 feet/mile with the main stem above Lake Cumberland averaging approximately 7 feet/mile.

Impacts

The Upper Cumberland River basin has been impacted by a variety of man's activities. The Cumberland Plateau portion of the basin has been heavily impacted by both deep and surface coal mining operations. Localized acid mine drainage, generally attributed to deep mining practices, has diminished in recent years due to an increase in surface mining. Acid mine drainage is now most prominent in portions of the Big South Fork of the Cumberland River.

Oil and natural gas drilling has occurred in the Big South Fork drainage since the late 1800's. In recent years, these operations have increased substantially in the Big South Fork subbasin and adjacent areas, resulting in an increase in brine impacts.

Impacts resulting from agricultural operations are limited on the Cumberland Plateaus, due to the lack of suitable land, but increase substantially as the river flows westward through the Interior Low Plateaus. Localized silvicultural operations are scattered through the basin, but are most abundant on the Cumberland Plateaus in and adjacent to the Daniel Boone National Forest. Silvicultural operations are also common in association with surface coal mining.

Domestic sewage pollution originates from small municipalities throughout the basin. These towns usually discharge treated effluents to small tributary streams that have low flows approaching zero. Generally, these streams are incapable of properly assimulating waste loads without a degradation of water quality. A notable example of this is Yellow Creek, which flows through Middlesboro. This small stream is heavily impacted by a tannery and a municipal wastewater treatment plant, in addition to siltation from coal mining operations.

Coal mining operations, oil and gas drilling, and municipal effluent discharges have impacted the aquatic biota throughout a major portion of the drainage. However, in some areas the aquatic life is quite diverse. A number of endangered species of fish and freshwater mussels are found in the basin. Four fish kills were reported from the basin in each of the reporting years (1982 and 1983). There are four ambient monitoring stations in the basin.

Problem Parameters

Fecal coliform bacteria and suspended solids were the major problem parameters in this basin. Copper and iron were also elevated. Chlordane was elevated in sediments at all sites.

Flow

The annual average discharge for the period of record (4 years) is 9,155 cfs for the Upper Cumberland at mile point 459.4. Mean discharge for water year 1982 was slightly above the annual average discharge (+1%). During water year 1983, mean discharge was 16% above annual average.

Hydrologic Unit 05130101 - Upper Cumberland River above Rockcastle River

A total of 955 miles of streams draining 1,999 square miles in Kentucky comprise this hydrologic unit. Major urban centers include Harlan (pop. 3,024), Pineville (pop. 2,599), London (pop. 4,002), Corbin (pop. 8,075), Williamsburg (pop. 5,560), and Middlesboro (pop. 12,251). Recreation centers include Laurel Reservoir, Levi Jackson State Park, Pine Mountain State Park, Cumberland Gap National Park, Martins Fork Reservoir, Kingdom Come State Park, and Cumberland Falls State Park. Two water quality monitoring stations are located in this hydrologic unit: Cumberland River at Pineville and Cumberland River at the Falls.

One hundred twelve miles have been recommended for stream use designations. Poor Fork of the Cumberland River and its tributaries from mile point 694.2 to its origin have been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation uses. Bad Branch, a stream not listed on the hydrologic unit map, has been recommended for Aquatic Life/Coldwater Aquatic Habitat use since it supports a reproducing trout fishery. The cities of Cumberland (RMI 719.57) and Harlan (RMI 694.36) withdraw drinking water from the Poor Fork and those points of withdrawal have been recommended for Domestic Water Supply. Violations of Kentucky Surface Water Standards for undissociated hydrogen sulfide, phthalate esters, mercury, aluminum and fecal coliform bacteria were observed during a stream designation study. Extensive coal mine operations occur throughout most of this watershed and municipal waste discharges from the aforementioned cities have impaired water quality and/or destroyed or reduced aquatic habitat throughout most of the drainage. For this reason, this stream reach is considered to partially support the recommended stream uses.

The Yellow Creek drainage in the vicinity of Middlesboro, Kentucky has been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact uses. The Yellow Creek drainage contains 46 stream miles. Also, Fern and Cannon Creek lakes (not listed on the hydrologic unit map) have been recommended for designation as Domestic Water Supply use. Two additional streams not listed on the hydrologic unit map, Shillalah Creek and Sugar Run, support a wild trout fishery and are recommended for Aquatic Life/Coldwater Aquatic Habitat use. A stream use designation study and historical data indicate that Kentucky Surface Water Standards for fecal coliform bacteria, phthalate esters, aluminum, mercury, iron, dissolved oxygen, pH and chromium have been violated. Extensive coal mining has occurred

throughout the drainage, degrading essential aquatic habitats. The city of Middlesboro has discharged municipal waste effluent of poor quality for years, which has resulted in eliminating or reducing aquatic life in the lower 15 miles of Yellow Creek. For these reasons, Yellow Creek is considered to be impaired and does not support the recommended designated uses.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 5.2 to a maximum of 15.8 with a mean range of 9.2 to 9.3 and a median range of 8.4 to 9.2.

o pH

For the reporting period pH ranged from a minimum of 6.7 to a maximum of 8.3 with a mean range of 7.3 to 7.4 and a median range of 7.3 to 7.4. For the period of record (1979-1983) pH ranged from a minimum of 6.7 to a maximum of 8.8 with a mean range of 7.4 to 7.6 and a median range of 7.4 to 7.5.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.2 to a maximum of 30.8 with a mean range of 6.8 to 8.3 and a median range of 3.8 to 5.3. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 33.6 with a mean range of 5.3 to 6.2 and a median range of 4.0 to 4.6.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 21.0 to a maximum of 162.0 with a mean range of 54.0 to 68.4 and a median range of 46.4 to 57.6. For the period of record (1979-1983) alkalinity ranged from a minimum of 21.0 to a maximum of 207.0 with a mean range of 54.3 to 75.9 and a median range of 50.0 to 67.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 161.0 to a maximum of 732.0 with a mean range of 278.0 to 325.0 and a median range of 242.0 to 271.0. For the period of record (1979-1983) conductivity ranged from a minimum of 104.0 to a maximum of 732.0 with a mean range of 273.8 to 336.3 and a median range of 254.0 to 294.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 1.2 to a maximum of 24.2 with a mean range of 6.7 to 7.0 and a median range of 5.3 to 5.4. For the period of record (1979-1983) chlorides ranged from a minimum of 1.2 to a maximum of 38.6 with a mean range of 6.5 to 7.7 and a median range of 5.1 to 5.8.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 37.3 to a maximum of 179.0 with a mean range of 72.5 to 77.3 and a median range of 59.3 to 61.9. For the period of record (1979-1983) sulfates ranged from a minimum of 25.0 to a maximum of 179.0 with a mean range of 66.9 to 78.3 and a median range of 62.0 to 73.0.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 1.17 with a mean range of 0.32 to 0.462 and a median range of 0.350 to 0.440. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 1.3 with a mean range of 0.33 to 0.43 and a median range of 0.35 to 0.43.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.020 to a maximum of 0.355 with a mean range of 0.068 to 0.091 and a median range of 0.091 to 0.075. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.005 to a maximum of 0.42 with a mean range of 0.073 to 0.091 and a median range of 0.046 to 0.070.

o Fecal Coliform

Fecal coliform standards were exceeded 69% of the time during the reporting period. The highest percentage of violations occurred at the Cumberland River at Pineville station.

Hydrologic Unit 05130102 - Rockcastle River

A total of 399 miles of streams draining 763 square miles comprise this hydrologic unit. Major urban centers include Mt. Vernon (pop. 2,334), McKee (pop. 759), and Livingston (pop. 334). Recreation centers include Woods Creek Lake and Lake Linville. One water quality monitoring station is located in this hydrologic unit: Rockcastle River at Billows.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 5.5 to a maximum of 12.4 with a mean of 8.6 and a median of 8.3.

o pH

For the reporting period pH ranged from a minimum of 6.6 to a maximum of 8.9 with a mean of 7.4 and a median of 7.4. For the period of record (1979-1983) pH ranged from a minimum of 6.6 to a maximum of 8.9 with a mean of 7.5 and a median of 7.5.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.5 to a maximum of 33.2 with a mean of 6.5 and a median of 5.0. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 33.2 with a mean of 5.3 and a median of 4.0.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 33.2 to a maximum of 94.0 with a mean of 57.3 and a median of 49.9. For the period of record (1979-1983) alkalinity ranged from a minimum of 33.2 to a maximum of 95.6 with a mean of 57.8 and a median of 58.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 107.0 to a maximum of 562.0 with a mean of 204.6 and a median of 177.0. For the period of record (1979-1983) conductivity ranged from a minimum of 107.0 to a maximum of 562.0 with a mean of 194.3 and a median of 175.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 2.9 to a maximum of 7.3 with a mean of 4.4 and a median of 4.4. For the period of record (1979-1983) chlorides ranged from a minimum of 1.4 to a maximum of 13.4 with a mean of 4.5 and a median of 3.8.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 14.7 to a maximum of 44.6 with a mean of 28.4 and a median of 29.0. For the period of record (1979-1983) sulfates ranged from a minimum of 14.0 to a maximum of 134.0 with a mean of 29.4 and a median of 27.5.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.105 to a maximum of 0.750 with a mean of 0.390 and a median of 0.420. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.05 to a maximum of 0.82 with a mean of 0.369 and a median of 0.345.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.013 to a maximum of 0.183 with a mean of 0.044 and a median of 0.032. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.005 to a maximum of 0.26 with a mean of 0.036 and a median of 0.023.

o Fecal Coliform

Fecal coliform standards were exceeded 4% of the time during the reporting period.

o Biological

The invertebrate collections from the Rockcastle River station expressed considerable diversity in feeding types and species composition. The available habitats for invertebrates are exceptional, both in abundance and types. There are no obvious influences upon the benthic community in relation to water quality. Siltation and nutrient enrichments are not detectable. This site also supports a diverse freshwater mussel fauna that includes 18 species collected to date.

No F.D.A. action levels were exceeded in fish tissue at this station in 1982 or 1983.

Hydrologic Unit 05130103 - Cumberland River below Rockcastle River

A total of 589 miles of streams draining 1,753 square miles comprise this hydrologic unit. Major urban centers include Monticello (pop. 5,677), Jamestown (pop. 1,441), Somerset (pop. 10,641), Burkesville (pop. 2,051), and Russell Springs (pop. 1,831).

Recreation centers include Lake Cumberland. One water quality monitoring station is located in this hydrologic unit: Cumberland River at Burkesville.

A total of 25.5 miles encompassing the Beaver Creek drainage near Monticello, Kentucky have been recommended for stream use designations. The entire Beaver Creek system has been recommended for Primary and Secondary Contact Recreation use. Approximately 5 miles of Beaver Creek supports a put and take trout fishery, therefore, it is recommended for Aquatic Life/Coldwater Aquatic Habitat use. The remainder of the drainage is recommended for Aquatic Life/Warmwater Aquatic Habitat use. A stream use designation study on the Beaver Creek system revealed Kentucky Surface Water Standard violations for free cyanide, phthalate esters, aluminum, iron and mercury. The Beaver Creek system has excellent habitat diversity and support a speciose aquatic flora and fauna. Except for a one mile reach of Elk Creek below the Monticello wastewater treatment plant, the entire drainage is considered to support the recommended designations. This one mile reach partially supports the recommended designated use.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 6.4 to a maximum of 12.4 with a mean of 9.7 and a median of 10.2.

o pH

For the reporting period pH ranged from a minimum of 7.0 to a maximum of 8.0 with a mean of 7.4 and a median of 7.4. For the period of record (1979-1983) pH ranged from a minimum of 6.5 to a maximum of 8.0 with a mean of 7.4 and a median of 7.4.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.0 to a maximum of 12.5 with a mean of 5.2 and a median of 4.2. For the period of record (1979-1983) acidity ranged from a minimum of 1.0 to a maximum of 35.0 with a mean of 6.7 and a median of 4.0.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 29.5 to a maximum of 363.0 with a mean of 60.2 and a median of 45.6. For the period of record (1979-1983) alkalinity ranged from a minimum of 29.5 to a maximum of 363.0 with a mean of 55.3 and a median of 49.6.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 139.0 to a maximum of 198.0 with a mean of 170.9 and a median of 166.0. For the period of record (1979-1983) conductivity ranged from a minimum of 100.0 to a maximum of 198.0 with a mean of 163.9 and a median of 165.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 1.1 to a maximum of 9.1 with a mean of 4.05 and a median of 4.1. For the period of record (1979-1983) chlorides ranged from a minimum of 1.1 to a maximum of 9.1 with a mean of 3.8 and a median of 3.6.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 13.8 to a maximum of 38.6 with a mean of 29.5 and a median of 30.1. For the period of record (1979-1983) sulfates ranged from a minimum of 11.0 to a maximum of 38.6 with a mean of 28.5 and a median of 29.9.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.225 to a maximum of 0.565 with a mean of 0.418 and a median of 0.420. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.225 to a maximum of 0.600 with a mean of 0.405 and a median of 0.400.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.006 to a maximum of 0.042 with a mean of .014 and a median of 0.012. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.005 to a maximum of 0.150 mg/l with a mean of 0.016 and a median of 0.012.

o Fecal Coliform

Fecal coliform standards were exceeded 17% of the time during the reporting period.

Hydrologic Unit 05130104 - South Fork Cumberland River

A total of 193 miles of streams draining 404 square miles comprise this hydrologic unit. The major urban center is Whitley City. Recreation centers include Big South Fork Wild River and Rock Creek Gorge. One water quality monitoring station is located in this hydrologic unit: South Fork Cumberland River at Yamacraw.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 5.2 to a maximum of 15.2 with a mean of 8.9 and a median of 9.1.

o pH

For the reporting period pH ranged from a minimum of 6.4 to a maximum of 7.7 with a mean of 7.0 and a median of 6.9. For the period of record (1979-1983) pH ranged from a minimum of 6.4 to a maximum of 8.7 with a mean of 7.0 and a median of 7.0.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.6 to a maximum of 27.3 with a mean of 5.4 and a median of 4.0. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 27.3 with a mean of 4.0 and a median of 3.2.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 9.0 to a maximum of 60.4 with a mean of 22.5 and a median of 19.3. For the period of record (1979-1983) alkalinity ranged from a minimum of 9.0 to a maximum of 60.4 with a mean of 22.3 and a median of 20.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 87.0 to a maximum of 356.0 with a mean of 172.0 and a median of 132.0. For the period of record (1979-1983) conductivity ranged from a minimum of 79.0 to a maximum of 356.0 with a mean of 164.9 and a median of 141.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 2.6 to a maximum of 34.4 with a mean of 6.8 and a median of 4.3. For the period of record (1979-1983) chlorides ranged from a minimum of 1.2 to a maximum of 34.4 with a mean of 5.3 and a median of 3.9.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 21.8 to a maximum of 97.7 with a mean of 47.0 and a median of 33.5. For the period of record (1979-1983) sulfates ranged from a minimum of 19.3 to a maximum of 102.0 with a mean of 47.5 and a median of 38.1.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.015 to a maximum of 0.32 with a mean of 0.174 and a median of 0.180. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.015 to a maximum of 0.425 with a mean of 0.176 and a median of 0.190.

o Total phosphorus

For the reporting period total phosphorus ranged from a minimum of 0.009 to a maximum of 0.078 with a mean of 0.036 and a median of 0.028. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.004 to a maximum of 0.235 with a mean of 0.038 and a median of 0.026.

o Fecal Coliform

Fecal coliform standards were exceeded 8% of the time during the reporting period.

Hydrologic Unit 05130105 - Dale Hollow Lake Tributaries

A total of 27 miles of streams draining 119 square miles comprise this hydrologic unit. The major urban center is Albany (pop. 2,083). Recreation centers include Dale Hollow Lake. There are no water quality monitoring stations in this unit.

SALT RIVER BASIN

The Salt River basin is the most centrally located basin in Kentucky. The main stem of the Salt River originates in central Boyle County, Kentucky, and flows northward for 30 miles to the vicinity of Lawrenceburg. From there, the river flows in a westerly direction about 95 miles to its confluence with the Ohio River at West Point, Kentucky (Ohio River mile point 351). Principal tributaries are Rolling Fork, Floyds Fork, Beech Fork, and Brashears Creek. There are 1,552 miles of streams in the basin depicted on the USGS hydrologic unit map. Total drainage area is 2,929 square miles.

The Salt River basin lies primarily within the Blue Grass section of the Interior Low Plateaus Province, with a small portion occurring in the Highland Rim section. The stream drains mainly Ordovician age limestone. Basin topography varies from irregular, steep-sided hills with V-shaped valleys to gently rolling hills with broad floodplains.

Average slope of the main stem of Salt River is 5.0 feet/mile, while Rolling Fork averages 6.0 feet/mile, Beech Fork averages 4.0 feet/mile, Brashears Creek averages 6.0 feet/mile, and Floyds Fork averages 7.0 feet/mile.

Impacts

Major impacts upon the Salt River are agricultural runoff, including fertilizer and pesticides, and domestic sewage. This has led to high nutrient loads in some areas. If planned oil shale operations in the Knobs area become reality, segments of the Salt River drainage could be impacted.

Many portions of the Salt River drainage support a diverse assemblage of aquatic organisms. Four fish kills were reported in 1982 and four in 1983.

Problem Parameters

Problem parameters include suspended solids, total phosphorus, fecal coliform bacteria, copper and zinc. Arsenic and chlordane were elevated in sediments.

Flow

The annual average discharge for the period of record (45 years) is 1572 cfs for the Salt River at mile point 22.9. Mean discharge for water year 1982 was below the annual average discharge (-29%). During water year 1983, mean discharge was 3% below annual average. The concentration effect of flow reduction during the reporting period was a contributing factor to observe increases in certain physicochemical parameters.

Biological

The 1983 biological collections from the Salt River station showed an appreciable increase in macroinvertebrate species diversity, periphyton, chlorophyll a and algal abundance.

In the years since 1979, the biological collections have reflected with considerable accuracy the physical characteristics of that stream, notably, turbidity from siltation and nutrient enrichment. The newly constructed Taylorsville Lake, upstream of the sampling site, and low flow conditions most likely have reduced those values enough to explain the increases in the 1983 collections. Water quality in this stream from the Taylorsville Dam downstream to the Ohio River is considered to be fair.

Hydrologic Unit 05140102 - Salt River/Floyds Fork

A total of 776 miles of streams draining 1471 square miles comprise this hydrologic unit. Major urban centers include Shelbyville (pop. 5,329), Shepherdsville (pop. 4,454), Fort Knox Military Reservation, Radcliff (pop. 14,519), Okolona, as well as urban areas of southern and eastern Jefferson County. Recreation centers include Taylorsville Lake, Guist Creek Lake, and McNeely Lake. Four water quality monitoring stations are located in this hydrologic unit: Salt River at Shepherdsville, Pond Creek at Manslick Road, Floyds Fork near Crestwood, Floyds Fork at Fisherville.

The Floyds Fork drainage, encompassing approximately 192 stream miles, has been recommended for designation as Aquatic Life/Warmwater Aquatic Habitat use. All of the stream miles have also been recommended for Primary and Secondary Contact Recreation use. The major impact to the Floyds Fork drainage is wastewater treatment plant effluent. Violations for Kentucky Surface Water Standards were observed for mercury, aluminum, phthalate esters, cadmium, dissolved oxygen, undissociated hydrogen sulfide, iron, pH and fecal coliform bacteria. Therefore, the Floyds Fork drainage is considered to partially support the recommended uses.

An additional 24 stream miles (Mill Creek drainage) on the Fort Knox Military Reservation has been recommended to be designated for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation uses. The major impacts to this stream are municipal waste from the city of Radcliff, Kentucky and Fort Knox and siltation arising from military activities in the watershed. Violations of Kentucky Surface Water Standards for cyanide, undissociated hydrogen sulfide, phthalate esters, unionized ammonia, and aluminum were observed during a stream use designation study. The Mill Creek system supports the recommended uses in the upper 12 miles but the remaining 12 miles only partially support the recommended uses.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 3.2 to a maximum of 13.4 with a mean range of 8.2 to 9.9 and a median range of 8.9 to 9.0.

o pH

For the reporting period pH ranged from a minimum of 7.0 to a maximum of 8.3 with a mean range of 7.5 to 7.9 and a median range of 7.5 to 7.9. For the period of record (1979-1983) pH ranged from a minimum of 6.6 to a maximum of 9.0 with a mean range of 7.5 to 7.9 and a median range of 7.5 to 7.9.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 0.0 to a maximum of 49.0 with a mean range of 12.4 to 14.0 and a median range of 8.8 to 11.8. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 49.0 with a mean range of 8.7 to 10.4 and a median range of 7.6 to 9.2.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 56.0 to a maximum of 213.0 with a mean range of 134.1. to 155.0 and a median range of 132.0 to 148.0. For the period of record (1979-1983) alkalinity ranged from a minimum of 8.4 to a maximum of 336.0 with a mean range of 130.1 to 200.0 and a median range of 132.0 to 220.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 170.0 to a maximum of 713.0 with a mean range of 394.5 to 589.6 and a median range of 371.0 to 593.0. For the period of record (1979-1983) conductivity ranged from a minimum of 170.0 to a maximum of 723.0 with a mean range of 413.8 to 565.2 and a median range of 430.0 to 575.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 4.0 to a maximum of 77.0 with a mean range of 7.8 to 42.5 and a median range of 8.1 to 43.7. For the period of record (1979-1983) chlorides ranged from a minimum of 4.0 to a maximum of 77.0 with a mean range of 8.2 to 39.6 and a median range of 8.0 to 38.6.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 16.3 to a maximum of 113.0 with a mean range of 42.5 to 88.9 and a median range of 43.0 to 92.0. For the period of record (1979-1983) sulfates ranged from a minimum of 3.5 to a maximum of 156.6 with a mean range of 39.5 to 87.0 and a median range of 38.2 to 87.5.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.04 to a maximum of 6.5 with a mean range of 1.9 to 2.6 and a median range of 2.28 to 2.43. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.04 to a maximum of 6.5 with a mean range of 0.94 to 2.45 and a median range of 0.79 to 2.2.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.022 to a maximum of 3.25 with a mean range of 0.103 to 1.58 and a median range of 0.06 to 1.48. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.02 to a maximum of 3.25 with a mean range of 0.146 to 1.47 and a median range of 0.10 to 1.48.

o Fecal Coliform

Fecal coliform standards were exceeded 59% of the time during the reporting period. The highest percentage of violations occurred at the Pond Creek at Manslick Road station.

Biological

The Salt River at Shepherdsville station was characterized by dense growths of filamentous green and blue-green algae as well as euglenoid algae and centric diatoms. A visible plankton bloom (chlorophyll a = 35.7 ug/l) was noted during July, 1983, consisting of Anacystis cyanea, a blue-green algae, and centric diatoms. Periphyton chlorophyll a values were above average (39.2 mg/m^2, Range (20.1-72.8) while AFDW values were near average (3.97 g/m^2, Range (2.00-6.47). A total of 181 algal species were identified from natural substrates. The abundance of planktonic species partially accounted for the above average number of taxa observed here. The diatom community was dominated by centric diatoms and eutrophic pennate diatom species. While the community was more speciose than usual in 1983, the community structure was similar to that observed since 1979. Algal abundance (biomass and standing crop) was greater

in 1983 than in previous years due to lower flow in addition to the presence of Taylorsville Lake (located 35 miles upstream). The Taylorsville Dam may be allowing suspended sediment to settle out of the water column, resulting in less turibidity at this site. Increased light penetration here may explain the enhanced algal productivity.

The invertebrate collections from this station reflect with considerable accuracy the physical characteristics of the stream. The organisms collected here are routinely associated with sluggish streams that maintain elevated nutrients and heavy silt loading during most of the year. The 1983 invertebrate collections were more diverse in species composition and community structure than previous years. Water quality is considered to be fair at this location.

No F.D.A. action levels were exceeded in fish tissue at this station in 1982 or 1983.

Hydrologic Unit 05140103 - Rolling Fork/Beech Fork/Chaplin River

A total of 776 miles of streams draining 1449 square miles comprise this hydrologic unit. Major urban centers include Bardstown (pop. 6,155), Springfield (pop. 3,179), and lebanon (pop. 6,590). Recreation centers include Beaver Creek Lake and Willisburg Lake. Two water quality monitoring stations are located in this hydrologic unit: Beech Fork at Maud and Rolling Fork near Lebanon Junction.

o pH

For the reporting period pH ranged from a minimum of 7.4 to a maximum of 8.1 with a mean range of 7.7 to 7.8 and a median range of 7.8 to 7.9. For the period of record (1980-1983) pH ranged from a minimum of 7.3 to a maximum of 8.1 with a mean range of 7.7 to 7.8 and a median range of 7.8 to 7.8.

o Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1973-1983) alkalinity ranged from a minimum of 48.0 to a maximum of 200.0 with a mean range of 128.6 to 141.1 and a median range of 120.0 to 150.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 185.0 to a maximum of 531.0 with a mean range of 333.7 to 398.4 and a median range of 280.0 to 390.0. For the period of record (1973-1983) conductivity ranged from a minimum of 58.0 to a maximum of 540.0 with a mean range of 347.0 to 357.0 and a median range of 335.0 to 350.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 2.1 to a maximum of 15.0 with a mean range of 4.7 to 7.8 and a median range of 4.5 to 5.0. For the period of record (1973-1983) chlorides ranged from a minimum of 0.6 to a maximum of 19.0 with a mean range of 4.9 to 6.0 and a median range of 4.7 to 5.4.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N was not measured. For the period of record (1974-1981) NO_2-NO_3-N ranged from a minimum of 0.09 to a maximum of 1.5 with a mean of 0.64 and a median of 0.62.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.08 to a maximum of 0.72 with a mean range of 0.144 to 0.358 and a median range of 0.13 to 0.29. For the period of record (1973-1983) total phosphorus ranged from a minimum of 0.04 to a maximum of 0.87 with a mean range of 0.19 to 0.24 and a median range of 0.15 to 0.19.

GREEN RIVER BASIN

The Green River basin has the largest surface drainage area of the river basins in the Commonwealth of Kentucky. Flowing approximately 330 miles in a northwesterly direction from its headwaters to its confluence with the Ohio River (mile point 636.4) above Henderson, Kentucky, the river drains an area of 8,821 square miles of west-central Kentucky and 408 square miles in north-central Tennessee. Principal tributaries include the Nolin, Barren, Mud, Rough and Pond rivers. There are 3,602 miles of stream in the basin depicted on the USGS hydrologic unit map. Major impoundments of this basin include Nolin, Barren, Rough and Green River reservoirs.

The Green River basin lies in the Interior Low Plateaus Province. The major section within this physiographic region is the Highland Rim or Pennyroyal. This area is generally a plateau of low relief, crossed by deeply entrenched streams and includes high, somewhat isolated, hills or outliers of rocks of adjoinging sections or provinces. Karst topography and cavern networks are a common characteristic of the section, although normal surface drainage is predominant for most of the area. The Highland Rim is underlain by Mississippian limestone. The remainder of the basin lies in the Shawnee Hills or western Kentucky coalfield and is underlain by strata of Pennsylvanian age. This section can be generally characterized as an area with hills and ridges on an upland terrain with expansive, nearly flat floodplains occurring along the lower Green River and its main tributaries.

The main stem of the Green River flows into the Ohio River at 338 feet above mean sea level (m.s.l.) and is controlled by a series of six locks and dams for navigational purposes. Upstream of these structures the river arises at an average slope of 1.6 feet/mile, with tributaries having averages ranging from 0.8 feet/mile to 7.7 feet/mile and having a maximum elevation of 1,040 feet above m.s.l.

Impacts

Since a large portion of the Green River lies in the western Kentucky coalfield, silt and acid from coal mining operations are the major impacts. These impacts can be locally heavy, rendering some streams severly degraded. Agricultural runoff, including livestock feeding operations, contribute nutrient loading to some streams. Brine from oil drilling has caused increased chloride levels in portions of the river for many years.

The aquatic biota of the coalfields has been degraded by siltation and acid mine drainage. Brines have also impacted the aquatic biota of the oil and gas regions of the basin. However, many subbasins of the drainage support a diverse assemblage of aquatic organisms. Two fish kills were reported in 1982 and five in 1983. There are 10 ambient monitoring stations in the basin.

Problem Parameters

Nitrite and nitrate-nitrogen and copper were elevated throughout the basin. Sediments showed high levels of chlordane.

Flow

The annual average discharge for the period of record (53 years) is 11,220 cfs for the Green River at mile point 63.4. Mean discharge for water year 1982 was slightly above (+2%) the annual average discharge. During water year 1983, mean discharge was 26% above annual average.

Hydrologic Unit 05110001 - Upper Green River and Nolin River

A total of 1,331 miles of streams draining 3,140 square miles comprise this hydrologic unit. Major urban centers include Campbellsville (pop. 8,715), and Columbia (pop. 3,710). Recreation centers include Green River Lake, Nolin Lake and Mammoth Cave National Park. Four water quality monitoring stations are located in this hydrologic unit: two on Green River, one on Nolin River and one on Bacon Creek.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 6.4 to a maximum of 14.0 with a mean range of 9.3 to 9.8 and a median range of 9.4 to 9.8.

o pH

For the reporting period pH ranged from a minimum of 6.8 to a maximum of 8.2 with a mean range of 7.5 to 7.7 and a median range of 7.5 to 7.7. For the period of record (1979-1983) pH ranged from a minimum of 6.7 to a maximum of 9.2 with a mean range of 7.5 to 7.7 and a median range of 7.5 to 7.8.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.7 to a maximum of 58.2 with a mean range of 5.8 to 13.7 and a median range of 4.4 to 10.0. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 58.2 with a mean range of 7.0 to 11.0 and a median range of 4.2 to 9.4.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 26.2 to a maximum of 188.0 with a mean range of 54.6 to 167.4 and a median range of 50.8 to 169.0. For the period of record (1979-1983) alkalinity ranged from a minimum of 25.2 to a maximum of 207.6 with a mean range of 58.9 to 162.7 and a median range of 54.5 to 169.0.

o Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 109 to a maximum of 609 with a mean range of 162.2 to 345.2 and a median range of 138.0 to 353.0. For the period of record (1979-1983) conductivity ranged from a minimum of 6.6 to a maximum of 750.0 with a mean range of 156.5 to 341.9 and a median range of 142.0 to 338.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 2.4 to a maximum of 57.4 with a mean range of 4.0 to 21.5 and a median range of 3.7 to 17.6. For the period of record (1979-1983) chlorides ranged from a minimum of 0.9 to a maximum of 57.4 with a mean range of 3.9 to 19.1 and a median range of 3.7 to 15.9.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 2.0 to a maximum of 60.3 with a mean range of 4.8 to 12.0 and a median range of 4.5 to 12.6. For the period of record (1979-1983) sulfates ranged from a minimum of 2.0 to a maximum of 70.5 with a mean range of 7.7 to 14.9 and a median range of 6.0 to 13.1.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.055 to a maximum of 14.7 with a mean range of 0.628 to 3.05 and a median range of 0.56 to 2.68. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.05 to a maximum of 14.7 with a mean range of 0.63 to 2.6 and a median range of 0.55 to 2.4.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.004 to a maximum of 1.33 with a mean range of 0.031 to 0.12 and a median range of 0.024 to 0.11. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.004 to a maximum of 1.33 with a mean range of 0.03 to 0.12 and a median range of 0.025 to 0.12.

o Fecal Coliform

Fecal coliform standards were exceeded 21% of the time during the reporting period. The highest percentage of violations occurred at the Bacon Creek station.

o Biological

The Green River at Munfordville station was characterized by moderate growths of filamentous green, blue-green, and red algae, as well as pennate diatoms. Periphyton chlorophyll a values were above average (26.0 mg/m^2, Range (18.0-31.4)) as were AFDW values (5.81 g/m^2, Range 3.88-9.71). Plankton chlorophyll a values were below average (6.5 ug/l) but are typical for streams. Benthic algal growths here are most likely enhanced by nutrient enrichment from agricultural activities as well as the relative lack of turbidity. A total of 141 algal species were identified from natural substrate collections. The diatom community was dominated by typical stream species as well as those characteristic of nutrient enrichment. The Green River appears to be a productive stream of good water quality.

The 1982-83 invertebrate collections from the Green River at Munfordville represented extremes in stream flow regimes. The 1982 collections were largely influenced by high water conditions. The 1983 collections represented an extended drought period. The invertebrate community structures and species composition reflected those extreme conditions with considerable accuracy in relation to the habitats and functional capacities of the affected organisms. Since the 1983 collections represented a threefold increase in the number of species (9 to 30), it is assumed that high water conditions during 1982 influenced those collections. The 1983 collections reflected considerable habitat partitioning and species diversity within most of the functional groups. Based on those observations, the water quality appears to be adequate and does not limit the benthic community.

No F.D.A. action levels were exceeded in fish tissue at this station in 1982 or 1983.

Hydrologic Unit 05110002 - Barren River

A total of 630 miles of streams draining 2264 square miles comprise this hydrologic unit. Major urban centers include Bowling Green (pop. 40,450) and Glasgow (pop. 12,958). Recreation center includes Barren River Reservoir. One water quality monitoring station is located in this hydrologic unit: Barren River at Bowling Green.

A total of 58 stream miles of the upper Gasper River (26 miles) and its tributaries (32 miles) has been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation use designations. A stream use designation study conducted in the upper Gasper River system revealed violations of Kentucky Surface Water Standards for aluminum, mercury and iron. This stream system supports an excellent diversity of aquatic habitats and a speciose aquatic community. With the exception of 10 miles of Black Lick Creek which partially supports recommended use designation, this area supports the recommended use.

- Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 6.4 to a maximum of 13.0 with a mean of 8.9 and a median of 8.9.

- pH

For the reporting period pH ranged from a minimum of 7.0 to a maximum of 8.0 with a mean of 7.8 and a median of 7.8. For the period of record (1979-1983) pH ranged from a minimum of 6.8 to a maximum of 8.1 with a mean of 7.7 and a median of 7.8.

- Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.6 to a maximum of 44.9 with a mean of 10.0 and a median of 8.0. For the period of record (1979-1983) acidity ranged from a minimum of 1.6 to a maximum of 64.0 with a mean of 10.0 and a median of 7.3.

- Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 51.3 to a maximum of 125 with a mean of 93.3 and a median of 98.4. For the period of record (1979-1983) alkalinity ranged from a minimum of 51.3 to a maximum of 174.0 with a mean of 100.8 and a median of 100.

- Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 181.0 to a maximum of 327.0 with a mean of 246.7 and a median of 247.0. For the period of record (1979-1983) conductivity ranged from a minimum of 180.0 to a maximum of 354.0 with a mean of 253.2 and a median of 250.0.

- Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 2.6 to a maximum of 98.5 with a mean of 11.2 and a median of 7.2. For the period of record (1979-1983) chlorides ranged from a minimum of 2.6 to a maximum of 98.5 with a mean of 9.6 and a median of 7.4.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 7.1 to a maximum of 26.0 with a mean of 13.3 and a median of 12.8. For the period of record (1979-1983) sulfates ranged from a minimum of 7.1 to a maximum of 43.0 with a mean of 17.9 and a median of 15.8.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.28 to a maximum of 2.12 with a mean of 1.15 and a median of 1.14. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.23 to a maximum of 2.12 with a mean of 1.1 and a median of 1.14.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.013 to a maximum of 0.67 with a mean of 0.071 and a median of 0.039. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.01 to a maximum of 0.67 with a mean of 0.06 and a median of 0.037.

o Fecal Coliform

Fecal coliform standards were exceeded 14% of the time during the reporting period.

Hydrologic Unit 05110003 - Green River from Barren River to Rough River

A total of 491 miles of streams draining 1,027 square miles are located in this hydrologic unit. Major urban centers include Morgantown (pop. 2,000) and Greenville (pop. 4,631). Recreation center includes Lake Malone. Two water quality monitoring stations are located in this hydrologic unit: Green River at Aberdeen and Mud River near Lewisburg.

Two miles of this unit, located at the source of the Mud River, have been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation uses. Stream use designation work indicate that Kentucky Surface Water Standards for aluminum, mercury and iron were violated. However, this study revealed that this two mile reach of stream supports a diverse, viable aquatic fauna. Therefore, this stream reach was determined to support the recommended use designation.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 2.4 to a maximum of 12.2 with a mean range of 6.9 to 9.1 and a median range of 6.7 to 9.0.

o pH

For the reporting period pH ranged from a minimum of 6.8 to a maximum of 8.1 with a mean range of 7.4 to 7.5 and a median range of 7.5 to 7.5. For the period of record (1979-1983) pH ranged from a minimum of 5.2 to a maximum of 8.2 with a mean range of 7.5 to 7.5 and a median range of 7.5 to 7.6.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 0.3 to a maximum of 87.8 with a mean range of 9.4 to 16.3 and a median range of 8.0 to 10.4. For the period of record (1979-1983) acidity ranged from a minimum of 0.00 to a maximum of 87.8 with a mean range of 9.7 to 13.9 and a median range of 8.0 to 9.6.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 33.8 to a maximum of 210.0 with a mean range of 97.5 to 144.3 and a median range of 96.7 to 156.0. For the period of record (1979-1983) alkalinity ranged from a minimum of 33.8 mg/l to a maximum of 210.0 with a mean range of 101.2 to 150.0 and a median range of 101.0 to 156.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 3.2 to a maximum of 51.0 with a mean range of 9.8 to 13.3 and a median range of 8.9 to 9.0. For the period of record (1979-1983) chlorides ranged from a minimum of 2.9 to a maximum of 63.7 with a mean range of 10.7 to 15.8 and a median range of 9.3 to 12.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 87.0 to a maximum of 561.0 with a mean range of 249.2 to 369.9 and a median range of 249.0 to 361.0. For the period of record (1979-1983) conductivity ranged from a minimum of 87.0 to a maximum of 561.0 with a mean range of 254.2 to 369.6 and a median range fo 251.0 to 375.0.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 5.0 to a maximum of 1470.0 with a mean range of 105.6 to 110.2 and a median range of 15.0 to 20.1. For the period of record (1979-1983) sulfates ranged from a minimum of 5.0 to a maximum of 1470.0 with a mean range of 61.8 to 64.4 and a median range of 16.5 to 21.0.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.03 to a maximum of 3.04 with a mean range of 1.1 to 1.5 and a median range of 1.23 to 1.56. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.03 to a maximum of 3.15 with a mean range of 1.04 to 1.5 and a median range of 1.13 to 1.49.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.027 to a maximum of 0.96 with a mean range of 0.085 to 0.166 and a median range of 0.063 to 0.125. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.025 to a maximum of 0.96 with a mean range of 0.076 to 0.199 and a median range of 0.058 to 0.153.

o Fecal Coliform

Fecal coliform standards were exceeded 22% of the time during the reporting period. The highest percentage of violations occurred at the Mud River station.

Hydrologic Unit 05110004 - Rough River

A total of 453 miles of streams draining 1,081 square miles comprise this hydrologic unit. The major urban center is Beaverdam (pop. 3,185). Recreation centers include Rough River Reservoir. One water quality monitoring station is located in this hydrologic unit: Rough River at Dundee.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 5.1 to a maximum of 12.8 with a mean of 9.1 and a median of 8.8.

o pH

For the reporting period pH ranged from a minimum of 6.7 to a maximum of 7.8 with a mean of 7.3 and a median of 7.2. For the period of record (1979-1983) pH ranged from a minimum of 6.3 to a maximum of 8.4 with a mean of 7.3 and a median of 7.3.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 0.3 to a maximum of 48.8 with a mean of 9.2 and a median of 8.0. For the period of record (1979-1983) acidity ranged from a minimum of 0.0 to a maximum of 53.0 with a mean of 9.9 and a median of 8.0.

o Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 34.0 to a maximum of 194.0 with a mean of 82.0 and a median of 76.6. For the period of record (1979-1983) alkalinity ranged from a minimum of 24.0 to a maximum of 194.0 with a mean of 78.2 and a median of 79.2.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 130 to a maximum of 256 with a mean of 202.3 and a median of 203.0. For the period of record (1979-1983) conductivity ranged from a minimum of 96.0 to a maximum of 268.0 with a mean of 200.2 and a median of 204.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 3.6 to a maximum of 13.6 with a mean of 5.1 and a median of 4.6. For the period of record (1979-1983) chlorides ranged from a minimum of 1.6 to a maximum of 21.0 with a mean of 5.0 and a median of 4.6.

o Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 3.54 to a maximum of 858.0 with a mean of 97.1 and a median of 22.0. For the period of record (1979-1983) sulfates ranged from a minimum of 3.5 to a maximum of 858.0 with a mean of 57.1 and a median of 19.0.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.15 to a maximum of 1.7 with a mean of 0.65 and a median of 0.57. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.15 to a maximum of 1.7 with a mean of 0.61 and a median of 0.56.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.015 to a maximum of 0.154 with a mean of 0.066 and a median of 0.050. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.015 to a maximum of 0.53 with a mean of 0.081 and a median of 0.055.

o Fecal Coliform

Fecal coliform standards were exceeded 21% of the time during the reporting period.

Hydrologic Unit 05110005 - Lower Green River

A total of 362 miles of streams draining 919 square miles comprise this hydrologic unit. The major urban center is Owensboro (pop. 54,450). Two water quality monitoring stations are located in this hydrologic unit: Green River near Beech Grove and Green River at Spotsville.

o pH

For the reporting period pH ranged from a minimum of 7.2 to a maximum of 8.0 with a mean of 7.7 and a median of 7.6. For the period of record (1980-1983) pH ranged from a minimum of 7.2 to a maximum of 8.2 with a mean of 7.7 and a median of 7.7.

o Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1974-1981) alkalinity ranged from a minimum of 45.0 to a maximum of 120.0 with a mean of 79.3 and a median of 80.0.

o Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 170.0 to a maximum of 450.0 with a mean range of 281.3 to 307.2 and a median range of 290.0 to 312.0. For the period of record (1974-1983) conductivity ranged from a minimum of 130.0 to a maximum of 577.0 with a mean range of 301.8 to 307.6 and a median range of 300.0 to 300.0.

o Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 3.3 to a maximum of 14.0 with a mean of 8.1 and a median of 8.3. For the period of record (1974-1983) chlorides ranged from a minimum of 2.9 to a maximum of 14.0 with a mean of 6.9 and a median of 6.4.

o NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.23 to a maximum of 1.5 with a mean of 0.95 and a median of 0.98. For the period of record (1974-1983) NO_2-NO_3-N ranged from a minimum of 0.05 to a maximum of 6.8 with a mean range of 0.82 to 0.97 and a median range of 0.83 to 0.87.

o Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.02 to a maximum of 0.32 with a mean range of 0.077 to 0.11 and a median range of 0.07 to 0.08. For the period of record (1974-1983) total phosphorus ranged from a minimum of 0.01 to a maximum of 1.48 with a mean range of 0.08 to 0.19 and a median range of 0.06 to 0.11.

Hydrologic Unit 05110006 - Pond River

A total of 327 miles of streams draining 799 square miles comprise this hydrologic unit. Major urban centers include the eastern half of Madisonville (pop. 16,979) and Central City (pop. 5,214). Two water quality monitoring stations are located in this hydrologic unit: Pond River at KY 85 bridge and Pond River at KY 189 bridge.

o Dissolved Oxygen (DO) (mg/l)

For the reporting period DO ranged from a minimum of 4.1 to a maximum of 13.2 with a mean range of 7.5 to 8.4 and a median range of 6.3 to 8.4.

o pH

For the reporting period pH ranged from a minimum of 5.1 to a maximum of 8.1 with a mean range of 7.1 to 7.5 and a median range of 7.0 to 7.6. For the period of record (1979-1983) pH ranged from a minimum of 4.0 to a maximum of 8.1 with a mean range of 6.97 to 7.6 and a median range of 7.1 to 7.6.

o Acidity (mg/l)

For the reporting period acidity ranged from a minimum of 1.7 to a maximum of 58.5 with a mean range of 9.57 to 10.3 and a median range of 7.6 to 9.0. For the period of record (1979-1983) acidity ranged from a minimum of 1.7 to a maximum of 58.5 with a mean range of 7.9 to 8.6 and a median range of 6.0 to 6.4.

- Alkalinity (mg/l)

For the reporting period alkalinity ranged from a minimum of 12.0 to a maximum of 132.0 with a mean range of 49.4 to 93.6 and a median range of 46.0 to 100.0. For the period of record (1979-1983) alkalinity ranged from a minimum of 0.0 mg/l to a maximum of 164.2 with a mean range of 46.9 to 91.4 and a median range of 46.0 to 93.8.

- Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 149.0 to a maximum of 2160.0 with a mean range of 312.6 to 964.9 and a median range of 311.0 to 729.0. For the period of record (1979-1983) conductivity ranged from a minimum of 143.0 to a maximum of 2160.0 with a mean range of 339.0 to 905.0 and a median range of 309.0 to 812.0.

- Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 5.8 to a maximum of 49.4 with a mean range of 13.8 to 16.0 and a median range of 12.4 to 12.5. For the period of record (1979-1983) chlorides ranged from a minimum of 2.5 to a maximum of 77.6 with a mean range of 13.3 to 19.3 and a median range of 11.4 to 12.5.

- Sulfates (mg/l)

For the reporting period sulfates ranged from a minimum of 13.0 to a maximum of 2500.0 with a mean range of 114.6 to 563.8 and a median range of 34.0 to 361.0. For the period of record (1979-1983) sulfates ranged from a minimum of 13.0 to a maximum of 2500.0 with a mean range of 84.4 to 491.8 and a median range of 34.8 to 380.0.

- NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.02 to a maximum of 1.89 with a mean range of 0.53 to 0.81 and a median range of 0.51 to 0.74. For the period of record (1979-1983) NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 3.6 with a mean range of 0.48 to 0.79 and a median range of 0.47 to 0.67.

- Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.007 to a maximum of 0.65 with a mean range of 0.079 to 0.116 and a median range of 0.060 to 0.78. For the period of record (1979-1983) total phosphorus ranged from a minimum of 0.005 to a maximum of 1.13 with a mean range of 0.08 to 0.09 and a median range of 0.05 to 0.07.

- Fecal Coliform

Fecal coliform standards were exceeded 44% of the time during the reporting period. The highest percentage of violations occurred at the Pond River 85 bridge station.

o Biological

The 1983 biological collections from the Pond River at 85 bridge station showed improvements in biological integrity from previous years. The biological communities appear to be stressed from water quality factors such as turbidity, pH and metals. Improvements in the macroinvertebrate biological community in 1983 were attributed to the extended low flow conditions. Water quality in this stream system is considered fair.

This site was characterized by moderate growths of filamentous blue-green and green algae. The community, exclusive of diatoms, was largely dominated by planktonic green and euglenoid algae. These taxa are associated with eutrophic conditions and are tolerant to sedimentation. Periphyton chlorophyll a values were below average (10.1 mg/m^2, Range (6.7-16.3)) while AFDW values were above average (8.12 g/m^2, Range (2.03-16.91)), suggesting much heterotrophic activity (i.e. bacteria, protozoans). Plankton chlorophyll a values were typical for the BWMP stations (10.6 ug/l). A total of 129 algal species were identified from natural substrates. The diatom community was dominated by epipelic, halophilic, and eutrophic species. It appears that the benthic algal community is being limited by turbidity and other water quality factors such as pH, metals, etc. No change has been observed here since sampling began in 1979.

The invertebrate collections from the Pond River at 85 bridge station are not exceptional for the available habitats. Most of the community is tolerant of many environmental conditions, including siltation and acid mine drainage. Because of the abundance of habitats for invertebrates it is obvious that certain water quality factors such as metals, turbidity, etc. are influencing the benthic community.

No F.D.A. action levels were exceeded in fish tissue at this station in 1983.

TRADEWATER RIVER BASIN

The Tradewater River basin is located in the western portion of the state within the Shawnee Hills Section of the Interior Low Plateaus Province. This area also contains the western Kentucky coalfield. The Tradewater River originates in northwestern Christian County and flows northwesterly for 132 miles to enter the Ohio River at mile 873.4, near Caseyville, Kentucky. Some of the principal tributaries to the river are Caney Creek, Buffalo Ceek, Piney Creek, Flynn Fork, Donaldson Creek, Clear Creek, Craborchard Creek (=Vaughn Ditch) and Cypress Creek (=Smith Ditch). There are 515 miles of streams in the basin depicted on the USGS hydrologic unit map. Lake Beshear is the major impoundment of this area. The Tradewater River drains an area of 943 square miles.

The main stem of the Tradewater originates near the Dripping Springs Escarpment and flows primarily through the deep alluvial and Pennsylvanian deposits of the interior lowlands. The eastern tributaries, which also lie in Pennsylvanian stratas, comprise some of the largest wetlands in the state. In contrast, smaller western tributaries are more upland in nature and flow through Mississippian deposits.

The basin is roughly elliptical in shape and averages approximately 32 miles in width. Elevations range from 320 feet above mean sea level (m.s.l.) at the mouth of the Tradewater River to 806 feet above m.s.l. just north of Hopkinsville, Kentucky. The main stem has an average slope of 0.6 feet/mile from its mouth to mile 73 at Olney. From Olney to its source the average slope is 5.4 feet/mile. In areas where the gradient is slight, wide floodplains and swampy conditions are common.

Impacts

Portions of the Tradewater River system have been heavily impacted by acid and silt from coal mining in the watershed. Many streams consistently exhibit pH in the range of 3-4 and are heavily silted. Agricultural runoff and domestic sewage discharges from small municipalities are secondary impacts.

The aquatic biota of the eastern tributaries and the mainstem of the Tradewater below Dawson Springs has been severly degraded by acid mine drainage and siltation. The western tributaries are presently serving as a refugia for the aquatic biota of the basin. Although no fish kills were officially reported during the 1982-1983 period, residents in the area indicated that localized fish kills frequently occur. One ambient monitoring station is located in the drainage basin.

Problem Parameters

Fecal coliform bacteria violations were frequent at the Tradewater monitoring station. Copper and iron levels were elevated in water samples and chlordane in sediment samples.

Flow

The annual average discharge for the period of record (43 years) is 334 cfs for the Tradewater River at mile point 72.65. Mean discharge for water year 1982 was below the average annual discharge (-22%). However, during water year 1983, mean discharge was 37% above annual average.

Hydrologic Unit 05140205 - Tradewater River

A total of 515 miles of streams draining 943 square miles comprise this hydrologic unit. Major urban centers include Madisonville (pop. 16,979), Dawson Springs (pop. 3,275), Providence (pop. 4,434), and Sturgis (pop. 2,293). The major recreation centers include Lake Beshear and Pennyrile State Resort Park. One water quality monitoring station is located in the basin on the Tradewater River at Olney.

Approximately 77 stream miles have been recommended for stream use designations. Fourteen miles of the Tradewater River around Dawson Springs plus 11 miles of Montgomery Creek have been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation use. The fourteen mile segment of the Tradewater River has historically not supported designated uses due to severe acid mine pollution from upstream, eastern tributaries, while Montgomery Creek (11 miles) supports the recommended stream uses. Stream use designation studies revealed violations of Kentucky Surface Water Standards for mercury and aluminum. Also, historical data from this stream reach indicate the pH standards are frequently violated. Sulfates are also elevated in this stream segment.

The Vaughn Ditch/Craborchard Creek stream system encompasses approximately 52 stream miles which has been recommended for designation as Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation use. Violations of Kentucky Surface Water Standards for aluminum, mercury, iron, un-ionized ammonia and phthlate esters were observed during stream use designation studies. A major portion of the drainage has been channelized, reducing or eliminating valuable aquatic habitat. Large scale coal mining and agriculture operations have also impaired the water quality and damaged aquatic habitats. Therefore, this stream system partially supports the recommended designated uses.

Owens Creek, a small tributary (4.5 miles) to the Tradewater River near Providence, Kentucky has been recommended for Aquatic Life/Warmwater Aquatic Habitat and Primary and Secondary Contact Recreation uses. This stream does not appear on the Kentucky hydrologic map and is, therefore, not considered in the total stream miles for the Tradewater basin. Violations of Kentucky Surface Water Standards for iron, mercury, phthalate esters, un-ionized ammonia and aluminum were documented during a stream use designation survey. Historical problems with low pH are known to occur in the drainage as a result of acid coal mine drainage. The stream has been channelized for most of its length impairing or eliminating valuable aquatic habitat. The lower 2.5 miles of Owens Creek partially supports the recommended designated uses, while the upper 2 miles does not support the recommended designated uses.

- pH

For the reporting period pH ranged from a minimum of 6.6 to a maximum of 7.8 with a mean of 7.2 and a median of 7.1.

- Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 198.0 to a maximum of 447.0 with a mean of 318.0 and a median of 315.0.

- Chlorides (mg/l)

For the reporting chlorides ranged from a minimum of 2.3 to a maximum of 6.8 with a mean of 4.55 and a median of 4.8.

- Total phosphorus

For the reporting period total phosphorus ranged from a minimum of .020 to a maximum of .220 with a mean of .068 and a median of .050.

LOWER CUMBERLAND RIVER BASIN

The lower Cumberland River basin lies in the Highland Rim Section of the Interior Low Plateaus Province in southwestern Kentucky. The low to moderate gradient streams in the Kentucky portion of the basin drain Mississippian limestones. The river in Kentucky flows northwesterly for 75 miles from the Tennessee border to the Ohio River (mile 920.4) near Smithland, Kentucky. Barkley Dam, near Lake City, Kentucky , impounds 118 miles of the river, 44 miles of which are in Kentucky. There are two major subbasins in this region, the Little River with 601 square miles and the Red River with a total drainage area of 1,460 square miles, of which 688 are in Kentucky. The lower Cumberland River drains 2,084 square miles in Kentucky and receives drainage from another 15,830 square miles of the Cumberland River in Tennessee and southeastern Kentucky. There are 704 miles of streams in the Kentucky portion of the basin depicted on the USGS hydrologic unit map.

The basin lies in two subsections of the Highland Rim, the Pennyroyal Plain and the Western Highland Rim. The Pennyroyal area is a well known karst region consisting of rough and hilly topography, with sinkholes, subsurface drainage, and limestone caverns. The Western Highland Rim subsection consists of a dissected upland plateau with some karst topography, but sinkhole plains are absent. Generally, this subsection is a ridge and valley area characterized by long, somewhat steep, slopes.

Elevations in the basin range from 302 feet above mean sea level (m.s.l.) at the confluence of the Cumberland and Ohio rivers to 863 feet at Pine Knob in Christian County. Slope of the main stem of the Cumberland River below Barkley Lake is 5.7 feet/mile to the point where Livingston Creek enters. The slope from Livingston Creek to the Ohio River is 2 feet/mile or less.

Impacts

Principal impacts to water quality of the basin include municipal wastewater effluent disposal and nonpoint source agricultural runoff. Mining impacts within the basin are limited to runoff from abandoned fluorspar mines and limestone quarries. Impacts from limestone quarries generally involve slight downstream increases in siltation and alkalinity. Industrial discharges have impacted the drainage, particularly in the Hopkinsville area.

The Kentucky portion of the Cumberland River supports a diverse aquatic biota typical of large rivers. No fish kills were reported in the drainage in 1982 or 1983.

Physiochemical data for the lower Cumberland are provided by the USGS gaging station located near Grand Rivers, Kentucky. Data are reported from October 1980 through September 1981.

Problem Parameters

Levels of nitrite-nitrite nitrogen were elevated at the sampling station in this basin.

Flow

The annual average discharge for the period of record (18 years) is 38,630 cfs for the lower Cumberland River at mile point 30.6. Mean discharge for water year 1982 was below the annual average discharge (-15%). However, during water year 1983, mean discharge was 9% above the annual average. The concentration effect of flow reduction during the reporting period was contributing factor to observed increases in certain physicochemical parameters.

Hydrologic Unit 05130205 - Lower Cumberland River

A total of 443 miles of streams draining 969 square miles comprise this hydrologic unit. Major urban centers include Hopkinsville (pop. 27,318), Princeton (pop. 7,073), and Cadiz (pop. 1,661). Recreation centers include Lake Barkley. One water quality monitoring station is located in this hydrologic unit: Cumberland River near Grand Rivers.

- pH

For the reporting period pH ranged from a minimum of 7.5 to a maximum of 8.1 with a mean of 7.8 and a median of 7.9. For the period of record (1980-1983) pH ranged from a minimum of 6.7 to a maximum of 8.3 with a mean of 7.8 and a median of 7.9.

- Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1967-1980) alkalinity ranged from a minimum of 47.0 to a maximum of 96.0 with a mean of 67.9 and a median of 67.0.

- Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 192.0 to a maximum of 266.0 with a mean of 210.0 and a median of 200.0. For the period of record (1966-1983) conductivity ranged from a minimum of 138.0 to a maximum of 370.0 with a mean of 196.9 and a median of 195.0.

- Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 2.9 to a maximum of 6.4 with a mean of 4.3 and a median of 4.3. For the period of record (1966-1983) chlorides ranged from a minimum of 1.7 to a maximum of 13.0 with a mean of 4.7 and a median of 4.3.

- NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N was not measured. For the period of record (1972-1981) NO_2-NO_3-N ranged from a minimum of 0.01 to a maximum of 1.2 with a mean of 0.36 and a median of 0.31.

- Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.03 to a maximum of 0.2 with a mean of 0.09 and a median of 0.085. For the period of record (1972-1983) total phosphorus ranged from a minimum of 0.03 to a maximum of 0.62 with a mean of 0.10 and a median of 0.09.

Hydrologic Unit 05130206 - Red River

A total of 260 miles of streams draining 687 square miles in Kentucky comprise this subbasin. Major urban centers include Elkton (pop. 1,815) and Adairville (pop. 1,105). There are no water quality monitoring stations located in this hydrologic unit.

TENNESSEE RIVER BASIN

The Tennessee River basin drains the eastern half of the Jackson Purchase region in the far western corner of the state. Of its total drainage area, 40,330 square miles, only 1,000 square miles are in Kentucky. Most of the 62 miles of the Tennessee River (mainstem) that lie in Kentucky are impounded within Kentucky Lake. There are 369 miles of streams in the Kentucky portion of the basin depicted on the USGS hydrologic unit map. The principal tributary in Kentucky is Clarks River, which has a total drainage area of 530 square miles.

The basin lies in the Eastern Gulf Coastal Plain area of the Coastal Plain Province. Underlaying bedrock is composed of a variety of shales, clays and sandstones of Tertiary and Cretaceous age. Basin topography is characterized by strongly rolling to nearly flat terrain; the uplands are variable and often wooded, while valleys are generally wide with extensive cultivation; slopes are steep in some areas along Kentucky lake.

Elevations in the basin vary from 325 feet above mean sea level (m.s.l.) south of Paducah to 640 feet above m.s.l. in southwestern Calloway County. The East Fork of Clarks River has an average slope of 4.6 feet/mile and the West Fork averages 7.0 feet/mile. The mainstem of the Tennessee River to Kentucky Lake Dam is influenced by the Lock and Dam 52 on the Ohio River with a pool elevation of 302 feet above m.s.l.

Impacts

Impacts to water quality within the Tennessee River basin include nutrient loading from domestic effluents, urban runoff and agricultural activities. Increased silt loads from cultivation of marginally hilly land immediately west of Kentucky Lake represents a threat to the aquatic life of streams in this area.

Industrial impacts are of special concern on the Tennessee River below Kentucky Lake where a large chemical manufacturing complex has developed. Industrial impacts have also influenced water quality in the Paducah area of the lower Tennessee and in the East Fork of Clarks River below Benton and Murray. High levels of heavy metals have been found in sediments of the East Fork Clarks River and pose a threat to the aquatic ecosystem. Physicochemical data for the lower portion of the Tennessee River is provided by the USGS station near Paducah. One fish kill was reported in 1983 and none during 1982. Two ambient monitoring stations are located in the basin on the Tennessee River near Paducah and Clarks River at Almo.

Flow

The annual average discharge for the period of record (18 years) is 65,450 cfs for the Tennessee River at mile point 21.6. Mean discharge for water year 1982 was below the annual average discharge (-10%). However, during water year 1983, adjusted mean discharge was 16% above the annual average. The concentration effect of flow reduction during the reporting period was a contributing factor to observed increases in certain physicochemical parameters.

Hydrologic Unit 06040005 - Kentucky Lake Tributaries

A total of 41 miles of streams draining 240 square miles comprise this hydrologic unit. Recreation centers include Kentucky Lake. No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 06040006 - Tennessee River/Clarks River

A total of 328 miles of streams draining 890 square miles comprise this hydrologic unit. Major urban centers include Paducah (pop. 29,315), Murray (pop. 14,248), and Benton (pop. 370). Recreation centers include Lower Tennessee River. Two water quality monitoring stations are located in this hydrologic unit: Tennessee River near Paducah and Clarks River at Almo.

- pH

For the reporting period pH ranged from a minimum of 6.6 to a maximum of 7.4 with a mean of 7.0 and a median of 7.1. For the period of record (1982-1983) pH ranged from a minimum of 6.6 to a maximum of 7.4 with a mean of 7.0 and a median of 7.0.

- Conductivity (µmhos/cm)

For the reporting period conductivity ranged from a minimum of 80.0 to a maximum of 310.0 with a mean range of 153.9 to 185.7 and a median range of 151.0 to 183.0. For the period of record (1976-1983) conductivity ranged from a minimum of 80.0 to a maximum of 310.0 with a mean range of 172.6 to 178.0 and a median range of 168.0 to 170.0.

- Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 4.4 to a maximum of 25.0 with a mean of 13.0 and a median of 14.0. For the period of record (1982-1983) chlorides ranged from a minimum of 4.4 to a maximum of 25.0 with a mean of 13.3 and a median of 14.0.

- NO_2-NO_3-N (mg/l)

For the reporting period NO_2-NO_3-N ranged from a minimum of 0.06 to a maximum of 0.72 with a mean of 0.37 and a median of 0.38. For the period of record (1976-1983) NO_2-NO_3-N ranged from a minimum of 0.04 to a maximum of 1.19 with a mean of 0.34 and a median of 0.33.

- Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.05 to a maximum of 1.3 with a mean range of 0.102 to 0.549 and a median range of 0.07 to 0.43. For the period of record (1976-1983) total phosphorus ranged from a minimum of 0.05 to a maximum of 1.41 with a mean range of 0.175 to 0.545 and a median range of 0.10 to 0.430.

MISSISSIPPI RIVER BASIN

The Mississippi River reaches its confluence with the Ohio River at Mississippi river mile 953.8 near Wickliffe, Kentucky and flows southward some 70 miles, forming the state boundary between Kentucky and Missouri. The basin drains a northern extension of the Mississippian Embayment within the far southwestern corner of the state, a physiographic province known as the Coastal Plain. The basin drains approximately 1,200 square miles of the state. Geology of the region is somewhat youthful, being composed of Tertiary age sands, gravels, and clays deposited during a recent subsidence of the Mississippi Embayment. Windblown deposits of loess blanket these Tertiary deposits and are especially well developed as bluffs just east of the river. Principal tributaries to the Mississippi include Mayfield Creek, Obion Creek, and Bayou de Chien. There are 372 miles of streams in the Kentucky portion of the basin depicted on the USGS hydrologic unit map. The Ohio River, the major tributary to the Mississippi River in this region, is discussed in another section.

Topography of the basin varies from strongly rolling to nearly flat terrain. Highest elevations occur along a northwest-southeast ridge which runs from western Calloway County to Ballard County and forms the divide betwen the Ohio, Mississippi, and Tennessee rivers. Uplands within the basin are smooth to rough with greatest variations in elevation occurring near streams. Extensive floodplain bottoms have developed along the principal tributaries and the Mississippi itself.

Impacts

Intensive cultivation of the basin area has led to serious sediment loadings to streams. Additional impacts to streams within the basin include agricultural nutrient runoff, domestic effluent discharges, logging, channelization, and, to a lesser extent, industrial waste influences. The tributary streams' aquatic biota has been impacted by siltation. One fish kill was reported from this basin in 1983, none in 1982. There is one ambient monitoring station in the basin.

Problem Parameters

Copper and iron were problem water problems, while iron and chlordane were problem sediment parameters.

Hydrologic Unit 08010201 - Bayou De Chien

A total of 382 miles of streams draining 966 square miles comprise this hydrologic unit. Major urban centers include Mayfield (pop. 10,705), Bardwell (pop. 988), and Clinton (pop. 1,720). Recreation centers include Murphy's Pond. One water quality monitoring station is located in this hydrologic unit: Bayou De Chien near Clinton.

- pH

For the reporting period pH ranged from a minimum of 6.6 to a maximum of 7.6 with a mean of 7.2 and a median of 7.2. For the period of record (1982-1983) pH ranged from a minimum of 6.6 to a maximum of 7.8 with a mean of 7.2 and a median of 7.1.

- Alkalinity (mg/l)

For the reporting period alkalinity was not measured. For the period of record (1970-1980) alkalinity ranged from a minimum of 32.0 to a maximum of 77.0 with a mean of 43.4 and a median of 41.0.

- Conductivity (μmhos/cm)

For the reporting period conductivity ranged from a minimum of 68.0 to a maximum of 129.0 with a mean of 90.0 and a median of 86.0. For the period of record (1970-1983) conductivity ranged from a minimum of 60.0 to a maximum of 220.0 with a mean of 109.2 and a median of 100.0.

- Chlorides (mg/l)

For the reporting period chlorides ranged from a minimum of 2.8 to a maximum of 7.0 with a mean of 4.7 and a median of 3.7. For the period of record (1970-1983) chlorides ranged from a minimum of 2.5 to a maximum of 7.0 with a mean of 4.2 and a median of 3.7.

- Total Phosphorus (mg/l)

For the reporting period total phosphorus ranged from a minimum of 0.03 to a maximum of 0.18 with a mean of 0.09 and a median of 0.07. For the period of record (1982-1983) total phosphorus ranged from a minimum of 0.03 to a maximum of 0.18 with a mean of 0.09 and a median of 0.07.

OHIO RIVER MAIN STEM

The Ohio River forms the northern border of the Commonwealth of Kentucky for 664 miles. The river receives impacts from all the major drainages as well as numerous minor basins within the state. In addition, the Ohio receives drainage from large portions of Pennsylvania, Ohio, West Virginia, Indiana and Illinois.

The Division of Water maintains no water quality monitoring stations on the main stem of the Ohio River. Monitoring of the Ohio main stem and lower reaches of major tributaries is the responsibility of the Ohio River Valley Water Sanitation Commission (ORSANCO), a compact of eight states in the Ohio River drainage basin. Information on water quality of the Ohio River main stem is contained in ORSANCO's Water Quality Report to Congress for the same reporting period.

OHIO RIVER MINOR TRIBUTARIES

There are 3,184 stream miles located in minor basins on the USGS hydrologic unit map within the state along the Ohio River. Drainage impacts occurring in these streams are largely unknown. There are no water quality monitoring stations on any of these Ohio River minor tributaries.

Hydrologic Unit 05090201 - Ohio River Minor Tributaries

A total of 329 miles of streams draining 568 square miles comprise this hydrologic unit. Major urban centers include Vanceburg (pop. 1,939), Maysville (pop. 7,983), Brooksville (pop. 680), and Alexandria (pop. 4,735). No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 05090203 - Ohio River Minor Tributaries

A total of 144 miles of streams draining 244 square miles comprise this hydrologic unit. Major urban centers include Burlington and Warsaw (pop. 1,328). No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 05140101 - Ohio River Minor Tributaries

A total of 258 miles of streams draining 437 square miles comprise this hydrologic unit. Major urban centers include Bedford (pop. 835), LaGrange (pop. 2,971), and northern Jefferson County. No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 05140104 - Ohio River Minor Tributaries

A total of 159 miles of streams draining 539 square miles comprise this hydrologic unit. Major urban centers include Vine Grove (pop. 3,583) and Hardinsburg (pop. 2,211). Recreation centers include Otter Creek Park. No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 05140201 - Ohio River Minor Tributaries

A total of 117 miles of streams draining 273 square miles comprise this hydrologic unit. Major urban centers include Cloverport (pop. 1,585) and Hawesville (pop. 1,036). No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 05140202 - Ohio River Minor Tributaries

A total of 140 miles of streams draining 999 square miles comprise this hydrologic unit. Major urban centers include Henderson (pop. 24,834) and Morganfield (pop. 3,781). No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 05140203 - Ohio River Minor Tributaries

A total of 166 miles of streams draining 403 square miles comprise this hydrologic unit. The major urban center is Marion (pop. 3,392). No water quality monitoring stations are located in this hydrologic unit.

Hydrologic Unit 05140206 - Ohio River Minor Tributaries

A total of 136 miles of streams draining 181 square miles comprise this hydrologic unit. Major urban centers include the western half of Paducah, LaCenter (pop. 1,044) and Kevil (pop. 382). No water quality monitoring stations are located in this hydrologic unit.

APPENDIX C

LOCATION OF TROPHICALLY CLASSIFIED LAKES

APPENDIX C

Location of Trophically Classified Lakes

River Basin	Lake	Hydrologic Unit	County
Mississippi Tennessee	Flat	08010100	Ballard
	Kentucky	06040003	Calloway, Marshall, Lyon, Trigg
Lower Ohio	Turner	05140206	Ballard
	George	05140203	Crittenden
	Mauzy	05140202	Union
	Scenic	05140202	Henderson
	Carpenter	05140201	Daviess
	Kingfisher	05140201	Daviess
Lower Cumberland	Barkley	05130205	Lyon, Trigg
	Energy	05130205	Trigg*
	Hematite	05130205	Trigg*
	Honker	04130205	Trigg*
	Morris	05130205	Christian
	Blythe	05130205	Christian
Tradewater	Pennyrile	05140205	Christian
	Beshear	05140205	Caldwell, Christian
	Loch Mary	05140205	Hopkins
	Peewee	05140205	Hopkins
	Providence City	05140205	Webster
	Moffitt	05140205	Union
Green	Campbellsville	05110001	Taylor
	Freeman	05110001	Hardin
	Green River	05110001	Taylor, Adair
	Liberty	05110001	Casey
	Metcalfe County	05110001	Metcalfe
	Nolin	05110001	Edmonson, Grayson, Hart
	Salem	05110001	Larue
	Shanty Hollow	05110001	Warren
	Spurlington	05110001	Taylor
	Barren River	05110002	Allen, Barren
	Mill Creek	05110002	Monroe
	Briggs	05110003	Logan
	Lewisburg	05110003	Logan
	Luzerne	05110003	Muhlenberg
	Malone	05110003	Muhlenberg, Todd, Logan
	Spa	05110003	Logan
	Caneyville	05110004	Grayson
	Rough River	05110004	Breckinridge, Grayson

APPENDIX C continued

River Basin	Lake	Hydrologic Unit	County
	Washburn	05110004	Ohio
	Grapevine	05110006	Hopkins
Salt	Guist Creek	05140102	Shelby
	Long Run	05140102	Jefferson, Shelby
	McNeely	05140102	Jefferson
	Shelby	05140102	Shelby
	Beaver	05140103	Anderson
	Marion County	05140103	Marion
	Sympson	05140103	Nelson
	Willisburg	05140103	Washington
Middle Ohio	Jericho	05140101	Henry
	Reformatory	05140101	Oldham
Upper Cumberland	Cannon Creek	05130101	Bell
	Chenoa	05130101	Bell
	Corbin	05130101	Laurel
	Cranks Creek	05130101	Harlan
	Laurel Creek	05130101	McCreary
	Laurel River	05130101	Laurel
	Martins Fork	05130101	Harlan
	Linville	05130102	Rockcastle
	Tyner	05130102	Jackson
	Wood Creek	05130102	Laurel
	Cumberland	05130103	Clinton, Pulaski, Russell, Wayne
	Dale Hollow	05130105	Clinton, Cumberland
Kentucky	Carr Fork	05100201	Knott
	Fishpond	05100201	Letcher
	Pan Bowl	05100201	Jackson
	Buckhorn	05100202	Perry, Leslie
	Bert Combs	05100203	Clay
	Campton	05100204	Wolfe
	Mill Creek	05100204	Powell
	Boltz	05100205	Grant
	Bullock Pen	05100205	Grant
	Corinth	05100205	Grant
	Elmer Davis	05100205	Owen

APPENDIX C continued

River Basin	Lake	Hydrologic Unit	County
	General Butler	05100205	Carroll
	Herrington	05100205	Boyle, Garrard, Mercer
	Stanford	05100205	Lincoln
	Wilgreen	05100205	Madison
Licking	A.J. Jolly	05100101	Campbell
	Cave Run	05100101	Bath, Menifee, Morgan, Rowan, Grant
	Doe Run	05100101	Kenton
	Greenbriar	05100101	Montgomery
	Kincaid	05100101	Pendleton
	Sand Lick Creek	05100101	Fleming
	Williamstown	05100101	Grant
	Carnico	05100102	Nicholas
Big Sandy	Fishtrap	05070202	Pike
	Dewey	05070203	Floyd
Little Sandy	Grayson	05090104	Carter, Elliott
	Greenbo	05090104	Greenup
Tygarts Creek	Smokey Valley	05090103	Carter

*Located in Land Between the Lakes area

APPENDIX D

FISH KILL SUMMARY

APPENDIX D

Fish Kill Summary

County	Stream	Date	Miles Affected	Cause	Number of Fish Killed
		1982			
Bullitt	Whittaker Run	Jul 27	0.75	Dairy Manure	500
Clinton	Pickens Br - Illwill Ck Dale Hollow Lake	Mar 28	4 miles and 40-100 acres (lake)	Crude oil	700
Cumberland	Williams Creek	May 12	0.75	Crude oil	-
Daviess	Big Ditch - Panther Ck	Jul 13	9.1	Anhydrous ammonia	7,900
Estill	Crooked Creek	Aug 5	0.1	Herbicides	200
Fayette	Gainsway Farm Pond	May	3 acres	Copper Sulfate	-
Fayette/Scott	North Fork Elkhorn Ck	Jun 6	15 (approx)	Zinc/cyanide	69,306
Fayette	South Fork Elkhorn Ck	Jul 6	-	WWTP malfunction	200
Fayette	West Hickman Ck	Aug 3	1.0	Municipal wastewater	570
Harrison	Indian Creek	Oct 15	-	Manure	4
Henry	Bartlett Branch	Nov 30	-	Unknown Chemicals	-
Jefferson	Beargrass Creek	Jul 29	-	Unknown	250
Johnson	Tom's Creek	May 20	6.0	Chicken Manure	-
Kenton	Banklick Creek	May 5	-	Chlorine	-

APPENDIX D continued

Fish Kill Summary

County	Stream	Date	Miles Affected	Cause	Number of Fish Killed
Lawrence	Little Blaine Creek	Jul 22	-	Chicken Manure	-
Leslie	Polls Creek - Cutshin Ck	Jan 6	4.0	Crude oil	-
Mason	Limestone Creek - Ohio R	Jul 30	2 - 3 acres	DO depletion	-
Nelson	Cox's Creek	Jul 3	3.0	Dairy manure	500
Nelson	Pottinger Creek	Sept 12	-	Manure	8,050
Nelson	Tributary to Chaplin R	Nov 10	-	Natural DO depletion	25
Pendleton	Fork Lick Creek	Nov 5	1.0	Hog manure	15
Perry/Breathitt	Rockhouse Fork	Jun 24	3.5	Acid mine water	-
Rowan	North Fork Triplett Creek	Sept 22	1.5	Pavement sealer	7,710
Russell	Lilly Creek	Jun 2	-	Municipal wastewater	200
Russell/Casey	Goose Creek	Aug 9	2.25	Dairy Manure	2,256
Wayne	Little South Fork	Apr 13	-	Crudge oil	50

APPENDIX D continued

Fish Kill Summary

County	Stream	Date	Miles Affected	Cause	Number of Fish Killed
		1983			
Bell	Yellow Creek	Sept 13	-	Municipal wastewater	-
Bourbon	Stoner Creek	Sept 10	-	Natural low DO	100
Bullitt	Farm Pond	Jun 3	-	Organic leachate	-
Clinton	Smith and Springs Creeks	Aug 22	2.1	Hog manure	31,375
Fayette	Lexingon Reservoir	Apr 8	1 acre	Diesel fuel	3
Franklin	Twin Creek	Apr 28	0.5	Parking lot sealant	100
Franklin	Elkhorn Creek	Aug 30 - Sept 2	15	Ammonia	-
Grayson	Beaver Dam Creek	Mar 10-14	3.83	Pentachlorophenol	11,896
Hardin	Valley Creek	Jul 19	-	Municipal wastewater	-
Harlan	Poor Fork Cumberland R	Jan 27	-	Trailer court waste	-
Harlan	Clover Fork Creek	Aug 9	-	Petroleum	200
Hickman	Mississippi River	Jun 15	-	Hydrochloric Acid	-
Johnson/Lawrence	Hammond Ck - Levisa Fk	Jul 7	-	Crude oil	-
Larue	North Fork Nolin River	Aug 14	0.6	Municipal wastewater	2,160
Leslie	Wolf - Raccoon - Cutshin Cks	Apr 7-8	8.0	Crude oil	-

APPENDIX D continued

Fish Kill Summary

County	Stream	Date	Miles Affected	Cause	Number of Fish Killed
Leslie	Polls Creek - Cutshin Cks	Jun 7	3.0	Blackwater	-
Leslie	Cutshin Creek	Jul 8	1.7	Crude oil	-
Leslie	Cutshin Creek	Aug 22	2.0	Dust inhibitor	-
Madison	Otter Creek	Jul 12	-	Municipal wastewater	-
Magoffin	Left Fk - Rockhouse Ck - Phipps Fk	May 25	-	Crude oil/brine	-
Magoffin	Oakley Br - Licking R	Nov 5	-	Diesel Fuel	-
Marshall	Watch Creek	Jan 9	1.2	Hog manure	2,044
Martin	Wolf Creek	Aug 8	-	Coal slurry	-
Mason	Limestone Creek	Aug 22	3 acres	Unknown	6,000
Monroe	White Oak Creek	Jul 24	-	Unknown	-
Nelson	Private Lake	Mar 4	3 acres	Municipal wastewater	-
Nelson	Froman - Cox Creeks	May 11	3.69	Hog manure	9,815
Owen	Owenton City Reservoir	Aug 19	-	Copper sulfate	3,000
Pendleton	South Fork Grassy Creek	May 13	6.5	Fuel oil and rendering plant effluent	-
Pendleton	Unnamed tributary	July 28	0.2	Motor oil	30

APPENDIX D continued

Fish Kill Summary

County	Stream	Date	Miles Affected	Cause	Number of Fish Killed
Perry	North Fork Kentucky R	Mar 28-31	-	Diesel fuel	-
Pike	Caney Creek	Aug 30	-	Diesel fuel	-
Scott	Little Eagle - Eagle Cks	May 1	-	Herbicide	-
Scott	North Fork Elkhorn Creek	Aug 1	0.5	Municipal wastewater	1,000
Scott	North Fork Elkhorn Creek	Aug 8	-	Natural low DO	500
Taylor	Little Brush Creek	Jul 21	-	Hog manure	-
Washington/Marion	Pleasant Run Creek	Jul 5	2.5	Dairy Manure	7,964

APPENDIX E

SIGNIFICANT SEDIMENT YIELD RATE WATERSHEDS

Appendix E

TOTAL AREA, PERCENT LAND USE, AND PRIMARY SEDIMENT SOURCE OF P.L 566 WATERSHEDS IN KENTUCKY WITH SIGNIFICANT SEDIMENT YIELD RATES.

RIVER BASIN	HYDRO-LOGIC UNIT	P.L. 566 WATER-SHED	WATER-SHED AREA (ACRES)	LAND COVER (PERCENT OF TOTAL AREA)					POTEN-TIAL SEDI-MENT SOURCE
				AGRICUL-TURAL	FOREST	MINING	INCORP. AREAS	WATER	
SEDIMENT DELIVERY CLASS: VERY HIGH									
GREEN	05110002	130	7,700	93.1%	6.1%	0.0%	0.0%	0.8%	AGRIC
		240	9,200	99.7	0.3	0.0	0.0	0.0	AGRIC
	05110006	060	8,050	4.5	15.4	80.1	0.0	0.0	MINING
SEDIMENT DELIVERY CLASS: HIGH									
OHIO R MIN TRIB	05140201	120	9,250	76.8%	17.4%	5.1%	0.0%	0.6%	AGRIC
		190	640	98.4	0.0	0.0	0.0	1.6	AGRIC
KENTUCKY	05100205	160	15,820	75.7	24.2	0.0	0.0	0.1	AGRIC
		200	15,990	90.3	3.6	0.0	6.1	0.0	AGRIC
GREEN	05110001	060	10,970	69.2	30.7	0.0	0.0	0.1	AGRIC
		240	14,380	72.9	27.0	0.0	0.0	0.1	AGRIC
		270	8,850	75.7	23.8	0.0	0.0	0.5	AGRIC
	05110002	UN6 1/	10,660	63.0	16.8	0.0	0.0	0.2	AGRIC
	05110004	030	33,260	84.6	14.4	0.0	1.0	0.1	AGRIC
SEDIMENT DELIVERY CLASS: MODERATE									
OHIO R MIN TRIB	05090203	250	7,060	89.5%	10.5%	0.0%	0.0%	0.0%	AGRIC
		UN1 1/	4,490	81.7	12.9	0.0	0.0	5.3	AGRIC
	05140201	140	7,030	94.9	0.7	1.0	0.0	3.4	AGRIC
		170	19,660	74.7	22.0	3.1	0.0	0.2	AGRIC
		210	25,050	74.3	23.9	1.1	0.0	0.7	AGRIC
	05140203	120	11,700	83.2	16.2	0.0	0.0	0.6	AGRIC
BIG SANDY	05070203	130	10,240	27.6	59.7	12.7	0.0	0.0	AGRIC
LICKING	05100101	090	24,620	67.1	32.8	0.1	0.0	0.0	AGRIC
KENTUCKY	05100205	080	23,160	67.5	27.1	0.0	5.4	0.0	AGRIC
		110	27,050	80.2	19.8	0.0	0.0	0.0	AGRIC
		190	18,720	83.9	4.9	0.0	11.2	0.0	AGRIC
GREEN	05110001	230	12,160	64.5	35.5	0.0	0.0	0.0	AGRIC
		250	6,900	44.3	54.5	0.7	0.0	0.4	AGRIC
		300	9,250	55.2	44.5	0.0	0.0	0.3	AGRIC
	05110002	340	37,540	87.1	11.2	0.0	1.5	0.2	AGRIC
	05110003	070	28,970	33.3	20.2	42.0	0.0	4.5	MINING
		090	23,840	39.6	36.7	22.3	0.0	1.5	AGRIC
	05110004	010	27,120	73.3	26.7	0.0	0.0	0.0	AGRIC
		050	19,670	65.1	30.3	0.3	2.3	2.0	AGRIC
		060	30,890	70.0	28.3	0.0	0.0	1.7	AGRIC
		070	24,580	65.9	34.0	0.0	0.0	0.1	AGRIC
	05110005	080	6,620	51.7	48.3	0.0	0.0	0.0	AGRIC
UPPER CUMBERLND	05130102	030	18,880	62.7	37.3	0.0	0.0	0.0	AGRIC
	05130103	090	9,350	66.2	33.8	0.0	0.0	0.0	AGRIC
	05130105	210	35,180	53.0	42.5	0.5	3.9	0.0	AGRIC
LOWER CUMBERLND	05130205	270	6,840	69.3	30.7	0.0	0.0	0.0	AGRIC
SALT	05140103	030	12,020	62.1	36.7	0.0	0.0	1.2	AGRIC
SEDIMENT DELIVERY CLASS: LOW									
OHIO R MIN TRIB	05090201	390	26,830	80.2%	17.0%	0.0%	2.7%	0.0%	AGRIC
	05090203	150	9,770	82.3	13.1	0.0	0.0	4.6	AGRIC
		240	15,650	84.7	13.8	0.0	0.0	1.5	AGRIC
	05140104	190	20,480	47.4	47.4	0.0	0.0	5.2	AGRIC
		240	5,540	47.7	46.6	0.0	0.0	5.6	AGRIC
	05140201	060	15,950	58.5	40.4	0.6	0.0	0.8	AGRIC
	05140203	060	8,950	54.9	43.4	0.8	0.0	1.0	AGRIC
		190	14,210	61.2	32.8	0.0	0.0	6.1	AGRIC
TRADEWATER	05140205	020	9,330	13.4	69.3	17.3	0.0	0.0	MINING
TYGARTS CREEK	05090103	200	2,740	28.8	60.2	4.0	0.0	6.9	AGRIC
LICKING	05100101	050	13,650	44.2	55.4	0.2	0.0	0.2	AGRIC
		080	31,140	52.0	47.4	0.6	0.0	0.0	AGRIC
		260	13,610	90.9	8.3	0.0	0.0	0.8	AGRIC
	05100102	030	19,100	87.0	12.7	0.0	0.0	0.3	AGRIC
		070	17,130	88.4	11.4	0.0	0.0	0.2	AGRIC
		080	30,560	72.8	27.1	0.0	0.0	0.1	AGRIC
KENTUCKY	05100201	190	12,030	34.7	64.9	0.4	0.0	0.0	AGRIC
		200	11,630	38.3	58.9	2.8	0.0	0.0	AGRIC
		230	5,130	32.9	67.1	0.0	0.0	0.0	AGRIC
	05100203	060	25,760	41.5	57.1	1.4	0.0	0.0	AGRIC
	05100204	090	5,530	29.5	70.5	0.0	0.0	0.0	AGRIC
		130	14,750	36.8	61.1	0.1	0.0	0.0	AGRIC
		180	31,000	61.0	38.9	0.0	0.0	0.0	AGRIC
	05100205	010	25,370	62.6	37.4	0.0	0.0	0.0	AGRIC
		100	70,900	81.1	16.8	0.0	1.9	0.2	AGRIC
		170	60,010	85.9	11.3	0.0	1.1	1.7	AGRIC
		180	61,870	75.3	24.7	0.0	0.0	0.0	AGRIC
		300	14,090	56.4	43.6	0.0	0.0	0.0	AGRIC
		320	21,410	88.8	10.8	0.0	0.0	0.4	AGRIC
		380	21,230	81.3	11.7	0.0	7.0	0.0	AGRIC
		400	15,470	95.3	4.7	0.0	0.0	0.0	AGRIC
GREEN	05110001	050	50,690	63.7	35.5	0.0	0.0	0.8	AGRIC
		060	6,460	42.1	57.9	0.0	0.0	0.0	AGRIC
		160	33,980	84.0	15.7	0.0	0.0	0.3	AGRIC
		170	33,660	78.6	18.6	0.0	2.4	0.4	AGRIC
	05110002	040	30,770	55.3	44.7	0.0	0.0	0.1	AGRIC
		050	20,040	52.5	46.6	0.0	0.0	0.8	AGRIC
		160	70,870	76.5	23.3	0.0	0.0	0.1	AGRIC
		170	11,760	44.8	8.8	0.0	27.2	0.0	AGRIC
		180	111,090	76.3	23.3	0.0	0.0	0.4	AGRIC

1/ : UN6 IS AN UNNUMBERED WATERSHED DRAINED BY DIFFICULT CREEK
UN1 IS AN UNNUMBERED WATERSHED DRAINED BY LANDING CREEK

RIVER BASIN	HYDRO-LOGIC UNIT	P.L. 566 WATER-SHED	WATER-SHED AREA (ACRES)	LAND COVER (PERCENT OF TOTAL AREA)					POTEN-TIAL SEDI-MENT SOURCE
				AGRICUL-TURAL	FOREST	MINING	INCORP. AREAS	WATER	
SEDIMENT DELIVERY CLASS: LOW (CONTINUED)									
GREEN	05110002	200	51,250	73.4	18.3	0.0	6.1	2.2	AGRIC
		230	47,630	91.7	2.0	0.0	6.2	0.0	AGRIC
		360	39,920	66.4	33.2	0.1	0.0	0.2	AGRIC
	05110004	040	81,590	62.0	29.6	0.0	0.0	8.4	AGRIC
		080	16,020	39.5	59.5	0.0	0.0	1.0	AGRIC
		090	26,320	47.8	52.1	0.0	0.0	0.0	AGRIC
		150	10,570	35.2	64.4	0.3	0.0	0.1	AGRIC
		160	46,600	51.0	39.1	7.6	2.2	0.2	AGRIC
		170	24,740	41.0	55.5	3.4	0.0	0.1	AGRIC
	05110005	040	26,200	57.6	30.4	10.5	0.0	1.5	AGRIC
		110	49,130	72.2	26.9	0.6	0.0	0.3	AGRIC
		130	6,640	56.8	43.2	0.0	0.0	0.0	AGRIC
		140	18,040	73.1	26.8	0.1	0.0	0.1	AGRIC
		150	15,590	49.2	46.1	4.2	0.0	0.5	AGRIC
	05110006	050	18,330	15.9	43.4	26.4	4.4	9.9	MINING
UPPER CUMBERLND	05130101	180	22,290	45.2	49.3	3.3	2.1	0.1	AGRIC
		240	12,040	24.5	66.6	8.8	0.0	0.1	AGRIC
LOWER CUMBERLND	05130205	260	19,430	79.6	20.4	0.0	0.0	0.0	AGRIC
SALT	05140102	070	18,370	58.8	41.0	0.0	0.0	0.2	AGRIC
TENNESSEE	06040006	070	6,850	55.3	38.7	0.0	6.0	0.0	AGRIC
MISSISSIPPI	08010201	020	46,740	84.5	15.2	0.0	0.0	0.3	AGRIC