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Kentucky River Basin: Unified Long-Range Water Resources Plan. Historic Water Supply Plans of the Kentucky River Basin

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Kentucky River Basin:

Unified Long-Range Water Resources Plan

Historic Water Supply Plans of the Kentucky River Basin

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Prepared for:
The Kentucky River Authority

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Final Draft
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Historic Water Supply Plans of the Kentucky River Basin

The Kentucky River Authority was mandated by regulatory statute 420 KAR 1:030, Section 4 to develop a Unified Long-Range Water Resources Plan (ULRWRP) for the Kentucky River Basin. This summary document was written by the Kentucky Water Resources Research Institute under a contractual agreement with the Kentucky River Authority in support of this plan. It addresses several required components of the ULRWRP, including:

- Acquisition and utilization of the Kentucky River Lock and Dam system;
- Construction, acquisition and control of projects and facilities;
- Regulation of flows and allocation of supplies;
- Basin-wide and specific local land and water conservation measures and practices; and
- Economic development.

This report provides summaries of the numerous documents written about the water resources of the Kentucky River. Section 1.0 provides a chronological listing of these documents. Due to the fact that many of these reports were written upon the request of a local, state or federal agency, or were required by state or federal legislation, Section 2.0 categorizes the historical documents by the agency or organization sponsoring the specific study. The document summaries in Section 3.0 are also categorized by the sponsoring entity.

Reports written about the Kentucky River basin cover a variety of topics, but focus primarily on water supply issues and the potential for developing additional supplies in the basin. Many proposals are offered for ways to increase storage in the mainstem pools of the river, as well as for potential reservoir sites in various river tributaries. The summary table at the conclusion of the report (Section 4.0) lists historically proposed water supply alternatives, along with a notation of which projects were actually implemented. For those supply alternatives not completed, an attempt is made to explain why it was not pursued.

Table of Contents

1.0 Chronological Listing of Reports..... 3

2.0 Listing of Reports by Sponsoring Agency/Organization 7

3.0 Summary of Reports 11

 3.1 Kentucky River Authority 11

 3.2 U.S. Army Corps of Engineers 25

 3.3 Kentucky Office of the Attorney General 30

 3.4 Kentucky-American Water Company 31

 3.5 Kentucky River Basin Steering Committee..... 32

 3.6 Kentucky Geological Survey 37

 3.7 Regional Water Supply Planning 38

 3.8 Lexington-Fayette Urban County Government 39

 3.9 Kentucky Natural Resources and Environmental Protection Cabinet..... 41

 3.10 U.S. Geological Survey 42

 3.11 Water Resource Development Commission 43

 3.12 Miscellaneous Reports..... 44

4.0 Proposed Kentucky River Basin Water Supply Projects 48

1.0 Chronological Listing of Reports

This section provides a chronological listing of water resource reports written about the Kentucky River Basin. Each of these reports is subsequently summarized in Section 3.0 of this document, and specific water supply projects proposed in the reports are listed in the table in Section 4.0.

- 1958, U.S. Army Corps of Engineers, *Review Report on Kentucky River and Tributaries for Flood Control and Allied Purposes.*
- 1978, U.S. Army Corps of Engineers, *Metropolitan Lexington Urban Study: Water Resources Analysis.*
- 1978, U.S. Army Corps of Engineers, *Special Report: Water Supply Alternatives to Red River Lake.*
- 1981, U.S. Department of Agriculture, *Kentucky River Basin Report on Water and Related Land Resources.*
- 1985, Daugherty & Trautwein, Inc., *Kentucky River Survey, Rehabilitation Study for Locks and Dams 5 through 14.*
- 1986, *Proceedings of the Kentucky River Conference.*
- 1987, Rebmann, J.R. and Suzanne M. Kilner, *A Multi-Purpose Surface Impoundment Proposal for the Kentucky River.*
- 1988, Rebmann, J. and Hassell, D., *The Kentucky River: An Outline of Issues for Water Supply Planning.*
- 1988, U.S. Army Corps of Engineers, *Interim Report Kentucky River and Tributaries: Station Camp Creek, Kentucky Reconnaissance Report, Volumes 1-3.*
- 1988, University of Kentucky College of Agriculture, *Prospects and Impacts for Reservoir Location: Jackson County, Kentucky.*
- 1989, *Proceedings of the Kentucky River Basin Technical Advisory Committee: Alternative Evaluation Workshop.*
- 1989, C.J. Fuller Consulting Engineers, A.M. Kinney, Inc. and Legeay Inc., *Kentucky River Survey: 1989 Update of Locks & Dams 5 through 14.*
- 1990, U.S. Army Corps of Engineers, Louisville District, Kentucky River, *Reconnaissance Level Cost Estimate Data.*

- 1990, HARZA Engineering Company, GRW Engineers, Inc. and Construction Dynamics Group, *Phase I Report: Water Demands and Water Supply Yield and Deficit.*
- 1990, Carey, D., *Water Availability Modeling and Analysis of the Kentucky River.*
- 1991, Environmental Science & Engineering, *Kentucky River Aquatic Study.*
- 1991, HARZA Engineering Company, *Phase II Report: Development of a Long-Range Water Supply Plan.*
- 1991, U.S. Geological Survey and Kentucky Natural Resources and Environmental Protection Cabinet, *Evaluation of the Drought Susceptibility of Water Supplies Used in the Kentucky River Basin in 1988.*
- 1992, HARZA Engineering Company, *Source of Supply/Safe Yield Study.*
- 1992, Carey, D., *Water Quality in the Kentucky River Basin.*
- 1992, University of Kentucky College of Agriculture, *The Kentucky River Basin: A Land Use and Recreation Study for the Kentucky River Authority.*
- 1992, Shepherd, Jack, *Report to Department of Natural Resources: Eagle Lake, Kentucky.*
- 1993, GRW Engineers, *Kentucky River Pool 9 Capacity Study.*
- 1994, Tellus Institute, *An Evaluation of Kentucky-American Water Company's Long-Range Planning.*
- 1994, Carey, D.I., Currens, J.C., Dinger, J.S., Kipp, J.A., Wunsch D.R. and Conrad, P.G., *Groundwater in the Kentucky River Basin.*
- 1995, Kentucky River Authority, *Station Camp Creek Preliminary Jackson County Reservoir Site Analysis.*
- 1996, Kentucky Water Resources Research Institute, *Kentucky River Basin Water Supply Assessment Study.*
- June 1996, Task II Report, Part 1 – Evaluation of Water Supplies in the North, South and Middle Fork Kentucky River Watersheds
- August, 1996, Task I Report – Summary and Evaluation of Water Supply Studies for the Kentucky River Basin
- September 1996, Task III Report – KYBASIN User's Manual: A Water Supply Assessment Model for the Kentucky River Basin
- September 1996, Task III Report – Water Use Estimation and Forecasting for the Kentucky River Basin
- September 1996, Task III Report – Deficit Analysis

- October 1996, Task IV Report – KYROM User’s Manual: A Drought Management Model for the Kentucky River Basin
- October 1996, Task V Report – Estimation of the Responsiveness of Water Use to Changes in Rates: A Methodology and Final Estimates Using KAWC Data
- December 1996, Task II Report, Part 2 – Evaluation of Water Supplies in the Red River, Dix River and Mainstem Watersheds of the Kentucky River
- December 1996, Task V Report – Development and Evaluation of Water Supply Alternatives
- November 1996, HARZA Engineering Company, *Feasibility and Environmental Assessment for Providing Additional Storage at Kentucky River Locks and Dams 8-14.*
- 1997, U.S. Army Corps of Engineers, *Upper Kentucky River Basin, Kentucky: Reconnaissance Phase Water Resources Study.*
- 1997, Kentucky Division of Water, *Kentucky River Basin Status Report.*
- 1997, U.S. Army Corps of Engineers, Louisville District, *Kentucky River Survey: Rehabilitation Study for Locks and Dams 5 through 9.*
- 1998, Kentucky Water Resources Research Institute, *Kentucky River Modeling and Monitoring Needs Assessment.*
- 1998, Kentucky Water Resources Research Institute, *Kentucky River Basin Water Quality Assessment Study.*
- 1998, Waltman R.M. and R. Jan Stevenson, *A Review of Research on the Kentucky River Ecosystem: Biota and Human Impacts*
- 1999, Kentucky Water Resources Research Institute, *Summary Report: 1999 Kentucky River Watershed Watch Data Collection Effort.*
- 1999, Fayette County Water Supply Planning Council, *Fayette County 20-Year Comprehensive Water Supply Plan.*
- 1999, Kentucky Infrastructure Authority, et. al., *Water Resource Development: A Strategic Plan.*
- 2000, Kentucky Water Resources Research Institute, University of Kentucky Dept. of Civil Engineering and Kentucky Division of Water, *1998-1999 Monitoring Strategy: Kentucky River Basin Management Unit.*
- 2000, Kentucky Water Resources Research Institute, *Summary Report: 2000 Kentucky River Watershed Watch Data Collection Effort.*
- 2000, Kenviron, *Feasibility Study for the Jackson County Lake Project and Alternatives.*

2001, Kentucky Water Resources Research Institute, *Summary Report: 2001 Kentucky River Watershed Watch Data Collection Effort.*

2001, University of Kentucky Department of Civil Engineering, *Impact of Raising Crest-Level of the Dam on North Fork Kentucky River in the Vicinity of Hazard Raw-Water Intake Tower.*

2002, Kentucky Water Resources Research Institute, *Kentucky River Basin Management Plan.*

2002, Kentucky Water Resources Research Institute, *Summary Report: 2002 Kentucky River Watershed Watch Data Collection Effort.*

2.0 Listing of Reports by Sponsoring Agency/Organization

This section provides a listing of water resource reports written about the Kentucky River Basin, grouped by the agency or organization sponsoring the study. Each of these reports is subsequently summarized in Section 3.0 of this document, and specific water supply projects proposed in the reports are listed in the table in Section 4.0.

2.1 Kentucky River Authority Studies

- 2.1.1 Kentucky River Authority, 1995, *Station Camp Creek Preliminary Jackson County Reservoir Site Analysis*.
- 2.1.2 Kentucky Water Resources Research Institute, 1996, *Kentucky River Basin Water Supply Assessment Study*.
 - Task I Report – Summary and Evaluation of Water Supply Studies for the Kentucky River Basin
 - Task II Report, Part 1 – Evaluation of Water Supplies in the North, South and Middle Fork Kentucky River Watersheds
 - Task II Report, Part 2 – Evaluation of Water Supplies in the Red River, Dix River and Mainstem Watersheds of the Kentucky River
 - Task III Report – Water Use Estimation and Forecasting for the Kentucky River Basin
 - Task III Report – KYBASIN User's Manual: A Water Supply Assessment Model for the Kentucky River Basin
 - Task III Report – Deficit Analysis
 - Task IV Report – KYROM User's Manual: A Drought Management Model for the Kentucky River Basin
 - Task V Report – Estimation of the Responsiveness of Water Use to Changes in Rates: A Methodology and Final Estimates Using KAWC Data
 - Task V Report – Development and Evaluation of Water Supply Alternatives
- 2.1.3 HARZA Engineering Company, November 1996, *Feasibility and Environmental Assessment for Providing Additional Storage at Kentucky River Locks and Dams 8-14*.
- 2.1.4 Kentucky Water Resources Research Institute, 1998, *Kentucky River Modeling and Monitoring Needs Assessment*.
- 2.1.5 Kentucky Water Resources Research Institute, 1998, *Kentucky River Basin Water Quality Assessment Study*.
- 2.1.6 Waltman R.M. and R. Jan Stevenson, 1998, *A Review of Research on the Kentucky River Ecosystem: Biota and Human Impacts*.
- 2.1.7 Kentucky Water Resources Research Institute, 1999, *Summary Report: 1999 Kentucky River Watershed Watch Data Collection Effort*.
- 2.1.8 Kentucky Water Resources Research Institute, University of Kentucky Dept. of Civil Engineering and Kentucky Division of Water, 2000, *1998-1999 Monitoring Strategy: Kentucky River Basin Management Unit*.

- 2.1.9 Kentucky Water Resources Research Institute, 2000, *Summary Report: 2000 Kentucky River Watershed Watch Data Collection Effort*.
 - 2.1.10 Kentucky Water Resources Research Institute, October 2001, *Summary Report: 2001 Kentucky River Watershed Watch Data Collection Effort*.
 - 2.1.11 University of Kentucky Department of Civil Engineering, November 2001, *Impact of Raising Crest-Level of the Dam on North Fork Kentucky River in the Vicinity of Hazard Raw-Water Intake Tower*.
 - 2.1.12 Kentucky Water Resources Research Institute, April 2002, *Kentucky River Basin Management Plan*.
 - 2.1.13 Kentucky Water Resources Research Institute, November 2002, *Summary Report: 2002 Kentucky River Watershed Watch Data Collection Effort*.
- 2.2 U.S. Army Corps of Engineers Studies
- 2.2.1 U.S. Army Corps of Engineers, 1958, *Review Report on Kentucky River and Tributaries for Flood Control and Allied Purposes*.
 - 2.2.2 U.S. Army Corps of Engineers, 1978, *Metropolitan Lexington Urban Study: Water Resources Analysis*.
 - 2.2.3 U.S. Army Corps of Engineers, 1978, *Special Report: Water Supply Alternatives to Red River Lake*.
 - 2.2.4 U.S. Army Corps of Engineers, 1988, *Interim Report Kentucky River and Tributaries: Station Camp Creek, Kentucky Reconnaissance Report, Volumes 1-3*.
 - 2.2.5 U.S. Army Corps of Engineers, Louisville District, Kentucky River, 1990, *Reconnaissance Level Cost Estimate Data*.
 - 2.2.6 U.S. Army Corps of Engineers, Louisville District, December 1997, *Kentucky River Survey: Rehabilitation Study for Locks and Dams 5 through 9*.
 - 2.2.7 U.S. Army Corps of Engineers, 1997, *Upper Kentucky River Basin, Kentucky: Reconnaissance Phase Water Resources Study*.
- 2.3 Kentucky Office of the Attorney General
- 2.3.1 Tellus Institute, 1994, *An Evaluation of Kentucky-American Water Company's Long-Range Planning*.
- 2.4 Kentucky-American Water Company Study
- 2.4.1 Environmental Science & Engineering, 1991, *Kentucky River Aquatic Study*.
 - 2.4.2 HARZA Engineering Company, 1992, *Source of Supply/Safe Yield Study*.
 - 2.4.3 GRW Engineers, 1993, *Kentucky River Pool 9 Capacity Study*.
- 2.5 Kentucky River Basin Steering Committee
- 2.5.1 *Proceedings of the Kentucky River Basin Technical Advisory Committee: Alternative Evaluation Workshop, July 1989*.
 - 2.5.2 HARZA Engineering Company, GRW Engineers, Inc. and Construction Dynamics Group, 1990, *Phase I Report: Water Demands and Water Supply Yield and Deficit*.

- 2.5.3 HARZA Engineering Company, 1991, *Phase II Report: Development of a Long-Range Water Supply Plan.*
- 2.6 Kentucky Geological Survey Study
 - 2.6.1 Carey, D., 1990, *Water Availability Modeling and Analysis of the Kentucky River.*
 - 2.6.2 Carey, D., 1992, *Water Quality in the Kentucky River Basin.*
 - 2.6.3 Carey, D.I., Currens, J.C., Dinger, J.S., Kipp, J.A., Wunsch D.R. and Conrad, P.G., 1994, *Groundwater in the Kentucky River Basin.*
- 2.7 Regional Water Supply Planning Meeting Report
 - 2.7.1 Rebmann, J. and Hassell, D., 1988, *The Kentucky River: An Outline of Issues for Water Supply Planning.*
- 2.8 Lexington-Fayette Urban County Government
 - 2.8.1 Rebmann, J.R. and Suzanne M. Kilner, 1987, *A Multi-Purpose Surface Impoundment Proposal for the Kentucky River.*
 - 2.8.2 Fayette County Water Supply Planning Council, 1999, *Fayette County 20-Year Comprehensive Water Supply Plan.*
- 2.9 Kentucky Natural Resources and Environmental Protection Cabinet
 - 2.9.1 Daugherty & Trautwein, Inc., 1985, *Kentucky River Survey, Rehabilitation Study for Locks and Dams 5 through 14.*
 - 2.9.2 C.J. Fuller Consulting Engineers, A.M. Kinney, Inc. and Legeay Inc., October 1989, *Kentucky River Survey: 1989 Update of Locks & Dams 5 through 14.*
 - 2.9.3 Kentucky Division of Water, November 1997, *Kentucky River Basin Status Report.*
- 2.10 U.S. Geological Survey
 - 2.10.1 U.S. Geological Survey and Kentucky Natural Resources and Environmental Protection Cabinet, 1991, *Evaluation of the Drought Susceptibility of Water Supplies Used in the Kentucky River Basin in 1988.*
- 2.11 Water Resource Development Commission
 - 2.11.1 Kentucky Infrastructure Authority, et. al., 1999, *Water Resource Development: A Strategic Plan.*
- 2.12 Miscellaneous
 - 2.12.1 U.S. Department of Agriculture, 1981, *Kentucky River Basin Report on Water and Related Land Resources.*
 - 2.12.2 *Proceedings of the Kentucky River Conference, 1986.*

- 2.12.3 University of Kentucky College of Agriculture, March 1988, *Prospects and Impacts for Reservoir Location: Jackson County, Kentucky.*
- 2.12.4 University of Kentucky College of Agriculture, May 1992, *The Kentucky River Basin: A Land Use and Recreation Study for the Kentucky River Authority.*
- 2.12.5 Shepherd, Jack, June 1992, *Report to Department of Natural Resources: Eagle Lake, Kentucky.*
- 2.12.6 Kenvirons, December 2000, *Feasibility Study for the Jackson County Lake Project and Alternatives.*

3.0 Summary of Reports

3.1 Kentucky River Authority

3.1.1 *Station Camp Creek Preliminary Jackson County Reservoir Site Analysis* (KRA, 1995)

The Jackson County Empowerment Zone Committee approached the Kentucky River Authority to examine the potential of developing a dam and reservoir on Station Camp Creek. This reservoir would serve a dual function as a water supply reservoir and a recreational area. Four sites were evaluated for their potential as a new Jackson County Reservoir. The reservoir surface area at normal pool ranged from 900 to 1250 acres, with storage capacities of 24 to 27 billion gallons. Cost estimates ranged from \$27.2 million to \$29.2 million.

3.1.2 *Kentucky River Basin Water Supply Assessment Study* (KWRI, 1996)

This study was initiated through a contract between the Kentucky River Authority and the University of Kentucky – Kentucky Water Resources Research Institute in 1995. The purpose of the study was to review the results and recommendations of the 1991-1992 Harza reports in light of the 1990 census data and new modifications to the Kentucky River. The study resulted in nine separate reports as identified below:

Task I Report – Summary and Evaluation of Water Supply Studies for the Kentucky River Basin

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

Task II Report – Part 2: Evaluation of Water Supplies in the Red River, Dix River and Mainstem Watersheds of the Kentucky River

Task III Report – Water Use Estimation and Forecasting for the Kentucky River Basin

Task III Report – KYBASIN User's Manual: A Water Supply Assessment Model for the Kentucky River Basin

Task III Report – Deficit Analysis

Task IV Report – KYROM User's Manual: A Drought Management Model for the Kentucky River Basin

Task V Report – Development and Evaluation of Water Supply Alternatives

Task V Report – Estimation of the Responsiveness of Water Use to Changes in Rates: A Methodology and Final Estimates Using KAWC Data

Task I Report – Summary and Evaluation of Water Supply Studies for the Kentucky River Basin

The Task I report provided a review and critique of previous water supply studies of the Kentucky River Basin. In particular, the review focused on the 1990 Harza study, entitled “Phase I Report: Water Demands and Water Supply Yield and Deficit” (see 2.5.1) and the 1991 Harza study entitled “Phase II Report: Development of a Long-Range Water Supply Plan” (see 2.5.2). The purpose of the overall KWRI study was to identify and assess unexamined or changed conditions that could significantly impact the conclusions and recommendations of the previous Harza studies.

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

This report examined municipal and private water supplies in the North, South and Middle Fork watersheds of the Kentucky River. The three basins, with a combined area of over 2,600 square miles, form the upper forks region of the Kentucky River and lie entirely within the Eastern Coal Field physiographic region of Kentucky. Current and projected water supply adequacy and water system needs were examined for the municipal water systems in Breathitt, Knott, Leslie and Letcher Counties in the North Fork Kentucky River basin, Leslie County in the Middle Fork Kentucky River basin and Clay and Owsley Counties in the South Fork Kentucky River basin. These included the following eight municipal water suppliers: Fleming-Neon Water Company, Whitesburg Municipal Water, Hindman Municipal Water Works, Hazard Water Department, Jackson Municipal Water Works, Booneville Water & Sewer and Manchester Water Works. These also included the following three purchasing districts: Vicco Water System, Hima-Sibert Water District and North Manchester Water District.

Among the findings of the report were the following:

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

Water Suppliers: As of 1994, ten municipal water suppliers provided water for about 39,310 people in the region, either directly or through purchasing water districts. Projected growth in residential water service varied widely among systems, ranging from very limited growth at the Jackson Municipal Water Works to the more than doubling of Whitesburg Municipal Water’s service.

Water Resources: Given an average annual precipitation rate for the basin of 46 inches, the water yield from the basin was estimated to be 1.36 cubic feet per second per square mile, or 880,000 gallons per day per square mile. This water yield corresponded to about 8,800 gallons per day for every person living in the basin.

Water Quality: Streams in the North and Middle Fork basins continued to have problems caused by siltation and pathogens. Mining, agriculture, septic systems and petroleum activities were the major sources of stream pollution. Other potential sources of pollution in the region were effluent discharge sites, hazardous waste handling sites, water treatment plants and solid waste landfills.

Water Supply Adequacy: The Water Resources Branch of the Kentucky Division of Water groups water systems into three classes of susceptibility to water shortages during drought conditions. Systems are grouped by comparing average withdrawal rates to water availability at the point of withdrawal during drought conditions. The drought susceptibility classes are:

- A. Systems unlikely to experience water shortage during drought conditions.
- B. Systems that should be examined for susceptibility to water shortage during drought. Plans need to be made for response to possible shortage.
- C. Systems that are likely to have water shortage during drought conditions. Plans for response to shortage are necessary.

The ability of each system to meet demands, either at the time of the study or over the projected planning period, was evaluated by determining its drought susceptibility. Water supplies for the Hazard Water Department, Whitesburg Municipal Water, Hyden-Leslie County Water District, Booneville Water and Sewer and Manchester Water Works were considered inadequate for current and future needs (Class C). Water supplies for the Fleming-Neon Water System were adequate for current needs, but were not certain to meet peak demands during a drought by the year 2000 or average demand during a drought by the year 2010 (Class B). Water supplies for Jackson Municipal Water Works and Hindman Municipal Water Works were considered adequate for current needs (Class A).

Cost of Full Service: Cost estimates for providing full public water service in the Upper Forks region were developed. It was assumed that water service would be provided along every fork in the county. The total estimated cost was about \$200 million, or an average of about \$27.5 million per county. An additional 90,000 people, or 34,000 households, in the region would be provided with public water through the installation of 2,500 miles of new water lines.

Task II Report – Part 2: Evaluation of Water Supplies in the Red River, Dix River and Mainstem Watersheds of the Kentucky River

This report examined municipal and private water supplies in the Red River, Dix River and mainstem Kentucky River watersheds. The current and projected water supply adequacy and water system needs were examined for the municipal water systems in Boyle, Grant, Lincoln, Madison, Owen, Powell, Scott, and Wolfe Counties. The study included the following eight municipal water suppliers: Bullock Pen Water District, Owenton Water Works, Georgetown Municipal Water, Danville Water Works, Stanford Water Works, Berea College Water, Beech Fork Water Commission and Campton Water Works. It also included the following twelve water purchasers: Tri-Village Water District, Perryville Water District, Parksville Water District, Junction City Water System, Lake Village Water Association, Hustonville Water

Works, McKinney Water District, Southern Madison Water District, Garrard County Water Association, Stanton Water, Clay City Water and Powells Valley Water District.

Among the findings of the report were the following:

Demographics: Moderate growth and high growth population projections from the Kentucky State Data Center, and the assumption that each county would provide a level of service by the year 2020 that was commensurate with the average level of service currently provided in the Bluegrass region, were used to produce estimates of water use for the years 2000, 2010 and 2020. Moderate growth assumes only minor gains from migration; high growth reflects recent trends in migration (1990-94). Growth in population of 13 to 30 percent is projected for the eight county study area.

Water Suppliers: Nineteen water suppliers provided water for about 36,000 people in the region, either directly or through purchasing water districts. Regional growth through extension of service and population growth was estimated to range from 25 to 40 percent greater than that provided by 1994 service. Projected growth for the Stanford, Georgetown, Berea and Beech Fork systems was similar to that for the region. The Danville system is projected to have limited growth. High growth is expected for the Bullock Pen, Owenton and Campton Systems.

Water Resources: Given an average annual precipitation rate for the basin of 46 inches, the water yield from the basin was estimated to be 1.36 cubic feet per second per square mile, or 880,000 gallons per day per square mile. This water yield corresponded to about 8,800 gallons per day for every person living in the basin.

Water Supply Adequacy: The Water Resources Branch of the Kentucky Division of Water groups water systems into three classes of susceptibility to water shortages during drought conditions. Systems are grouped by comparing average withdrawal rates to water availability at the point of withdrawal during drought conditions. The drought susceptibility classes are:

- A. Systems unlikely to experience water shortage during drought conditions.
- B. Systems that should be examined for susceptibility to water shortage during drought. Plans need to be made for response to possible shortage.
- C. Systems that are likely to have water shortage during drought conditions. Plans for response to shortage are necessary.

The ability of each system to meet demands, either at the time of the study or over the projected planning period, was evaluated by determining its drought susceptibility. Except for Georgetown Municipal Water, supply system improvements in recent years had created sources of supply which were expected to be adequate to meet anticipated demands through the year 2020. The Georgetown system was serving 25-33 percent of its customers by purchasing water from the Frankfort Plant Board system. This alternative source, combined with the potential for reducing system leakage, mitigates the drought susceptibility of Georgetown. Based on projected demands, Stanford Water Works and Bullock Pen Water District needed to expand their treatment capabilities within the next five to ten years, and Owenton Water Works needed to expand its treatment capability within ten to fifteen years.

Task III Report – Water Use Estimation and Forecasting for the Kentucky River Basin

In this report, aggregate monthly water use was estimated for summer, peak demand and non-summer off-peak demand periods for the Kentucky River Basin. Water use was estimated for the 1970-1993 period, using Kentucky Division of Water use data, U.S. Census data for county demographic and economic conditions and U.S. Weather Service data for weather conditions. Factors such as population and manufacturing employment were found to generally affect water use. Temperature and rainfall in current and preceding months were found to affect use during the summer, peak period.

Population forecasts, both moderate and high growth series, were used along with manufacturing employment forecasts for water use forecasts. Water use forecasts were made for years out to 2020 under 1930 drought conditions for comparison with water supply estimates. The use estimates were made assuming pricing and other demand management policies remained constant. For Pool 9, under 1930 weather conditions and high (moderate) population growth, 2020 water use was forecast to be 70 (55) mgd, which is equal to 220 gallons per person per day. The aggregate water use for the basin was forecast to be 129 (110) mgd.

Since less was known about agricultural use of water for irrigation in the Kentucky River Basin, it could not be estimated in the same manner as use by existing water systems. A different approach was taken, which relied on inventories of agricultural activity, use rates of the activity, and the sources of supply other than the Kentucky River. It was estimated that agricultural demand for the Kentucky River water would be approximately 5 mgd during a 1930 drought, and would largely be drawn from areas which are near or below Pool 9.

Task III Report – KYBASIN User's Manual: A Water Supply Assessment Model for the Kentucky River Basin

KYBASIN is a computer model developed for the Kentucky River Authority by the Kentucky Water Resources Research Institute (KWRI) for the express purpose of simulating the Kentucky River Basin under a severe drought. This model was developed as part of the KWRI *Kentucky River Basin Water Supply Assessment Study*.

The KYBSASIN computer model was developed to simulate water exchanges and movement in the basin. KYBASIN is a planning tool designed to quantify daily water supply and deficits in the basin under a series of user-defined conditions. These conditions describe the design drought, demand forecasts, and physical parameters of the river system. Subsequent to its development, the model has been used in the development of the KRA Valve Operating Plan and by the Kentucky Division of Water in the modification of mainstem water withdrawal permits.

Task III Report – Deficit Analysis

This report quantified water supply in the Kentucky River Basin during a severe drought for the existing supply system/resources under current and projected demand forecasts. This quantification of the susceptibility of the basin to a severe drought was necessary for the Kentucky River Authority to properly develop a long-range water supply plan.

Impacts of the two most severe droughts on record, occurring in 1930 and 1953, were imposed on water demand forecasts for 1994, 2000, 2010 and 2020. Two demand forecasts were developed for each future year to reflect two population projections, one assuming a moderate population growth rate and one assuming a high population growth rate.

The analyses in this report identify potential water supply deficits in the basin under a severe drought occurrence, assuming current supply resources are not upgraded. The deficits ranged from 2.2 billion gallons for the 1953 drought occurring in 1994 to 9.7 billions gallons for the 1930 drought occurring in 2020 with high population growth.

The main finding of the deficit predictions was that significant water shortages would be incurred if a severe drought was to occur in the basin. Water shortages of varying intensity would occur basin-wide, with the largest deficits concentrating in pool 9. The susceptibility of the basin to a severe drought reinforced the need for an effective drought management strategy and long range water supply plan.

The results of this report were intended to inform and alert decision makers of the susceptibility of the basin to a severe drought; identify the magnitude and location of water shortages; isolate significant factors influencing water supply shortages; and provide an initial reference point for evaluating potential water supply alternatives aimed at eliminating or reducing water supply deficits in the basin during a severe drought. The final results of the report were modified and updated in the subsequent Task V Report in order to reflect the potential use of low level release valves in providing access to water supply storage below existing dam crests.

Task IV Report – KYROM User's Manual: A Drought Management Model for the Kentucky River Basin

The Kentucky River Operation and Management model is a computer application developed for the Kentucky River Authority by the Kentucky Water Resource Research Institute (KWRI) for the purpose of simulating the Kentucky River Basin during drought periods. The model is intended as a tool, providing estimates for future deficits in the basin over a 28-day horizon. Potential deficit management measures can be evaluated by their impact on reducing predicted deficits. The model allows decision-makers to quickly determine the impact of changes in reservoir releases, valve release strategies, crest gate operation, and demand curtailment on predicted deficits. The KYROM results enable decision-makers to develop an effective plan to manage water supply during a drought.

The KYROM model uses a similar hydraulic engine to that used by the KYBASIN model to simulate river behavior and predict deficits. A primary difference between the two models is their planning horizons. The KYROM model is intended to assist decision-makers at the time of drought, whereas the KYBASIN model is intended to assist decision-makers in preparing for a specific design drought. Consequently, the decision variables available in the KYROM model reflect drought management strategies/solutions that can be implemented immediately. KYROM decision variables do not include long-term structural changes to the river system as a means to manage the drought.

Task V Report – Development and Evaluation of Water Supply Alternatives

This report addressed the development and evaluation of alternative plans to provide for the long-range water supply needs for the Kentucky River Basin. The report is divided into the following four chapters: Chapter 1 – a summary of the previous Harza study and overview of the current KWRRRI study; Chapter 2 – a review of the results of the Task III deficit analysis; Chapter 3 – a discussion and evaluation of alternative long range plans; and Chapter 4 – a summary of the study along with conclusions and recommendations.

For the purposes of the report, the long-range water supply needs were quantified on the basis of forecasted demands for the years 1994, 2000, 2010 and 2020 under a 1930 drought. Each alternative was evaluated using the KYBASIN model (Ormsbee and Herman, 1996). The model was used to identify the reduction in water supply deficits associated with each supply alternative. The cost of each alternative was then determined using “reconnaissance level” costs developed as part of this study.

Potential supply alternatives were sub-divided into two major categories: 1) demand-side alternatives and 2) supply-side alternatives. Demand-side alternatives included those alternatives where future water supply deficits were reduced or managed through either long-term conservation pricing or short-term demand (drought) management strategies. Supply-side alternatives included those alternatives where future supply deficits were met through the development of additional water supplies. It was determined that the overall water shortage problem in the Kentucky River Basin could not be solved through conservation or demand management alone, but would require the implementation of some type of supply-side alternative.

Three major categories of supply alternatives were considered. These included main-stem alternatives, off-stem reservoirs and a treated water pipeline from Louisville to Lexington.

In order to reduce/eliminate the deficit for the lower basin (Pools 4-8), three separate options were considered, including: 1) short-term demand management; 2) relaxation of the minimum flow requirements; and 3) installation/rehabilitation of low-level release valves in dams 4-8. Based on an evaluation of the alternatives, it was recommended that the deficits in Pools 4-8 be eliminated by construction of low-level release valves in dams 4-8.

An evaluation of the impact of the installation/rehabilitation of low-level valves in dams 9-14 revealed that the 2020 high-demand deficit of 7.0 (in Pools 9-14) could be reduced to 3.0 billion gallons. The remaining deficit of 3 billion gallons could be addressed through five separate strategies, including 1) demand management; 2) installation of temporary crest gates on dams 9-14; 3) construction of a new dam at Lock and Dam Site 8; 4) construction of one or more off-stem reservoirs; and 5) construction of a treated water pipeline from Louisville to Lexington. From an economic perspective, the construction of valves in dams 9-14 along with the construction of temporary crest gates was found to be the best water-supply alternative. The second most economically viable option was the construction of an off-stem reservoir. Either alternative completely eliminated the remaining 3 billion gallon deficit.

Based on the results of this study, the following overall recommendations were made:

- 1.) Provide inter-pool release capabilities for Pools 4-14.
- 2.) Determine an effective operational policy for such facilities by considering the environmental impacts associated with their operation.
- 3.) Provide supplemental supply augmentation for Nicholasville by lowering the raw water intake (if necessary).
- 4.) Select a secondary water supply alternative from the following: temporary crest gates or permanent raising of dams 9-14, off-stem reservoirs, treated water pipeline from Louisville to Lexington, and main-stem dam at Lock and Dam 8.
- 5.) Utilize demand management to supplement the selected water supply alternative.
- 6.) Continue to work toward the development of a drought management plan for implementation prior to completion of adequate water supply facilities.

The conclusions of this report were inherently dependent on deficit projections made using the KYBASIN model. Variations in the KYBASIN model assumptions could increase or decrease the deficit projections by 1 to 2 billion gallons. In addition, reliance on the valve alternative for elimination of the majority of the deficit was dependent on an assumption that it would not result in adverse environmental impacts. Finally, more detailed studies of any selected plan would be necessary to finalize the selection of the optimum location and size of facilities, evaluate the potential environmental impact, optimize the engineering design of the facilities and determine the associated financial and political feasibility.

Task V Report – Estimation of the Responsiveness of Water Use to Changes in Rates: A Methodology and Final Estimates Using KAWC Data

This report analyzed the impact of changes in water and sewer rates on aggregate water use by Kentucky American Water Company (KAWC) customers from 1970 to 1993. For this estimation, researchers used a slightly modified version of the same econometric model developed to forecast use of the entire Kentucky River Basin.

Estimates based on the model showed that increases in water rates lead to statistically and economically significant changes in water use. “Elasticities” measure changes in use in percentage terms, thus, price (or rate) elasticity is simply the percentage change in (per capita) water use with respect to a given percentage change in rate. In this report, elasticities for water use with respect to water rates were estimated to be approximately -0.69 for peak use, -0.30 for off-peak use and -0.43 for the entire year. Thus, the response of water users to water rates was found to be especially noticeable during the summer months of peak demand.

3.1.3 Feasibility and Environmental Assessment for Providing Additional Storage at Kentucky River Locks and Dams 8-14 (HARZA, 1996)

This study was conducted in order “to develop and evaluate alternative measures to increase water supply storage and minimize the effects of major droughts on water supply in the Kentucky River basin” and was performed as a follow-up to the KWRI study. Specifically, for

Locks and Dams 8-14, it examined alternative methods of raising the dams up to four feet and using the water stored in the four feet below the existing dam crests.

It was found that the amount of water available within the four feet below the dam crests approximates the amount of water that could be made available by raising the dams. Approximately 3.7 billion gallons of static storage, or 40 percent of the expected water supply deficit in the event of a 1930 drought, would be made available from mining the pools. In addition, the cost of accessing this water was much less than the cost of raising the dams. In order to access the water, measures must be in place to transfer water from upstream to downstream pools when water levels are below the dam crests.

By raising the dams four feet, an additional 3.8 billion gallons would be made available. Various approaches to raising the dams were evaluated, including permanent fixed increases, various types of gates, flashboards and bulkheads and combinations of these measures. The fixed crest alternative was shown to be the least expensive, but had the greatest potential environmental impact since it would result in a permanent year-round increase in the normal pool levels. The gated alternatives are the most expensive, but minimize potential impacts since they would only be raised during low flow periods. The study recommended that the Authority implement the hydraulically operated hinged steel crest gate alternative for raising the dams.

Based on the findings of potential water storage increases and associated cost estimates, the following sequence of recommendations was made in the report:

- 1) Develop storage below dam crests (Pools 9, 10, 13 and 14)
- 2) Lower Beattyville and Nicholasville intakes (Pools 14 and 8)
- 3) Raise Dam 10
- 4) Raise Dam 9
- 5) Raise Dam 14
- 6) Raise Dam 13
- 7) Raise Dam 11 (following further study of potential impacts to agricultural fields)
- 8) Raise Dam 12 (following further study of potential impacts to agricultural fields)

3.1.4 *Kentucky River Modeling and Monitoring Needs Assessment* (KWRI, 1998)

In this report, three basic monitoring responsibilities of the Kentucky River Authority were identified: planning, operations and management. The report characterized all data currently available for use in supporting these functions, including streamflow, rainfall and water quality data. An attempt was then made to identify additional data needs. As a guide to satisfying these data needs and implementing a comprehensive monitoring network, the report provided a prioritization of proposed monitoring stations. By developing and implementing such a monitoring network, additional data could be collected on a continuing basis so as to provide a framework from which the Kentucky River Authority could make informed and scientifically-based operations and management decisions.

3.1.5 *Kentucky River Basin Water Quality Assessment Study* (KWRI, 1998)

This reports documents the procedures and results of the KWRI Kentucky River Water Quality Assessment Study, which was authorized by the Kentucky River Authority in 1997. The major tasks of the study included:

- 1) Develop water quality model of the Kentucky River system.
- 2) Identify and access existing sources of data.
- 3) Characterize biological impacts during low flow periods.
- 4) Test the developed water quality model with existing data.
- 5) Identify additional data needs and develop a monitoring network proposal.

Specifically, this report summarizes the work associated with the development, calibration and application of the CE-QUAL-W2 (Cole and Buchak, 1994; Corps of Engineers, 1990) water quality model to the Kentucky River. The primary objective of applying this model to the Kentucky River was to assess the impact of the operation of low-level control valves on the water quality of the river. This was accomplished by modeling the impact of the valves for low flow conditions associated with the 1930 drought of record along with demand projections for the year 2020. The results of the study indicated that for the modeled scenario, the proposed valves can be used to draw down the individual pools on the Kentucky River by at least four feet without causing significant chronic or acute impacts to the biota of the river.

3.1.6 *A Review of Research on the Kentucky River Ecosystem: Biota and Human Impacts* (Waltman R.M. and R. Jan Stevenson, 1998)

This report was prepared for the Kentucky River Authority as a part of the "Development of a Water Quality Model for the Kentucky River: Preliminary Identification of Basin Monitoring Needs." Its purpose was to supply relevant information for the development of a model to characterize biological impacts during low flow periods in the mainstem of the Kentucky River.

Specific communities susceptible to the alteration of the natural flow regime included decomposers, benthic organisms and pelagic organisms. Through this study, critical values for temperature and dissolved oxygen in relation to fish, and for dissolved oxygen in relation to macroinvertebrates, were identified in order to develop a dynamic model of the Kentucky River Ecosystem.

3.1.7 *Summary Report: 1999 Kentucky River Watershed Watch Data Collection Effort* (KWRI, 1999)

This report summarizes the results of the 1999 volunteer water quality sampling effort in the Kentucky River Basin. The Kentucky River Authority provided funding in support of the Kentucky River Watershed Watch monitoring network, and the Kentucky Water Resources Research Institute produced the annual summary report.

Sampling occurred at 93 separate sites across the basin at three different times for three main groups of parameters: herbicides/pesticides, pathogens, and nutrients and metals. In addition,

basic physical parameters (temperature, pH and dissolved oxygen) were also sampled. In general, the observed impacts associated with the measured herbicides and pesticides were minimal. In addition, dissolved oxygen readings were above a minimum threshold of 5 mg/L for nearly all cases. High fecal counts were observed in the North Fork of the Kentucky River and in both the North and South Forks of Elkhorn Creek, as well as Clear Creek, Town Branch and Jessamine Creek. The main nutrient of concern was phosphorus, which appeared in significant concentrations in both the North and South Forks of Elkhorn Creek and in Jessamine Creek. Significant metal concentrations were observed at three different sites on the Eagle Creek East Fork, North Fork of Kentucky River and Benson Creek.

It was recommended that, for at least the next two years, additional synoptic sampling be conducted in the headwater basins, while more frequent sampling is conducted at a smaller set of focused sites and for fewer constituents in the lower basins.

3.1.8 1998-1999 Monitoring Strategy: Kentucky River Basin Management Unit (KWRI, U.K. Dept. of Civil Engineering and KDOW, 2000)

During the fall of 1997 and spring of 1998, more than 30 organizations and agencies provided input for the development of a monitoring strategy for the Kentucky River Basin under the Kentucky Watershed Management Framework. The intent of the coordinated planning process was to carefully consider agency resources and capabilities, taking into account where and when each was conducting field work, in order to make the best use of available resources and collect the best information at the least cost. The coordinated planning effort was to take a multimedia approach by considering surface water and groundwater, water quality and quantity, biology, toxicity, fish tissue and sediment. Six overall objectives were to be met in developing the basin monitoring plan. These were:

- 1) Describe current conditions.
- 2) Characterize the impacts of predominant land uses.
- 3) Characterize least-impacted streams.
- 4) Meet sampling requirements for TMDL determinations.
- 5) Analyze trends.
- 6) Characterize groundwater/surface water interaction.

This report provides a summary of the strategic monitoring plan and the results associated with the 1997-1998 sampling effort in the Kentucky River Basin. It describes a standard set of water quality parameters and sampling regimes which were designed around types of land use/land cover to enable maximum utilization of programmatic resources and the best characterization of water quality.

3.1.9 Summary Report: 2000 Kentucky River Watershed Watch Data Collection Effort (KWRI, 2000)

This report summarizes the results of the 2000 volunteer water quality sampling effort in the Kentucky River Basin. The Kentucky River Authority provided funding in support of the

Kentucky River Watershed Watch monitoring network, and the Kentucky Water Resources Research Institute produced the annual summary report.

The sampling effort was conducted so as to be consistent with the scientific study plan developed by the Kentucky River Watershed Watch scientific advisory board, which describes monitoring objectives, methods, parameters, quality assurance and data management. Sampling occurred at 140 different sites across the basin. Sampling parameters assessed in the report include temperature, dissolved oxygen, conductivity, pH, fecal coliform, nutrients, herbicides, pesticides and metals.

In general, the observed impacts associated with the measured herbicides and pesticides were minimal. In addition, dissolved oxygen readings were above a minimum threshold of 5 mg/l for nearly all cases. High fecal counts were observed in the North Fork of the Kentucky River and in both the North and South Forks of Elkhorn Creek, as well as Clear Creek, Hickman Branch and Jessamine Creek. This finding was consistent with sample results from previous years.

The main nutrient of concern was phosphorus, which appeared in significant concentrations in both the North and South Forks of Elkhorn Creek and in Jessamine Creek. Significant metal concentrations were observed at several sites. Two of the sites had maximum metal concentrations in multiple categories: Hickman Creek, south of Nicholasville and Lotts Creek.

Following this second year of monitoring by the Kentucky River Watershed Watch sampling program, it was again recommended that additional synoptic sites be established in the headwater basins, while more frequent sampling be conducted at a smaller set of focused sites and for fewer constituents in the lower basins.

3.1.10 Summary Report: 2001 Kentucky River Watershed Watch Data Collection Effort (KWRI, 2001)

This report summarizes the results of the 2001 volunteer water quality sampling effort in the Kentucky River Basin. The Kentucky River Authority and Eastern Kentucky PRIDE provided funding in support of the Kentucky River Watershed Watch monitoring network, and the Kentucky Water Resources Research Institute produced the annual summary report.

The sampling effort was conducted so as to be consistent with the scientific study plan developed by the Kentucky River Watershed Watch scientific advisory board, which describes monitoring objectives, methods, parameters, quality assurance and data management. Sampling occurred at 144 different sites across the basin. Sampling parameters assessed in the report include temperature, dissolved oxygen, conductivity, pH, fecal coliform, nutrients, herbicides, pesticides and metals.

Dissolved oxygen readings were above a minimum threshold of 5 mg/l for nearly all cases. High fecal counts were observed in the North Fork of the Kentucky River, as well as in Clear Creek, Hickman Branch and Jessamine Creek. Focused fecal sampling in Breathitt County revealed continued significant impacts from straight pipes.

An evaluation of the nutrient results revealed that the main nutrient of concern was phosphorus, which appeared in significant concentrations in Jessamine Creek. Significant metal concentrations were observed at several sites. Five of the sites had maximum metals concentrations in multiple categories: Hickman Creek, south of Nicholasville; Muddy Creek, Army Depot in Union City; Black Spring, tributary of Clear Creek; Lost Creek; and Beech Fork, at Stone Coal Branch.

3.1.11 *Impact of Raising Crest-Level of the Dam on North Fork Kentucky River in the Vicinity of Hazard Raw-Water Intake Tower* (U.K. Dept. of Civil Engineering, November 2001)

Due to increasing water demand, the City of Hazard planned to expand its water treatment plant capacity. The raw water source for the Hazard plant is a pool formed on the North Fork of the Kentucky River by a low-level dam located a short distance (approximately 500 feet) downstream of its water intake structure. In order to insure adequate water supply during drought conditions, Hazard was considering increasing pool storage on the North Fork by raising the existing dam an additional two feet. The Kentucky River Authority, which oversees the North Fork of the Kentucky River, contracted with the University of Kentucky to perform a hydraulic modeling study to assess the potential floodplain impact of raising the dam.

Researchers at the University of Kentucky evaluated the impacts of raising the dam on 10-year, 50-year and 100-year flood water profiles. Varying profiles were computed by raising the dam's crest level by 8 feet above its existing height at 1-foot intervals. The well-established modeling tool, HEC-RAS, was utilized to compute the water surface profiles. All necessary data for the study was provided by the Kentucky River Authority.

The stream reach modeled in the study covered a length of 14.25 miles of the North Fork, from the upstream side of Raccoon Branch to the downstream side of Lick Branch. It was found that the greatest increase in water surface elevation was 2.7 inches, which resulted from an 8-foot increase in the crest level of the dam during a 100-year flood event. Corresponding values for 50-year and 10-year flood discharges were 3.2 inches and 4.5 inches, respectively. An increase in dam height of only 2-3 feet resulted in much more moderate increases in water surface elevation, ranging from 0.5 to 0.9 inches.

Guidelines established by the Federal Emergency Management Agency (FEMA) normally do not permit any increases to the 100-year floodplain water surface elevation as a result of changes or development within the floodplain. However, the Kentucky Division of Water may provide a waiver in cases involving increased water storage, as long as the increase in 100-year floodplain water surface elevations is negligibly small. Considering Hazard's necessity for increased raw water storage and the minor increase in water surface elevation associated with raising the dam by two feet, the study recommended that Hazard file for a permit to increase the height of the dam. A request to waive the FEMA guidelines should be based on the HEC-RAS results of this study.

3.1.12 *Kentucky River Basin Management Plan* (KWRI, April 2002)

The *Kentucky River Basin Management Plan* was prepared for the KRA by the University of Kentucky – Kentucky Water Resources Research Institute. It is a product of the activities associated with the first cycle of the Kentucky Watershed Management Framework, a dynamic, flexible structure for coordinating watershed management across Kentucky. Through this framework, watershed data are analyzed at five-year intervals, and watershed planning is expanded and improved in each cycle. Existing state and local programs are connected through the geographic focus of the watershed, promoting comprehensive efforts mobilized around managing these watersheds.

The Management Plan presents information and priorities identified in the first Kentucky River basin cycle (1997 – 2002), and sets forth priorities for activities during the second cycle. The document is divided into two major sections, entitled *Management Plans* and *Watershed Summaries by Region*. The first section provides Watershed Management Plans for the three priority watersheds in the basin—the Red River Gorge Watershed, the South Elkhorn Creek Watershed and the Eagle Creek Mouth Watershed. This section also summarizes Program Management Plans, which describe how activities of partner agencies will be coordinated during the second basin cycle scheduled to take place from July 2002 to July 2007. The *Watershed Summaries* describe relevant conditions in each of the basin's 97 watersheds, providing descriptive information (geography, waterways, land and water use and agency data assessment), results of framework rankings, highlights of critical issues and activities, diagrams of the watershed's position in the basin and related maps. The Management Plan can be viewed in its entirety at the website address <http://www.uky.edu/WaterResources/Watershed>.

3.1.13 *Summary Report: 2002 Kentucky River Watershed Watch Data Collection Effort* (KWRI, 2002)

This report summarizes the results of the 2002 volunteer water quality sampling effort in the Kentucky River Basin. The Kentucky River Authority provided funding in support of the Kentucky River Watershed Watch monitoring network, and the Kentucky Water Resources Research Institute produced the annual summary report.

The sampling effort was conducted so as to be consistent with the scientific study plan developed by the Kentucky River Watershed Watch scientific advisory board, which describes monitoring objectives, methods, parameters, quality assurance and data management. Sampling occurred at 165 different sites across the basin. Sampling parameters assessed in the report include temperature, dissolved oxygen, conductivity, pH, fecal coliform, nutrients, herbicides and metals. Based on the findings of the 2002 report, ten of the most impacted streams are listed in the following table.

2002 KRWW Ten Most Impacted Streams

Stream	County	Pollutants
Ten Mile Creek	Grant	High conductivity/sulfate
Dreaming Creek	Madison	High metals, nitrogen, phosphorus
Town Branch/Wolf Run	Fayette	High nitrogen, phosphorus, fecals
South Fork Elkhorn Creek	Fayette, Woodford, Scott	High metals, nitrogen, phosphorus
Clarks Run	Boyle	High metals, nitrogen, fecals
Muddy Creek	Madison	High metals, fecals
West Hickman Creek	Jessamine	High fecals
Jessamine Creek	Jessamine	High fecals
Silver Creek	Madison	High fecals
Clear Creek	Woodford	High fecals

3.2 U.S. Army Corps of Engineers

3.2.1 Review Report on Kentucky River and Tributaries for Flood Control and Allied Purposes (USACOE, 1958)

This report addressed the advisability of improvements to the Kentucky River and its tributaries for flood control and other compatible purposes, and the improvement and expansion of the navigation system. In conducting the survey, the Corps held two public hearings and consulted various federal, state and local agencies.

The report describes existing and authorized Corps of Engineers' flood control projects, including one that had been completed, one under construction and three that had been authorized:

- 1) The "Jackson local protection project," located on the North Fork of the Kentucky River in Breathitt County, involved a 150-foot cutoff channel to reduce the 100-year frequency flood height by five feet. Construction of the channel was completed in October of 1956.
- 2) The construction of Buckhorn Reservoir had begun on the Middle Fork of the Kentucky River, about one-half mile upstream of Buckhorn. The reservoir was planned to provide flood control, as well as low flow increases in summer months.
- 3) Although construction had not yet begun, three additional flood control projects had been authorized by the Flood Control Act of 1938 for the Kentucky River Basin: the Jessamine Creek Reservoir on the main stem, the Booneville Reservoir on the South Fork and the local protection project at Frankfort. Under the Flood Control Act of 1944, the two planned reservoirs were also authorized for expansion to provide for hydroelectric power in combination with flood control.

During one of the public hearings, considerable opposition was expressed over the proposed construction of the Jessamine Creek dam. Representatives of the Kentucky Historical Society were concerned that the resulting reservoir would inundate Boonesboro, the site of the first white settlement west of the Appalachian Mountains. Others were concerned that the scenic value of the Kentucky River would be diminished.

In addition to these projects, twenty-five dam sites were investigated for flood control, water supply, low-flow regulation and pollution abatement in the Kentucky River Basin. Several channel improvement and local protection projects were also investigated. Additional studies were conducted to determine the advisability of improving the current navigation system on the Kentucky River and expanding it to the upper tributaries. Factors considered for navigation improvements included existing and potential commerce and potential savings in transportation costs.

In summary, the following recommendations were issued in the report:

- 1) The comprehensive plan for flood control and related purposes in the Ohio River should be modified to include reservoirs on Carr Fork, North Fork near Walkers Creek, Red River and Eagle Creek at an estimated cost to the federal government of \$37,598,000.
- 2) That the existing authority for the Jessamine Creek Reservoir should be disregarded upon authorization of the four recommended reservoirs.
- 3) That further improvements for navigation on the Kentucky River and its tributaries not be conducted at this time, due to limited prospective benefits to commerce.

In addition to their flood control benefits, the reservoirs at Carr Fork, Red River and Eagle Creek were anticipated to provide recreational benefits. The Carr Fork Reservoir was also expected to provide increased flow in the North Fork of the Kentucky River for the Hazard area. The Red River Reservoir would provide low flow regulation, which would improve water quality, propagate aquatic life and benefit recreational use. Additionally, the Red River Reservoir was cited as a source of future water supply for communities below the mouth of the Red River currently using the main stem of the Kentucky River as a source (i.e., Winchester, Lexington, Harrodsburg and Frankfort).

The Appendices of this report contain further details about the Kentucky River Basin's hydrology and flood control studies and include multiple flood profile curves, stage frequency curves and dam outlet discharge rating curves.

3.2.2 Metropolitan Lexington Urban Study: Water Resources Analysis (USACOE, 1978)

This report summarized the study area's water resource problems and needs, outlined water resource objectives and assessed the impacts of alternatives. In doing so, it identified a range of water resource alternatives for local consideration. Focus areas of the report included 1) flood control and flood plain management; 2) water related recreation; 3) water supply; 4) wastewater management; and 5) sludge management.

The section on water supply projected water supply demands for the 50-year planning period (1980-2030), based on high and low population projections. Due to hydrologic characteristics, the present location of water supply service areas, and the identification of existing and future water demand/supply relationships, the study area was divided into three segments: 1) Kentucky River, downstream of Dix River confluence; 2) Kentucky River, upstream of Dix River confluence; and 3) secondary tributaries which are used as a supply source for communities in

the study area. It was determined that existing and future water demands downstream of the Dix River confluence could be met by the sum of the combination of flows from uncontrolled basin runoff, navigation lock leakages, municipal sewage treatment discharges and Dix Dam leakage. Thus, alternative water supply sources were not necessary for this segment of the Kentucky River. For water suppliers upstream of the Dix River, it was determined that in order to meet future demand during 1930 drought conditions, pool drawdown would expose some of the water intakes. Therefore, it was concluded that supply alternatives would need to be developed for this segment. Of the communities using secondary tributaries for water supply, four were found to be in need of supplemental supply storage in order to meet future demand. These communities requiring supplemental storage included Paris, Millersburg, North Middletown and Georgetown.

3.2.3 Special Report: *Water Supply Alternatives to Red River Lake* (USACOE, 1978)

This report presented a general overview of the future water supply needs and potential alternatives for central Kentucky, including Red River Lake. The primary study area included communities which used the Kentucky River as their primary water supply source and would have benefited from water storage at the proposed Red River Lake. These communities included Clay City, Frankfort, Harrodsburg, Lancaster, Lawrenceburg, Lexington, Nicholasville, Owenton, Richmond, Stanton, Versailles, Wilmore and Winchester. In order to best evaluate all water supplies available to those in the primary study area, the entire Kentucky River Basin was considered as a secondary study area. Further, areas outside the basin were considered for interbasin transfer of water supplies that could meet the needs of the primary study area.

Two different population projections were used to estimate water demand for a 50-year planning period. Population projections calculated by OBERS (Office of Business Economics Research Service) were generally significantly lower than those made by Spindletop Research. This resulted in two significantly different projections for the 2030 water demand during 1930 drought conditions. However, water supply alternatives were considered in relation to their ability to meet demands of either or both projections.

Both demand-side measures to reduce water consumption and supply-side measures to provide additional water supplies were evaluated in the study. Although demand reduction through water pricing strategies, reuse and conservation was predicted to potentially reduce consumption by 20 percent, future demands would still exceed available supplies. Such measures were, however, included as components in combination with other supply-side alternatives.

Supply-side measures were categorized as meeting demands of the individual community or regionally. Alternatives considered for individual communities included independent reservoirs requiring the construction of a new treatment plant facility and reservoirs that would supplement flows in the Kentucky River near each community's existing water supply intake. Regional alternatives included utilization of Kentucky River pool storage, interbasin water transfer, groundwater sources, reallocation of water storage in existing multi-purpose reservoirs and new impoundments. Economically, the regional alternatives were found to be more cost-effective for the communities being studied.

Based on an evaluation of water demand through 2030 and a 1930 drought reoccurrence, it was determined that the study communities of Lancaster, Lexington, Nicholasville, Richmond and Winchester would need additional water supply storage. It was concluded that two major components could provide for the storage needs. The region could utilize 2½ feet of the 6 feet of authorized navigational pool storage between Lock and Dam 8 and Lock and Dam 14. In addition, the construction of a reservoir on Station Camp Creek would provide water storage of 16,000 acre-feet. The cost of these two plan elements was estimated to be \$6.1 million. Further studies were recommended to refine economic data and integrate social and economic considerations for the plan.

3.2.4 *Interim Report Kentucky River and Tributaries: Station Camp Creek, Kentucky Reconnaissance Report, Volumes 1-3 (USACOE, 1988)*

This report was requested due to continuing flood damage problems, minor water supply problems and concerns over future water shortages in the Station Camp Creek watershed. The U.S. Corps of Engineers conducted studies of Station Camp Creek for a multipurpose reservoir that could meet the areas' water supply, flood control and recreation needs.

Station Camp Creek is a fifth-order stream formed by the confluence of South Fork Station Camp Creek and War Fork in Jackson County, Kentucky. Over one-half of the 217 square miles of Station Camp Creek watershed lies within the Daniel Boone National Forest. Most of the basin is heavily forested, although significant agricultural development exists in the floodplain of the lower 15 miles of the Station Camp Creek channel.

The first step in determining the feasibility of a reservoir was selecting an initial dam site for evaluation and developing cost curves for a range of storage capacities. Then, current and projected flood reduction, water supply, recreation and hydropower needs were determined and the potential for the site to meet the needs ascertained. The results of these evaluations were used to develop a cost allocation analysis and determine economic feasibility.

To minimize environmental impact, a proposed dam site was chosen at river mile 11.8 on lower Station Camp Creek. A design and cost estimate study analyzed a variety of pool configurations and construction methodologies.

In order to be considered for federal support, a water supply project cannot be deemed a single-purpose water supply project. National policy assigns the financial burden for municipal and industrial water supply to the users, municipalities or other non-Federal entities. An exception is made for a project where at least ten percent of the anticipated benefits are attributable to flood control, navigation and/or agricultural water supply (or National Economic Development). The Station Camp Creek study determined that less than 10 percent of the anticipated benefits for the reservoir were attributable to flood control, navigation and/or agricultural water supply. Based on the conclusions of the report, it was determined that the Corps of Engineers would no longer consider the proposed Station Camp Creek dam.

3.2.5 *Reconnaissance Level Cost Estimate Data* (USACOE, 1990)

As authorized by the Water Resources Department Act of 1974, the Kentucky Department of Natural Resources and Environmental Protection Cabinet requested this study from the U.S. Army Corps of Engineers for fiscal year 1990. The title of the request was the "Central Kentucky Water Supply Study."

Costs were estimated for a list of priorities that were selected by Harza Engineering Company, a consulting engineer previously hired by the Kentucky River Basin Steering Committee. These projects related to the construction of new locks and dams on the upper Kentucky River. Separate cost estimates were calculated for new dams only, as well as for both new locks and dams, at Locks and Dams 5, 8, 9, 10, 11, 12 and 14 and within Pools 10 and 12. Two pool levels were considered for all of these options except for Lock and Dam 9, for which three different pool levels were considered.

The Corps' cost estimates were to be assessed by order of magnitude only (preliminary reconnaissance estimates), and more detailed study was recommended. However, the cost estimates were intended to be of assistance in narrowing down the range of water supply alternatives under consideration. The study's resulting reconnaissance level estimates ranged from \$17 million for a new dam only at Lock and Dam 8 to \$134 million for a new, higher Lock and Dam 9.

3.2.6 *Kentucky River Survey: Rehabilitation Study for Locks and Dams 5 through 9* (USACOE, 1997)

The purpose of this study was to perform inspections on Kentucky River Locks 5-9 and identify features that were in need of repair in order to restore operation of the locks. The preliminary designs, repair sequence and cost estimates were prepared as a result of these inspections.

A list of general and specific repair items were compiled and prioritized based on their importance to restoring lock operations. General tasks outlined in the repair recommendation included dewatering of the locks, installation and/or rehabilitation of gate valves, replacement of miter gate components, repair of lock walls, and miscellaneous repairs identified after the locks are dewatered.

Cost estimates were developed based on the assumption that work on Locks 8 and 9 would be completed in 1998 and work at Locks 5, 6 and 7 would be performed in 1999.

3.2.7 *Upper Kentucky River Basin, Kentucky: Reconnaissance Phase Water Resources Study* (USACOE, 1997)

In the 1996 Energy and Water Appropriation Bill, the Corps of Engineers was directed to conduct a reconnaissance level study that addressed the potential for reallocating water storage in existing Corps lakes (Carr Creek Lake) and other alternatives, in order to meet increasing water supply needs in the Upper Kentucky River Basin. Specifically, the area of concern included the three uppermost counties of Knott, Letcher and Perry in the North Fork Kentucky River Basin.

Although the primary focus of the study was the water supply reallocation of Carr Creek Lake storage, secondary objectives included the consideration of an alternate single-purpose water supply impoundment and a regional water treatment plant and distribution lines.

The study was based on water needs through the year 2020, when most, if not all, of the systems under consideration would have difficulty meeting needs during a severe and prolonged drought. It was determined that the service area would require approximately 10 million gallons per day (mgd) by 2020 in order to serve the current service area, as well as the rural unserved area.

Two alternatives were considered for supply storage—Carr Creek Lake and a potential impoundment on Line Fork. Each of these alternatives would be used to provide supplemental flows to the North Fork Kentucky River. The estimated cost of providing the flows from Carr Creek Lake was \$40 million, and the cost estimate for the Line Creek impoundment was estimated to be \$32 million. However, the Carr Creek Lake option is less costly for combined releases and river flows of up to 12 mgd, and the Line Creek option is more cost effective for flows greater than 12 mgd. As long as slight losses in recreation and flood control are acceptable, the Carr Creek Lake option appeared to be the preferred choice.

In order to treat water from either of these alternatives, a regional water treatment plant on the North Fork Kentucky River, downstream of Line Fork and Carr Fork, was considered. The initial plant capacity would be 5 mgd and cost approximately \$11.2 million, with the ability to expand the plant to treat 10 mgd for an additional estimated cost of \$5.2 million (1996 dollars). Transferring the water to existing water systems in the three-county area would require about 70.2 miles of water lines at an approximate cost of \$37.1 million. A preliminary estimate of \$112 million was made for constructing rural water lines to currently unserved areas.

In order to request any amount of water supply storage affecting authorized purposes of Carr Creek Lake, applicants were directed to submit a report providing detailed information on related costs and impacts. The appropriation of this storage allocation would then require Congressional approval.

3.3 Kentucky Office of the Attorney General

3.3.1 *An Evaluation of Kentucky American Water Company's Long-Range Planning* (Tellus Institute, 1994)

The Kentucky Office of the Attorney General's Utility and Rate Intervention Division retained The Tellus Institute to evaluate the demand management and water supply planning activities of the Kentucky-American Water Company. This review resulted from the Attorney General's intervention in *An Investigation of the Sources of Supply and Future Demand of Kentucky-American Water Company*, Kentucky Public Service Commission Case No. 93-434.

The areas of Tellus' investigation included the planning process, demand forecasting, demand-side management programs, supply assessment, integration of supply and demand, and pricing, metering and rate design. The review was ultimately designed to answer two main questions:

- 1) Is KAWC using reasonable and prudent programs and methods to cost-effectively plan for the future water supply needs of its customers?
- 2) Is the proposed pipeline needed and cost-effective in comparison to other reasonably available alternatives?

The study noted that KAWC had ample water supply to meet its average day demand through the year 2020, as well as for the maximum day of the year under normal conditions. The uncertainty was with KAWC's ability to serve its maximum day demand under extreme weather conditions, particularly during a severe and prolonged drought.

Among Tellus' concerns with KAWC's approach were the following:

- 1) KAWC never quantified the risk of extreme weather. Information is needed to determine if the cost of alleviating the problem bears a reasonable relationship to the benefits achieved.
- 2) Given the potential shortage during extreme drought conditions, it was expected that the company would plan for peak management or emergency response, rather than the construction of major baseload facilities. Options to the pipeline included conservation programs, rate structure changes designed to reduce peak demand, drought emergency measures, more rigorous examination of other purchased water alternatives and the upgrading of Kentucky River facilities. The KAWC's chosen supply alternative, the pipeline to the Louisville Water Company, was very expensive—for the cost of the treated water, as well as for the construction of the pipeline.
- 3) The company's demand model did not factor in their increase in water rates resulting from the high cost of constructing the pipeline.
- 4) The public should have been more involved in this type of long-term planning. Further, KAWC did not integrate supply and demand options into a consistent framework, and dismissed less expensive conservation options in favor of the more costly pipeline proposal.

Given these findings, Tellus concluded that KAWC failed to successfully meet several aspects of the planning process and ultimately failed to develop a course of action which provided cost-effective, reliable service for its customers. Therefore, Tellus recommended that the Kentucky Public Service Commission instruct KAWC to conduct a more thorough, integrated analysis of its water service options.

3.4 Kentucky-American Water Company

3.4.1 *Kentucky River Aquatic Study* (Environmental Science & Engineering, 1991)

In 1990, the Kentucky-American Water Company (KAWC) contracted Environmental Science & Engineering, Inc. (ESE) to conduct a water quality/biota study of the Kentucky River Basin. The study area was the set of pools located between Lock and Dam #10 and Lock and Dam #4 (Pools 9 through 4). This stretch is the most populated 111 miles of the main stem of the river.

ESE focused on the effect that low-flow scenarios (those below the 7Q10 flow) would have on water quantity, water quality, recreational users, downstream users and aquatic life.

The ESE study implemented the use of a dynamic water quality model developed by the U.S. Army Corps of Engineers called the Water Quality for River-Reservoir Systems (WQRSS). Due to the lack of historical information, much of the data for the ESE study was manufactured, and calibration relied heavily on the recommended coefficients of the manual. Available data that was used included United States Geological Survey (USGS) river stage and flow for locks and dams 4, 6 and 10.

The ESE Kentucky River Aquatic Study provided three main recommendations. The first recommendation was that the water quality in Pools 9 and 6 be monitored when the flow rates of Pools 10 and 6 fall beneath 150 cfs. In particular, temperature and dissolved oxygen measurements should be collected. The second recommendation was that the stage at Pool 9 should be continuously monitored, possibly through the installation of a gaging station at Lock and Dam #9. Thirdly, the report recommended that a low-flow assessment on large aquatic animals be performed. The ESE water quality report concluded that the KAWC withdrawal permit for Pool 9 could be increased from 55 mgd to 62 mgd without significantly impacting the biota of the river during short-term, low-flow conditions (i.e., 7Q10 flows for less than 30 days).

3.4.2 *Source of Supply/Safe Yield Study (HARZA, 1992)*

This study was performed for the Kentucky-American Water Company (KAWC) by HARZA Engineering Company in order to evaluate the safe yield of the Kentucky River for the KAWC intakes in Pool 9 of the river. The safe yield was determined by simulating the operation of the Kentucky River system for the 1930 drought as adjusted for current conditions in the basin. The safe yield was defined as the maximum flow rate that could be sustained during the period when projected demands for the year 2020 could not be met. In computing the safe yield, the leakage through all locks and dams was assumed to be 50 cfs. In addition, it was assumed that the water stored in the pools was available for use and that minimum release requirements would not be met whenever pool water levels were below the crest levels. However, demands for Kentucky-American were reduced to the safe yield level during the time period that the projected demands could not be met. Under these conditions and assuming the 7Q10 requirement at Pool 9 to be 120 cfs, a safe yield of 35 MGD was determined.

3.4.3

Kentucky River Pool 9 Capacity Study (GRW Engineers, 1993)

Report not available.

3.5 Kentucky River Basin Steering Committee

Following the drought in of 1988, Lexington Mayor Scotty Baesler formed the Kentucky River Basin Steering Committee to address the perceived water supply problem in central Kentucky.

The outcome of the Committee's discussions was a list of potential water supply alternatives that could be further evaluated by an engineering and consulting firm.

3.5.1 Proceedings of the Kentucky River Basin Technical Advisory Committee: Alternative Evaluation Workshop (1989)

The Technical Advisory Committee was formed to assist decision-making by the Kentucky River Basin Steering Committee. In this capacity, the Technical Committee conducted a workshop at the Carnahan House in Lexington, Kentucky, to evaluate the major alternative categories proposed for dealing with the regional water supply problem. The alternative categories included: 1) Pool Storage (on-river storage), 2) Release Storage (tributary storage), 3) Off-Site Storage (single community reservoirs and pump storage), 4) Interbasin Transfers and 5) Conservation. The goal of the workshop was to identify the advantages and disadvantages of each category, as well as provide a list of critical data needs for use in preparing Requests for Proposals.

Discussion during the workshop was summarized in a table format, titled *Outline of Long-Range Water Supply Proposals*. This table lists proposed water supply projects according to the major categories listed above and provides the following types of information: plan description, plan components, and technological, environmental, economic, social and legal impacts (both adverse and beneficial). This information was intended to help the overall Steering Committee in drafting a request for proposals to evaluate selected water supply alternatives which resulted in the selection of Harza Engineering Company performing a comprehensive water supply study of the Kentucky River Basin.

The Harza study resulted in two separate reports entitled "Phase I Report: Water Demands and Water Supply Yield and Deficit" and "Phase II Report: Development of a Long Range Water Supply Plan." The purpose of the Phase I study was to develop a recommended design drought and design deficit for use in evaluating supply alternatives in the Phase II study.

3.5.2 Phase I Report: Water Demands and Water Supply Yield and Deficit (Harza et. al., 1990)

This report identified expected future demands in the region, as well as the resulting deficit for a range of hydrologic conditions including the 1930 drought of record and the 1953 and 1988 droughts.

Daily Streamflows: Daily streamflows in the historical drought periods were computed using flows recorded by the U.S. Geological Survey (USGS) at Kentucky River Locks and Dams 4, 6, 10 and 14. The Harza analysis of historical droughts confirmed that the 1930 drought is the most severe of record with a return period greater than 100 years at all the USGS recording stations within the study area. The 1953 drought is the second most severe with a return period of approximately 100 years at Locks 10 and 14 and a return period of less than 50 years at Lock 6. The 1930 and 1953 droughts lasted for periods of 4 to 6 months. The 1988 drought, although severe, lasted for a relatively short period (2 months). Streamflows for the 1930 historical drought were adjusted for the effects of Carr Forks and Buckhorn Reservoirs and differing levels

of municipal and industrial withdrawals and discharges so that consistent sequences of adjusted streamflows were used in the analysis.

Water Demands: Water demands were forecast on a monthly average basis for each of the major municipalities and industries in the study area and combined into the total demand for each pool. A summary of the observed 1990 and forecasted 2050 net demands (withdrawals minus return flows) for the month of August are provided in the following table.

Observed and Forecasted August Monthly Demands (mgd)

Pool	1990 Demands	2050 Demands (Without Conservation)	2050 Demands (With Conservation)
4	8.0	6.7	5.7
5	3.3	3.9	3.3
6	0.8	0.9	0.9
7	- 11.7	- 12.7	- 12.9
8	6.0	6.7	6.0
9	44.8	48.8	42.8
10	2.5	2.6	1.9
11	11.1	11.0	10.2
12	3.2	3.2	3.2
13	0.0	0.0	0.0
14	1.1	1.2	1.1

Water Supply Deficits: Water supply deficits were computed for each of the Kentucky River pools between Frankfort (Pool 4) and Beattyville (Pool 14) for current water demands and for projected water demands through the year 2050. Hydrologic conditions considered included the drought of record (1930), the second most severe drought (1953) and the most recent drought (1988), as well as "statistical" droughts (100-year and 50-year). The effects of a conservation program and a water shortage response plan were developed. A water supply deficit was defined as the difference between the water demand and the water supply when the water supply is less than the demand. In calculating the deficit, Harza included irrigation as one of the major demand types. The following table provides the computed total deficits for Kentucky River Pools 4 through 14 for historical droughts for 1990 and 2050 projected demands.

Simulated Demand Deficits (Billion Gallons)

Drought	Conservation	1990	2050
1930	No	8.1	8.7
1953	No	6.4	7.0
1988	No	1.3	1.2
1930	Yes ¹	5.9	6.5
1988	Yes ¹	1.0	1.2

¹Assumed a water shortage response program reduces demand during droughts similar to the demand reductions during the 1988 drought. Water shortage response measures were assumed to be in effect for all water users in the basin.

Recommendations: Based on the results of the study, the report recommended that the 1930 year drought be used as the design drought and that the design deficit be 7 billion gallons. The design deficit of 7 billion gallons was found to be the deficit for the 1930 drought for 2050 forecasted water demands with implementation of an effective water shortage response program, rounded upward from 6.5 billion gallons to account for slightly higher forecasted demands in 2020 than in 2050. The Harza report determined that the recommended design deficit was similar to the deficit that would occur for the 100-year drought for 2020 conditions without an effective water shortage response plan.

3.5.3 Phase II Report: Development of a Long Range Water Supply Plan (Harza et. al., 1991)

Based on the results of the Phase I report, Harza completed this second study developing, evaluating and recommending a long-range plan to provide for the projected water supply deficits for the various communities/utilities and individuals who depend on the Kentucky River for water supply.

Alternative Plans: Twenty-seven alternative water supply plans were developed and evaluated for the study. All of the plans would provide for the entire projected supply deficit. Major elements of the plans included:

- 1.) Rehabilitation/reconfiguration of the Kentucky River Locks and Dams;
- 2.) Small Upstream Reservoirs on Kentucky River tributaries; and
- 3.) Pipelines from the Ohio River

The Kentucky River plan elements included new dams at existing sites of Locks and Dams, as well as at new sites. Increasing pool water levels by up to 15 feet and the lowering of existing water supply intakes were considered. Small Upstream Reservoir plan elements included dams of 50 to 150 feet in height with storage volumes of 1.2 to 7.0 billion gallons. Ohio River pipelines included pipelines from Maysville and Louisville with capacities of 40 million gallons per day (mgd) to 60 mgd and having lengths of 72 miles to 155 miles. The alternative long-range plans were developed by using single plan elements capable of meeting the entire deficit and by combining smaller elements.

Criteria Evaluation: The supply plans were evaluated based on ten criteria specified by the Kentucky River Basin Steering Committee, including cost, environmental, social and cultural concerns; water quality impacts; legal, administrative and operational concerns; and potential recreational and tourism benefits. The evaluation was carried out using a scoring procedure that weighted the importance of the various criteria and scored each alternative's performance in meeting each criterion. The selection of the recommended plan was based on the ranking of the 27 alternatives on all the prescribed criteria.

Comparison of Alternatives: Long-range water supply plans utilizing dams at the existing or proposed new sites on the Kentucky River scored consistently higher than plans utilizing other elements. Plans utilizing a combination of Kentucky River sites and small Upstream Reservoirs

scored slightly lower than those using only Kentucky River sites. Plans utilizing solely Small Upstream Reservoirs ranked third. Plans utilizing pipelines from the Ohio River ranked fourth.

The eleven highest ranked plans utilized new dams on the Kentucky River for all or a part of the required storage. Of these, the five most favorable plans used only the Kentucky River and included between two and four new dams. The highest ranked plan included a new dam at a site between existing Locks and Dams 10 and 11 and a new dam at Lock and Dam 12.

The following table was provided to show a comparison of the estimated present value costs of the alternatives. The first column shows the range of estimated costs of the water storage facilities alone. The second column shows the range of estimated costs including the estimated cost of rehabilitating/reconfiguring the Locks and Dams that are not part of the water storage facilities. The least cost alternative was the development of Small Upstream Reservoirs. A single Small Upstream Reservoir could be developed to satisfy the projected deficit of 7 billion gallons at an estimated present value cost of approximately \$111 million, including the cost of rehabilitating or reconfiguring the Kentucky River Locks and Dams not used for water storage purposes. This was approximately \$16 million less than the least costly alternative using the Kentucky River Locks and Dams.

**Summary Comparison of Present Value Construction
and Operation and Maintenance Costs
(Costs in Million Dollars)**

<u>Alternative</u>	<u>Water Storage Plan Elements</u>		<u>Water Storage Plus Rehab/Reconfig of Locks and Dams</u>	
	<u>Minimum</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Maximum</u>
Kentucky River Dams	\$60M	\$127 M	\$127 M	\$180 M
Small U/S Res and L/Ds	\$51 M	\$82 M	\$124 M	\$149 M
Small U/S Rservoires	\$29 M	\$57 M	\$111 M	\$139 M
Pipelines and Combinations	\$126 M	\$163 M	\$207 M	\$245 M

The Recommended Plan: The recommended long-range water supply plan was to develop two or three new dams on the Kentucky River to store water for use during droughts. The new dams would replace existing locks and dams or would be constructed at new sites. The sites considered most favorable were existing Locks and Dams 10, 11 and 12 and two new sites identified in this report as 10A and 12A, which are in the pools of the existing Locks and Dams 10 and 12. Combinations of new facilities at these sites consistently scored higher than all other alternatives.

The recommended plan was not the least costly alternative. Alternatives based on the Kentucky River were ranked higher than those based on Small Upstream Reservoirs because the Kentucky River alternatives were expected to result in fewer potential environmental, social and cultural impacts. In relation to most other criteria, including legal, administrative, operational and water quality, the alternatives were generally equal.

A key element of the recommended plan was the development and implementation of conservation measures including a water shortage response program as described in the Phase 1

report. If these measures were not implemented, or were ineffective, the water supply deficit for the design drought would exceed the storage capacity of the recommended plan by over one billion gallons.

3.6 Kentucky Geological Survey

3.6.1 *Water Availability Modeling and Analysis of the Kentucky River* (Carey, 1990)

This report provided a preliminary evaluation of water supply in the Kentucky River basin down to and including Pool 5. The evaluation was conducted by using historical streamflow records from Lock 10 (1908-1960) and a computer model of the Locks and Dams, Buckhorn Lake and Reservoir #4 in Lexington.

Conclusions of the report included:

- 1) Leakages through Lock and Dams 5 and 9 threaten significant water supply shortages in both pools.
- 2) With reasonable maintenance of the locks and dams, water supplies would be adequate for all users through 2050, except for those in Pool 9. Thus, the demand for water from Pool 9 will require alternative supplies.
- 3) Alternative #1 – Piping water from Pool 6 to Pool 9: With average lock and dam maintenance (maximum of 34.1 mgd leakage), piping 40 mgd of water from Pool 6 would be required to relieve demand in Pool 9 by the year 2042. With good L&D maintenance (maximum of 16.3 mgd leakage), 20 mgd would be required from Pool 6.
- 4) Alternative #2 – Surface water reservoir: With average L&D maintenance, 13,800 acre-feet of water storage would be required to meet demand in 2042. With good L&D maintenance, 4,600 acre-feet of storage would be needed.
- 5) With a reasonable level of L&D maintenance, water supply needs can be met without extraordinary measures. Maintenance of the existing locks and dams, in combination with piping water from Pool 6, would be a feasible alternative to meeting demands with minimal adverse impacts. However, if pool leakage problems are not addressed, it will be difficult to meet water supply needs.

3.6.2 *Water Quality in the Kentucky River Basin* (Carey, 1992)

This report summarized the most recently published information on water quality and related regulations in the Kentucky River Basin. A review of data collected up to 1990 showed that water pollution problems existed throughout the basin. Due to inadequate treatment of municipal wastes, failing septic systems and agricultural runoff, fecal coliform bacteria in stream was a widespread problem. Iron, lead, manganese, mercury and silver were all found to exceed state standards and federal guidelines for drinking water and aquatic life at most sampling sites. Chloride discharges from oil and gas operations had impaired aquatic life in many smaller streams in the Knobs region. In the Bluegrass Region, organic enrichment and high nutrient loads from wastewater treatment plants and farms reduced aquatic life. In addition, detectible levels of heavy metals and the organic pesticides chlordane, aldrin, dieldrin and DDT were found in tissues of fish living in the Kentucky River.

3.6.3 *Ground Water in the Kentucky River Basin* (Carey et. al., 1994)

This study investigated the hydrogeology of the Kentucky River Basin and the potential of ground water as a water supply source for its residents. At the time of the study, ground water supplied approximately 135,000 people in the basin, or approximately 19 percent of the total population and 36 percent of the rural population. It was concluded that discharge from well fields and springs could be used to supplement surface supplies during a drought. Additional research into ground water distribution and quality was found to be needed, as well as the establishment of wellhead protection programs and other pollution prevention programs.

3.7 Regional Water Supply Planning Meeting Report

In November 1988, Mayor Scotty Baesler called a meeting to discuss issues relating to water supply planning in the Bluegrass Region of Kentucky.

3.7.1 *The Kentucky River: An Outline of Issues for Water Supply Planning* (Rebmann, J. and D. Hassell, 1988)

This report was prepared as background information for the Regional Water Supply Planning Meeting, held on November 30, 1988. Thus, the report simply provided a summary of relevant issues and did not provide specific water supply recommendations. It includes sections covering the following topics:

- Physical Features of the Kentucky River Basin
- Population and Area Statistics
- Other Impacts of Water Use on Kentucky River
 - Waste/Sewage Disposal, Industrial/Agricultural, Mining/Silviculture, Construction/Sedimentation, Recycling of Water and Wastewater
- Locations of Locks and Dams
 - History, Pools for Water Use, Disposition of Locks and Dams
- Water Supply Approach
 - Imagined or Real Need, Normal Water Use, Use in a Drought Situation, Benchmark 1930 Drought, Drought Effect upon Communities, Communities' Effect on the River in a Drought Situation
- Conservation
 - Industrial Water Re-Use, Pricing, Residential Plumbing Restrictions, Drought Mandated Limitations, Public Information, No Growth Policy
- Economics of Dams for Multi-Use
 - Limited Multi-Purpose Benefits, Economics and Future Development and Growth, Flood Control, Water Quality, Water Quantity, Recreational Benefits, Cost-Benefit Ratio
- Water Recreation Benefits
 - Problems and Needs, Specific Planning Objectives, Potential Recreation
- Water Supply – How to Finance our Future Needs
- Environmental Impacts of Dam Construction

Tributary Dams vs. Mainstem or Modification of Current Locks and Dams, Physical Elements, Hydrological Elements, Biological Elements, Socio-Economic Elements, Unavoidable Adverse Effects, Environmental Enhancement of an Impoundment

- Alternatives for Future Water Supply

Larger Dams on Kentucky River, Red River Dam, Booneville Dam, Diversion of Water from Cave Run Lake, Muddy Creek, Modification of Current Locks and Dams 9 and 10, North Fork Reservoir, Falmouth Lake, Station Camp Creek, High Bridge Dam, Water from Ohio River or Cumberland Lake, New System of Replacement Dams for the Kentucky River

3.8 Lexington-Fayette Urban County Government

3.8.1 *A Multi-Purpose Surface Impoundment Proposal for the Kentucky River* (Rebmann, J.R., 1987)

This report was prepared for Lexington Mayor Scotty Baesler and the Urban County Council. It addressed how a moderate sized multi-purpose dam placed just upstream of High Bridge on Pool 7 could address a variety of water needs. The proposed dam would affect Pools 7, 8 and 9 and would create an impoundment approximately 50 miles long. The impoundment would ensure an adequate water supply for the Fayette County region, as well as providing recreational benefits.

Recommendations of the report included:

- providing financial support for the maintenance and upkeep of the existing Kentucky River Locks and Dams;
- encouraging the creation of the Kentucky River Authority;
- requesting that the U.S. Army Corps of Engineers initiate a study of costs, socioeconomic benefits and negative impacts of construction of the proposed dam;
- continuing to investigate and promote positive aspects of the dam for water supply, recreation, potential hydroelectric power and the potential of providing 10% of benefits as flood control; and
- investigating state, local and private funding sources for construction of the dam.

3.8.2 *Fayette County 20-Year Comprehensive Water Supply Plan* (Fayette County Water Supply Planning Council, 1999)

This water supply plan was developed in response to a regulatory requirement of the Kentucky Division of Water. The Lexington-Fayette Urban County Government developed the county's water supply plan, rather than having it completed by the Bluegrass Area Development District. The LFUCG worked in conjunction with the county's water supplier, the Kentucky-American Water Company, to complete the plan.

The Fayette County plan followed the prescribed format outlined by the Kentucky Division of Water and included:

- Section 1 – Introduction and Formation of Planning Unit
- Section 2 – Planning Council and Planning Representative

- Section 3 – Notification
- Section 4 – Planning Objectives and the Work Plan
- Section 5 – County Base Map
- Section 6 – Water Use and Water Use Forecast
- Section 7 – Water Supplier Source Assessment
- Section 8 – Supply Adequacy Assessment
- Section 9 – Supply Protection
- Section 10 – Water Resources Inventory
- Section 11 – Water Supply Alternatives
- Section 12 – Primary Water Supply Alternative
- Section 13 – Emergency Plans: Water Shortage Response Plan and Supply Contamination Plan
- Section 14 – Implementation Plan
- Section 15 – Plan Approval Signatures

Kentucky-American's primary water intake is located in Pool 9 of the Kentucky River approximately 12 miles south of Lexington, and a secondary intake is located in Jacobson Reservoir (Reservoir #4). KAWC has a permit to withdraw up to 63 mgd from the Kentucky River and 16 mgd from Jacobson Reservoir. Raw water is treated at two separate facilities that are able to treat a combined capacity of 65 million gallons per day.

The KAWC developed a spreadsheet computer model for calculating water demand projections. Using population projections from the Urban Research Institute at the University of Louisville, historical average daily use and other factors, the "average day demand," "maximum day demand" and "drought average day demand" were calculated. The average day demand was expected to increase from 43.39 mgd in 1998 to 45 mgd in 2020. The projected maximum day demand increased from 64.67 mgd in 1998 to 81.97 mgd in 2020. And, the drought average day demand was predicted to increase from 50 mgd in 1998 to 58 mgd in 2020.

An assessment of supply availability in Kentucky River Pool 9 and projected demand showed that the river has a sufficient water supply to meet demand under normal conditions. However, during even a mild drought, the demand would likely exceed the existing available river supply prior to the year 2010, and certainly by 2020. It was also projected that the current treatment capacity of 65 mgd would be adequate until shortly after the year 2000, based on average monthly demand projections. Additional treatment capacity and/or another source of treated water would be needed at this time.

The Council considered a variety of alternatives for additional water supply and narrowed these to a few options which seemed to be the most feasible. All potential long-term solutions involved the continued use of the Kentucky River and the presence of the existing dams. Therefore, the structural stability of the dams and the operability of the low-flow valves were critical to maintaining the Kentucky River as the major supply source. One considered alternative was increased water storage on the Kentucky River and additional pumping and treatment capacity. Increased river storage capacity would be developed through the addition of crest gates on all or some of dams 9 – 14, a single large reservoir on the Kentucky River or a dam/reservoir on a tributary of the river. Another alternative was the construction of a treated water pipeline to the Louisville Water Company.

The Council evaluated the supply alternative of developing additional storage on the mainstem Kentucky River, along with added treatment capacity of about 25 mgd at the KAWC plant. The option of increased river storage through the construction of movable crest gates on locks #9, #10, #13 and #14 would increase the available raw water to 70 mgd during the peak demand month of a drought. Perceived technical and funding obstacles, as well as potential environmental problems, resulted in the dismissal of this option in favor of the treated water pipeline to Louisville. Additionally, it was determined that the storage capacity of the Kentucky River would have to be improved beyond installing crest gates in order to meet projected demands.

The construction of a dam and reservoir at a location off the main stem of the Kentucky River was chosen as the Council's secondary alternative. Stored water would be released only when needed to make up for a shortfall from the Kentucky River source. The reservoir could be located anywhere upstream of Pool 9. This alternative would require the addition of 23 mgd of treatment capacity.

Ultimately, a 23 mgd pipeline was designed by the KAWC to transport treated water from the Louisville Water Company. Water from this pipeline would supplement the existing supply from the Kentucky River. Citizen concerns regarding construction, environmental impact and water quality were being addressed in the pipeline design. This alternative supply source was selected as the preferred alternative, and the KAWC expected to petition the Kentucky Public Service Commission in late 1999 for the construction of the water line.

It was the charge of the Planning Council to make recommendations for meeting the water supply needs of Fayette County. Ultimately, the selection of an acceptable alternative was to be determined through the input and approval of entities such as the Kentucky River Authority, Kentucky American Water Company, the Public Service Commission, Lexington-Fayette Urban County Government, U.S. Army Corps of Engineers and the Kentucky State Legislature.

3.9 Kentucky Natural Resources and Environmental Protection Cabinet

3.9.1 *Kentucky River Survey, Rehabilitation Study for Locks and Dams 5 through 14* (Daugherty & Trautwein, 1985)

After signing the Memorandum of Understanding with the U.S. Army Corps of Engineers transferring ownership responsibilities of Locks and Dams Number 5 through 14, the Kentucky Finance and Administration Cabinet authorized the completion of this report. The report described the condition of the Locks and Dams, the rehabilitation costs for needed repairs, minor and major maintenance needs, historical information and usage data.

A combination rehabilitation and replacement program was recommended. Locks and Dams #5 and #12 were cited as needing the most immediate repairs. The report recommended the replacement of #5 within the next 5-10 years and the replacement of #12 within the next 10-15 years. These repairs were to be followed by the sequential replacement of Locks and Dams #6

through #14 at the rate of one lock and dam every five years. In support of the cost-effectiveness of this recommendation, the report noted the relatively high yearly maintenance costs on the structures and the likelihood of continuing crib failures in each lock and dam.

3.9.2 *Kentucky River Survey: 1989 Update of Locks & Dams 5 through 14* (C.J. Fuller Consulting Engineers, Inc. et. al., 1989)

This report provided an update of portions of the 1985 study by Daugherty and Trautwein to show the current condition of Locks and Dams 5 through 14, changes in condition that may have occurred since the 1985 survey, maintenance operations or the lack thereof, and any remedial construction of the facilities. It also identified the extent of routine and major maintenance required to enable the facilities to operate adequately. In addition, this study concurred with the dam replacement schedule proposed in the 1985 study.

Due to signs of their potential failure, the survey focused on the oldest four of the ten Locks and Dams studied; 5, 6, 7 and 8. Updated costs of major maintenance, routine maintenance and safety/ improvement items for all ten locks and dams were estimated in the report.

3.9.3 *Kentucky River Basin Status Report* (Kentucky NREPC Division of Water, 1997)

This report fulfilled the first activity of Phase I (scoping and data gathering) of the Kentucky Watershed Management Framework. It described conditions and trends in water quality and quantity, as well as watershed integrity, for the Kentucky River Basin. It was intended to provide indicators of the basin's condition and predictors of areas needing attention. Based on this report and other information sources, the Kentucky River Basin team prepared a strategic data collection plan.

3.10 U.S. Geological Survey

3.10.1 *Evaluation of the Drought Susceptibility of Water Supplies Used in the Kentucky River Basin in 1988* (USGS, 1991)

Major public water supply systems and self-supplied commercial and industrial water systems in the Kentucky River Basin were inventoried to evaluate the adequacy of raw water sources to meet its 1988 system demand during a drought. Future demand was not evaluated in this report.

The study indicated that 70 public water suppliers withdrew about 80 million gallons of water per day in 1988, and provided treated water to more than 554,000 people. Domestic per capita use averaged 72 gallons per day in the study area. Nearly 98 percent of the water withdrawn by the permitted facilities was from surface water sources.

It was found that water supplies were adequate to meet most of the supplier demands in the basin. However, public suppliers in Lexington, Georgetown and Stanford were found to be likely to have water supply shortages during drought conditions. Additionally, five other public water suppliers in the Kentucky River basin had the potential for water shortages during drought

situations due to inadequate drinking water treatment plant capacities. During 1988, the average withdrawals were near or greater than 80 percent of capacity at Danville City Water Works, Hyden-Leslie County Water District, Manchester Municipal Utilities, Owenton Water Works and Versailles Municipal Water.

3.11 Water Resource Development Commission

3.11.1 *Water Resource Development: A Strategic Plan* (KIA, et. al., 1999)

As directed by Governor Paul Patton's Executive Order 96-1339, the Water Resource Development Commission prepared this strategic plan for water resource development in Kentucky with the goal of providing the best available water and sewer service to every Kentuckian by the year 2020. The main objectives of the strategic plan for water systems were as follows:

- Inventory all water systems in Kentucky and assess their respective strengths and weaknesses;
- Develop recommendations to build on the strengths and eliminate the weaknesses of Kentucky's water systems; and
- Develop strategies to improve the level of water service for Kentucky.

In order to fulfill these objectives, the following tasks were completed:

- Characterized the physical plant, finances and management of existing systems;
- Identified areas where immediate and long-term extension of public water service is indicated, as well as any improvements to existing systems to accommodate expansion, and estimated costs;
- Identified areas where extension of public water service is not indicated and developed recommendations for improving water systems in these areas;
- Identified areas of health and safety concerns about drinking water and wastewater treatment and developed recommendations;
- Developed recommendations and strategies for the operation, maintenance and management of water systems that enhance the use, efficiency and effectiveness of resources; and
- Developed recommendations and strategies to improve the regulatory and funding environment for water development.

It was projected that an additional 500,000 Kentuckians will be served by public water systems by the year 2020. Twelve-thousand miles of new water distribution lines would enable these new customers to be served.

Following the involvement of more than 40 state, regional and local groups, several general recommendations were made to improve water service to Kentuckians, including the encouragement of a regional approach to planning and developing of public water supplies.

3.12 Miscellaneous

3.12.1 *Kentucky River Basin Report on Water and Related Land Resources* (USDA, 1981)

This study was conducted by the U.S. Department of Agriculture in cooperation with the Kentucky Department for Natural Resources and Environmental Protection. It was intended to assist the state in alleviating basic resource problems and meeting present and projected food and fiber needs. The main objectives of the study were to:

- 1) Identify the basic water and related land resource problems and concerns;
- 2) Provide information on the quantity and relative quality of the basin's natural resources;
- 3) Identify and evaluate alternatives for reducing soil resource problems and meeting future food and fiber production needs; and
- 4) Indicate opportunities and ways that federal, state and local agencies may alleviate the basic resource problems.

Major water and related land resource problems and concerns identified were: excessive soil erosion and sedimentation, loss of prime farmland, flooding, water supply and quality and pollution—particularly due to solid waste. Water supply and quality problems were cited as being predominantly seasonal shortages, inadequate local sources, inferior quality and inadequate storage, treatment and distribution systems. The most obvious pollutants were noted as being suspended sediment, sewage and industrial or mining refuse.

A water supply estimate of 69 million gallons per day was predicted for “key cities and towns that obtain water from the Kentucky and Red Rivers” in the year 2000. Further, present and projected 2000 water needs were provided for individual cities.

The majority of the study focuses on nine alternative plans that are primarily directed toward reducing the agricultural resource problems and meeting projected food and fiber needs for 2000. These alternatives suggest a variety of approaches to preserving agricultural land, shifting agricultural uses of the land and implementing conservation and management programs.

3.12.2 *Proceedings of the Kentucky River Conference* (1986)

The Kentucky River Conference was held in November 1986 at Shakertown in Kentucky. It was organized by the citizen group, Lexington Directions, a group dedicated to identifying issues of public concern to the residents of Lexington and Central Kentucky; informing residents, through public discussion groups, about issues important to the community; and assisting the local government in developing solutions to community problems. The Kentucky River Conference was organized to generate further discussions about the Kentucky River and its importance to lives of Central Kentuckians.

This document includes copies of the presentations made during the 1986 conference. The titles of the presentations are as follows:

- "Kentucky River Overview," James R. Rebmann, Lexington-Fayette Urban County Government
- "Population Projections for the Kentucky River Basin," Thomas R. Ford, Ph.D., Center for Developmental Change, University of Kentucky
- "Kentucky River Water Usage, Trends and Projections," Don R. Hassall, Bluegrass Area Development District
- "The Kentucky River Locks and Dams: Their Future and Their Importance," Vic Hellard, Kentucky River Task Force
- "Outlook for Lexington and Surrounding Counties," Robert Edens, Kentucky-American Water Company
- "Corps of Engineers Current Projects and Plans for Future Projects," Jim Duck, U.S. Army Corps of Engineers
- "Perspectives of a Small Water Company," Richard Lewis, Winchester Municipal Utilities
- "Maintaining Good Water Quality on the Kentucky River," Donald Harker, Division of Water, Cabinet for Natural Resources and Environmental Protection
- "The New National Water Quality Assessment Program and the Kentucky River," James Smoot, United States Geological Survey
- "Ongoing Strip Mine Pollution in the Upper Kentucky River," Bradley Branson, Ph.D., Department of Biology, Eastern Kentucky University
- "Water Resources Programs at the Kentucky Geological Survey," Jim Dinger, Ph.D., Water Resources Section, Kentucky Geological Survey
- "Monitoring the Kentucky River," Dillard Griffin, Kentucky-American Water Company
- "Environmental Protection and Economic Development," William A. Duncan, Mountain Association for Community Economic Development

3.12.3 Prospects and Impacts for Reservoir Location: Jackson County, Kentucky (U.K. College of Agriculture, 1988)

This study was conducted in order to identify potential impoundment sites and funding sources for a reservoir in Jackson County, Kentucky. Jackson County residents foresaw several potential benefits of a reservoir, including flood control, an alternative water supply, recreation and a catalyst for a diversified economic base. In general, residents believed that a "large" reservoir would best meet a variety of needs.

The Jackson County Development Commission invited landuse planning researchers from the University of Kentucky to evaluate alternative reservoir sites and to develop and present a computer-aided model of the proposals. The main objectives of the study were:

- 1) To utilize citizen participation in determining model criteria for locating reservoir sites;
- 2) To develop planning criteria for locating a reservoir;
- 3) To provide economic data for potential funding of a reservoir;
- 4) To document the process of the study for public officials, concerned citizens and others in the future;
- 5) To provide a presentation to inform the public on site selection and the impacts of alternative reservoir sites.

A variety of proposed reservoir sizes, locations and uses were considered, along with their potential funding mechanisms. Economically and environmentally, a 600-acre reservoir on the Steer/War/Hughes Forks was deemed the most defensible. Additional investigation by geologists, soil experts and others was recommended. Following this assessment, it was also recommended that two single purpose floodwater retarding structures be constructed.

3.12.4 *The Kentucky River Basin: A Land Use and Recreation Study for the Kentucky River Authority* (U.K. College of Agriculture, May 1992)

This study was conducted by fifth year landscape architecture students at the University of Kentucky and was submitted to the Kentucky River Authority and other appropriate agencies "for the purpose of guiding the wise use of the Kentucky River Basin as a resource for humans, plants and animals which share this unique environment." It covered land use policies and defined the recreational potential of the basin.

3.12.5 *Report to Department of Natural Resources: Eagle Lake, Kentucky* (Shepherd, J., June 1992)

This report provided a proposal for a dam site to be located 61.3 miles above the mouth of Eagle Creek, a tributary of the Kentucky River. With a drainage area of 156 square miles, the resulting reservoir was estimated to have the potential for a maximum storage of 510,000 acre-feet of water. It would be located 24 miles north of Lexington in Scott and Owen Counties. The report author foresaw the proposed reservoir as a water supply source for central and northern Kentucky, as well as a flood control impoundment.

3.12.6 *Feasibility Study for the Jackson County Lake Project and Alternatives* (Kenvirons, 2000)

This study was authorized by a contract between the Jackson County Empowerment Zone Community, Inc. and Kenvirons in order to evaluate potential projects which could increase the county's water supply. Costs were estimated for four alternative long-range water supply projects:

- Reservoir on War Fork
- Reservoir on Sturgeon Creek
- Potable Water Transmission Main from the Wood Creek Water District
- Raw Water Transmission Main from Lock 14 of the Kentucky River

These alternatives were evaluated and ranked based on the costs associated with the project's construction, land acquisition, household relocations, utility relocations and operation, maintenance and replacement costs.

In addition to potential reservoir sites on War Fork and Sturgeon Creek, 13 other potential sites were evaluated and subsequently eliminated. Criteria for their continued consideration included

a minimum yield of 3.5 mgd; the absence of any threatened, endangered or protected species; and no special resource designation for the waterway.

The most feasible and recommended alternative for sufficiently increasing Jackson County's water supply was the construction of a reservoir on War Fork. In addition to building the reservoir, the implementation of this alternative would require the construction of a raw water transmission main from the reservoir to the Jackson County Water Association's treatment facilities and the expansion of the water treatment plant. Further detailed engineering, environmental and economic studies were recommended to optimize the specific features of this recommended alternative.

4.0 Proposed Kentucky River Basin Water Supply Projects

The following table provides a comprehensive listing of historically proposed water supply projects for the Kentucky River Basin. The organizations proposing these alternatives are also listed, along with references to the specific report detailing their proposal. Additionally, a brief discussion of each proposed project is provided with a description of any action taken toward implementing the project. In instances where projects have not implemented, an explanation is given as to why it was not pursued.

4.0 Proposed Kentucky River Basin Water Supply Projects

Rehabilitation/Reconfiguration of Kentucky River Locks and Dams			
Proposal	Source, Year*	Discussion	Action Taken
Rehabilitation of Locks 5-9	USACOE, 1997 (2.2.6)	Specific repairs were recommended and prioritized for each of the five Locks (5, 6, 7, 8 and 9) in order to restore their operation. A repair sequence and preliminary designs and cost estimates were provided. General tasks outlined in the repair recommendation included dewatering of the locks, installation and/or rehabilitation of gate valves, replacement of miter gate components, repair of lock walls, and miscellaneous repairs identified after the locks are dewatered.	These repairs were not implemented. The KRA has determined that it will apply fee revenues toward funding this work.
Increase height of dams 10, 9, 14, 13, 11 and 12 (in that order)	Harza, 1996 (2.1.3)	Increased dam heights would increase storage capacities of upstream pools. Unit cost of creating storage in Pool 13 much higher than in Pools 10-12, and less demand to justify expense; therefore, lower priority. Projects to raise dams 11 and 12 will first require further study of potential impacts to agricultural fields.	KRA funding approved to build new Dam 10, raising it by 4-6 feet. Expect to begin construction in 2005. Evaluation and design of renovation on Dam 9 expected to be complete in FY 2003. Next priority will be Lock & Dam 11.
Installation of temporary crest gates or permanent raising of dams 9 - 14 WITH low-level valves in Locks & Dams 9-14	KWRI, 1996 (2.1.4)	Assuming pools are mined to within 4 feet below dam crests, the projected 1930 drought supply deficits would be eliminated. Determined to be most cost-effective of solutions considered.	Low level valves have been installed. KRA is currently pursuing implementation on dam 10 with possible implementation on dams 9, and 11.
Increase height of Dams 5-8	Harza, 1991 (2.5.3)	The Harza study examined the effects of raising all Kentucky River Dams 5-14 as a plan element for consideration in a water supply solution. Initial screening criteria included: location of site in relation to location of water supply deficit, cost of developing storage at the site, and height of dam with potential impacts of flood hazards.	Not implemented. Proposal to increase to the heights of Dams 5-8 eliminated because projected water supply deficit downstream of Pool 9 is insufficient to justify the expense of raising these dams to increase storage.
Proctor Proposal - Raise Dams 12 (by 17 ft), 13 (by 10 ft) and 14 (by 5 ft), then raise Dams 5-10 (each by 5 ft)	KRB Tech. Advisory Committee, 1989 (2.12.5)	Increases storage capacity by 22.8 billion gallons at an estimated cost of \$65 million. Not certain to be a long-term solution.	Not implemented due to high cost and flooding impacts.
Rehabilitation and replacement of Locks and Dams 5-14	C.J. Fuller Consulting, 1989 and Daugherty & Trautwein, 1985 (2.9.1 and 2.9.2)	Initially, recommends maintenance of Locks & Dams 5-8. Within 5-10 years, replacement of Lock & Dam #5. Within 10-15 years, replacement of L&D #12. Every 5 years thereafter, sequential replacement of L&D #6-14.	Kentucky River Authority plans to build new higher dam (by 4-6 feet) immediately upstream of Lock & Dam 10. Plan also includes rehab/ replacement and raising of Lock and Dam 9. Minor maintenance measures have been conducted on the Locks and Dams on an as needed basis.
Raise Locks and Dams 9 and 10	USACOE, 1978 (2.2.3)	Dam 9 would be raised by 21 feet and Dam 10 by 24 feet at a cost of \$65.3 million. Not cost-effective as a single component to adequately increasing water supply storage.	In 2002, the KRA decided to raise Dam 10 by either 4 or 6 feet to create additional storage. Plans to increase height of Dam 9 are also being developed.

* Number in parentheses refers to reference document in summary of historical reports.

Low-Level Release Valves in Kentucky River Locks & Dams			
Proposal	Source, Year	Discussion	Action Taken
Installation/Rehabilitation of low-level release valves in Locks & Dams 9-14	KWRI, 1996 (2.1.4)	Enables continued flows between pools during drought conditions through releases of water below dam crests. Will not completely eliminate the 1930 drought year supply deficits in Pools 9-14, but reduces 2020 high demand deficit from 7.0 to 3.0 billion gallons.	KRA funded and completed installation of valves in Dams 11-14. Rehab/replacement of lock filling/emptying valves for 9-10 completed.
Installation/Rehabilitation of low-level release valves in Dams 4 - 8	KWRI, 1996 (2.1.4)	Enables continued flows between pools during drought conditions.	Not completed. KRA waiting to combine valve installation with dam repairs. Meanwhile, Locks 5-8 have gate valves that can be used to release water downstream (but are in need of renovation).
Install low-level release valves in Dams 8, 9, 10, 13 and 14	Harza, 1996 (2.1.3)	Develops storage capacities below dam crests by enabling transfer of water from upstream to downstream pools when water levels fall below dam crest levels. In addition to transferring water to meet supply needs, low-level valves enable minimum flow requirements for water quality needs.	KRA funded and completed installation of valves in Dams 11-14. Rehab/replacement of lock filling/emptying valves for 9-10 completed.

Mainstem Impoundments			
Proposal	Source, Year	Discussion	Action Taken
Construction of new dam at Lock and Dam #8 WITH low-level valves in Locks & Dams 9-14	KWRI, 1996 (2.1.4)	Proposed dam would be approx. 52 feet high with a crest elevation of 554 feet. Resulting pool would exceed height of Lock and Dam #9 by 5 feet. A residual supply deficit of 1.1 billion gallons remains for projected 2020 high-demand conditions.	Not implemented due to high cost, environmental and cultural impacts, potential concerns on flooding, the elimination of recreational boat traffic between downstream pools.
Construction of two to three new dams in Pools 10, 11 and/or 12	Harza, 1991 (2.5.3)	Dams to be sited at two or three of the following potential locations: existing Lock and Dam 10, 11 and/or 12 OR new sites in Pools 10 and/or 12 (10A and/or 12A). Site 10A is located between existing Locks and Dams 10 and 11 and Site 12A is located between Locks and Dams 12 and 13. <i>In this study, this was determined to be the ultimate solution for providing adequate water supply within the Kentucky River Basin.</i>	Not implemented due to high cost, environmental and cultural impacts, potential concerns on flooding, the elimination of recreational boat traffic between downstream pools.
Multi-Purpose Impoundment at Pool 7 (High Bridge Dam site)	Harza, 1991 (2.5.3), USACOE, 1988 (2.2.4) and Rebmann and Kilner, 1987 (2.8.1)	Dam to be constructed just upstream of High Bridge in Pool 7, creating an approx. 50-mile impoundment. Proposed dam would raise Pool 7 water level by approx. 45 feet, submerging Locks and Dams 8 and 9. Would provide an additional 80,000 to 90,000 AF of storage at a 1987-estimated cost of \$45 million. Additional storage would ensure an adequate water supply for the Fayette County region, including Lancaster, Nicholasville, Lexington and Winchester, as well as provide recreational benefits.	Not implemented because of high cost, environmental and cultural impacts, and the elimination of recreational boating traffic between downstream pools.
Multi-Purpose Impoundment in Pool 7 (Jessamine Creek Reservoir)	Rebmann and Hassell, 1988 (2.7.1)	To be located in Pool 7 just below the mouth of Little Hickman Creek, less than 1 mile upstream from Camp Nelson. Would have increased pool by about 115 feet, flooding up to Dam 14. Construction authorized in 1938, expanded in 1944 to provide hydropower, and deauthorized in 1962.	Not implemented because of increased development along the stream, as well as public opposition to the project due to potential impacts to Boonesboro and the Palisades region of the river.
Multi-Purpose Impoundment in Pool 5	USACOE, 1982, Rebmann and Hassell (2.7.1, p.XI-1)	Studied in relation to flooding problems in southern Frankfort. Proposed dam increased Pool 5 elevation by 135 feet, flooding up to Dam 13, at a cost of \$958 million to \$1 billion. Assessment of dams of various heights with multiple purposes resulted in cost-benefit ratios of 0.46 to 0.51, much less than the greater than 1.0 necessary for federal projects.	Not implemented due to poor cost-benefit ratios resulting from high relocation costs, high construction costs and low net storage volumes.

Other Mainstem Alternatives			
Proposal	Source, Year*	Discussion	Action Taken
Relaxation of the minimum flow requirement between pools 4-8	KWRI, 1996 (2.1.4)	Could result in significant environmental impacts, but would eliminate the supply deficit in Pools 2-8.	Not pursued in favor of use of low-level valves in dams 4-8, and because of potential environmental impacts.
Pipe water from Pool 6 to Pool 9	KGS, 1990 (2.6.1)	The pipeline from Pool 6 to 9 would augment Pool 9 supplies and was being considered by the Kentucky-American Water Company. KGS estimated that, with average lock and dam maintenance (maximum of 34.1 mgd leakage), piping 40 mgd of water from Pool 6 would be required to relieve demand in Pool 9 by the year 2042. With good L&D maintenance (maximum of 16.3 mgd leakage), 20 mgd would be required from Pool 6.	Not implemented due to the cost of a new treatment plant, pumping, and pipeline. Would still need additional storage on the river to make this feasible.
Dredging Pools to increase storage	KRB Technical Advisory Comm., 1989 (2.12.5)	Dredging would be a continuous process, as an estimated 580,000 tons of sediment are suspended and flow pass Lock & Dam 4 each year. Intakes would need to be altered to withdraw water from the expanded river pools. Also, could be disposal issues for hazardous or non-usable dredged materials.	Not implemented because dredging was not considered a reliable way to significantly increase river storage.
Utilization of navigational storage in Pools 8 - 14 for water supply	USACOE, 1978 (2.2.3)	Original lock and dam system was created to provide for a 6-foot navigation channel. Current uses on the Kentucky River only require a 3 1/2-foot navigational pool. The remaining 2 1/2 feet of navigational pool storage have the potential for water supply usage. This option was conditional on the presence of functioning flow regulation devices between Locks and Dams 8 - 14. Estimated to provide 7,490 AF of storage at 1978 cost of \$975,000 to \$2.655 million.	This plan has been essentially implemented through the installation/rehabilitation of low level valves in dams 9-14, with a maximum allowable drawdown of up to 4 feet.

Offstream Impoundments			
Proposal	Source, Year*	Discussion	Action Taken
War Fork Reservoir (Jackson County)	Kenvirons, 2000 (2.12.7); Harza, 1991 (2.5.3)	The Harza study noted the potential storage of a reservoir on War Fork to be 979 million gallons at a cost of \$9 million. In a study requested by the Jackson County Empowerment Zone Community, it was concluded that a reservoir on War Fork would be the most cost-effective alternative for providing an adequate long-range water supply to Jackson County residents.	Jackson County Water Association is continuing to pursue the construction of the War Fork Reservoir as their primary water supply alternative to Beulah Lake.
Line Fork impoundment	USACOE, 1997 (2.2.7)	Water storage in Carr Creek Reservoir determined to be more cost-effective than Line Fork Reservoir for amount of storage needed.	Not pursued in favor of Carr Creek Reservoir storage.
Construction of one or more off-stem reservoirs WITH low-level valves in Locks & Dams 9-14	KWRI, 1996 (2.1.4)	Eliminates deficit for 2020 high-demand condition. Rated as second most economically viable to temporary crest gate option.	Partially implemented. Low-level valves functioning in Locks and Dams 9 and 11-14, but off-stem reservoir(s) not constructed due to higher unit costs than other alternatives, and potential environmental impacts.
Station Camp Creek Reservoir (Jackson County)	KRA, 1995 (2.1.2); Harza, 1991 (2.5.3); and USACOE, 1988 and 1978 (2.2.3 and 2.2.4)	Station Camp Creek is a tributary entering Pool 11 of the Kentucky River. Harza proposed five potential sites in this upstream basin with estimated costs of \$9 to \$35 million. A Station Camp reservoir could eliminate the entire supply deficit by creating storage of 3 to 7 billion gallons. The proposed reservoir would dually serve water supply and recreation purposes. Consideration for federal funding was dropped because less than 10% of reservoir's benefits attributable to national economic development (i.e., flood control, navigation or agricultural water supplies)	Not implemented because federal funding was not available for reservoir as proposed. Also, there is strong opposition against a dam on Station Camp Creek due to its environmental and biological resources and habitat.
Eagle Lake (Scott and Owen Counties)	Shepherd, 1992 (2.12.6)	Proposed dam site 61.3 miles upstream of mouth of Eagle Creek tributary of Kentucky River. Drainage area of 156 square miles, estimated water storage capacity of 146 billion gallons.	Not implemented due to cost and environmental concerns.
Falmouth Lake	KRB Technical Advisory Comm., 1989 (2.12.5)	Authorized for construction in 1936 at mile 60.6 of Licking River, with total storage of 898,300 acre-feet. A proposal suggested pumping raw water from Falmouth Lake to Georgetown (about 14 miles), then to a new or existing treatment plant. Cost-effectiveness studies in 1985 resulted in cost-benefit ratios of 0.37 to 0.89. Project classified as authorized but inactive in 1981.	Not implemented due to poor cost-benefit ratios.

Offstream Impoundments (Continued)			
Proposal	Source, Year*	Discussion	Action Taken
South Fork impoundment (Booneville Reservoir)	KRB Technical Advisory Comm., 1989 (2.12.5); Rebmann and Hassell, 1988 (2.7.1); and USACOE, 1978 (2.2.3)	Located on South Fork Kentucky River in Owsley and Clay counties. Booneville Dam originally authorized by 1938 Flood Control Act. Project site covers 2,500 to 2,900 acres, with a drainage area of 665 square miles and potential capacity of 192,000 acre feet.	Not implemented due to poor cost-benefit ratios. Also, site more densely populated than other proposed reservoir sites.
Billey Fork impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 12 of the Kentucky River. Proposed reservoir has potential usable storage of 1.45 billion gallons at cost of approx. \$10.6 million.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Boone Creek impoundment	Harza, 1991 (2.5.3)	No viable water impoundment sites in the lower part of this basin. Upper basin contains sites for minor impoundments.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Contrary Creek impoundment*	Harza, 1991 (2.5.3)	Tributary to Pool 14 of the Kentucky River. Proposed reservoir has potential usable storage of 1.55 billion gallons at cost of approx. \$8.5 million.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Crystal Creek impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 14 of the Kentucky River. Proposed reservoir has potential usable storage of 998 million gallons at cost of approx. \$7.9 million.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Fourmile Creek impoundment*	Harza, 1991 (2.5.3); USACOE, 1978 (2.2.3)	Tributary to Pool 10 of the Kentucky River. Developed area around Winchester drains into basin, and one major power line crosses probable site of impoundment. Recommended for consideration as a minor water impoundment. Potential usable storage of 2.6 billion gallons at a cost of approx. \$8.7 million. Was also considered by the USACOE as single-community water supply solution for Winchester, but was determined that a regional supply solution would be more cost-effective.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Holly Creek impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 14 of the Kentucky River. Proposed reservoir has potential usable storage of 1.24 billion gallons at cost of approx. \$12 million. Eliminated due to high unit cost of storage.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.

Offstream Impoundments (Continued)			
Proposal	Source, Year*	Discussion	Action Taken
Lower Buffalo impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 14 of the Kentucky River. Proposed reservoir has potential usable storage of 1.23 billion gallons at cost of approx. \$10.9 million.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Lower Devils Creek impoundment*	Harza, 1991 (2.5.3)	Tributary to Pool 14 of the Kentucky River. Proposed reservoir has potential usable storage of 1.68 billion gallons at cost of approx. \$9.1 million.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Lower Howard impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 9 of Kentucky River. Proposed reservoir has potential usable storage of 2.1 billion gallons at cost of approx. \$10.5 million.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Miller Creek impoundment	Harza, 1991 (2.5.3)	Although total drainage area of basin represents one of the larger subbasins of the Kentucky River, there is no suitable site for a major impoundment. Four subbasins of Miller Creek of less than 25 square miles each are candidates for very small reservoirs.	Not implemented due to expectation that water supply alternatives utilizing small upstream reservoirs would result in greater environmental, social and cultural impacts than other alternatives.
Muddy Creek reservoir	Harza, 1991 (2.5.3); KRB Technical Advisory Committee, 1989 (2.12.5); USACOE, 1978 (2.2.3)	Muddy Creek is tributary to Kentucky River at Pool 10 in Madison County. Reservoir would offer up to 15,600 AF of storage, with 54 square miles of drainage area. Would require relatively little relocation and no major highway relocation. However, a major gas pipeline intersects the proposed site and would need to be relocated. Also, a large portion of the Blue Grass Army Depot lies within the headwaters of this basin and has the potential to contribute chemicals and other materials harmful to a water supply. The reservoir would not create sufficient storage to meet entire demand projections. Harza eliminated in 1991 due to water quality concerns. Removed from consideration by Kentucky River Basin Steering Committee on 7/26/89.	Not implemented due to water quality concerns.
Noland Creek impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 10 of Kentucky River. Proposed reservoir has potential usable storage of 735 million gallons at approx. cost of \$7.4 million.	Not implemented due to high unit cost of storage.

Offstream Impoundments (Continued)			
Proposal	Source, Year	Discussion	Action Taken
North Fork impoundment near Beattyville (Lee and Breathitt Counties)	Harza, 1991 (2.5.3); KRB Technical Advisory Comm., 1989 (2.12.5); Rebmann and Hassell, 1988 (2.7.1); and USACOE, 1978 (2.2.3)	Reservoir would be close to point of demand, relatively small and located in areas where environmental and cultural impacts would not preclude development. Would store water in reservoir during wet season and release it into the main channel during periods of water deficiency. USACOE report proposed reservoir with 1,318 square mile drainage area and 38,000 AF of storage. 1978 cost cited as \$24.3 million. Would require levees in Jackson for flood protection and has potential for heavy siltation from adjacent strip mining activities. Recommended by USACOE District Office, eliminated by Federal Office. Also, removed from consideration by Kentucky River Basin Steering Committee on 7/26/89.	Not pursued due to high cost and potential damage to Jackson.
North Fork impoundment (Walker Creek Site)	Harza, 1991 (2.5.3, p.IV-5)	Has a large drainage basin. Most likely location about 7 miles upstream of Beattyville in remote reach of North Fork of Kentucky River. Reservoir construction would involve relatively minimal relocation of people and roads. Would require construction of levee at Jackson to protect from flooding. Would also require significant silt control measures due to extensive coal mining activity in headwaters of this basin.	Not implemented due to water quality concerns.
Otter Creek impoundment	Harza, 1991 (2.5.3)	No viable water impoundment sites in the lower part of this basin due to presence of numerous power lines and pipelines and part of the Richmond urban area. However, the basin does contain candidate sites for minor impoundments.	Not implemented due to expectation that water supply alternatives using small upstream reservoirs would result in greater environmental, social and cultural impacts.
Sturgeon Creek impoundment*	Harza, 1991 (2.5.3)	Includes several upstream sites that are technically suitable for major water storage project. An approx. 100-foot high dam on this tributary to Pool 13 would meet all projected deficits in Pools 13 and downstream. Potential storage of 7 billion gallons at a cost of approx. \$25.2 million.	Not implemented due to significant relocation requirements. Also, region's coal mining activity could negatively impact water quality and reservoir siltation.
Upper Howard Creek impoundment*	Harza, 1991 (2.5.3)	Relatively large basin, with stream discharging into Pool 10 of the Kentucky River above Lexington's intake. Several technically feasible sites for minor and major impoundments. Potential storage of approx. 1.44 billion gallons at cost of approx. \$7.1 million.	Not implemented due to need to relocate numerous gas pipelines, roads, railroads and bridges, as well as other types of development. Also eliminated due to the low amount of storage provided.
Upper Devils Creek impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 14 of Kentucky River. Proposed reservoir has potential usable storage of 1.3 billion gallons at cost of approx. \$8.4 million.	Not implemented due to expectation that water supply alternatives using small upstream reservoirs would result in greater environmental, social and cultural impacts. Also eliminated due to the low amount of storage provided.

Offstream Impoundments (Continued)			
Proposal	Source, Year*	Discussion	Action Taken
Walker Creek impoundment	Harza, 1991 (2.5.3)	Tributary to Pool 14 of Kentucky River. Proposed reservoir has potential usable storage of 1.5 billion gallons at approx. cost of \$13.6 million.	Not implemented due to high unit cost of storage and water quality concerns.
Boone Creek Reservoir (Garrard County)	USACOE, 1978 (2.2.3)	Considered as a single community alternative for Lancaster, replacing its Kentucky River source. Depending on demand predictions and storage requirement, was estimated to cost \$2 to \$2.3 million.	Not implemented because of determination that a regional supply solution would be more cost-effective than this single-community alternative.
Clear Creek Reservoir (Woodford County)	USACOE, 1978 (2.2.3)	Considered as single community alternative for Nicholasville, replacing its Kentucky River source. Depending on demand predictions and storage requirement, was estimated to cost \$7.7 to \$9.1 million.	Not implemented because of determination that a regional supply solution would be more cost-effective than this single-community alternative.
Drowning Creek Reservoir	USACOE, 1978 (2.2.3)	Considered as single community alternative for Richmond in order to supplement Kentucky River flows at its intake. Depending on demand predictions and storage requirement, was estimated to cost \$1.9 to \$2.06 million.	Not implemented because of determination that a regional supply solution would be more cost-effective than this single-community alternative.
Red River Lake	USACOE, 1978 (2.2.3) and Rebmann and Hassell, 1988 (2.7.1)	This reservoir was authorized for construction as part of the flood control plan for the Kentucky River Basin in the Flood Control Act of 1962. It was planned by the USACOE as a multipurpose reservoir for flood control, recreation, and water supply and water quality storage. Expected to provide approx. 24,770 acre-feet of water storage.	Not implemented due to public interest in protecting the Red River Gorge natural area. It was determined that region's water supply needs could be better met through Kentucky River pools and Station Camp Creek Reservoir.
Shallow Ford Reservoir	USACOE, 1978 (2.2.3)	Considered as single community storage for Nicholasville in order to supplement Kentucky River flows at its intake. Depending on demand predictions and storage requirement, was estimated to cost \$1.25 to \$1.39 million.	Not implemented because of determination that a regional supply solution would be more cost-effective than this single-community alternative.
Sugar Creek Reservoir (Garrard County)	USACOE, 1978 (2.2.3)	Considered as single community storage for Lancaster in order to supplement Kentucky River flows at its intake. Depending on demand predictions and storage requirement, was estimated to cost approx. \$1.75.	Not implemented because of determination that a regional supply solution would be more cost-effective than this single-community alternative.
Eagle Creek Lake	KRB Technical Advisory Committee, 1989 (2.12.5)	To be located in Grant and Owen Counties with 247 square mile drainage area. Estimated summer pool storage capacity of 66,271 acre-feet. 1974 estimated cost of \$27.8 million. Authorized by Flood Control Act of 1962. Classified as inactive in April 1975.	Not implemented due to excessive inundation of farmland that would result from reservoir's construction.
Construction of reservoirs on Carr Fork, North Fork near Walkers Creek, Red River and Eagle Creek	USACOE, 1958 (2.2.1)	Included in a comprehensive plan for flood control and related purposes in the Ohio River, issued by the U.S. Army Corps of Engineers.	Carr Creek Lake completed in 1976. Proposed reservoirs on North Fork, Red River and Eagle Creek not implemented.

Ohio River Pipeline Alternatives			
Proposal	Source, Year*	Discussion	Action Taken
Treated water pipeline from Louisville to Lexington WITH low-level valves in Locks & Dams 9-14	KWRI, 1996 (2.1.4)	Assuming a minimum capacity of 15 mgd is reserved for use as drought augmentation, a residual supply deficit of 1.1 billion gallons remains for 2020 projected high-demand conditions. Rated as third most economically attractive option, behind temporary crest gates and off-stem reservoir.	Partially implemented. Low-level valves functioning in Locks and Dams 9 and 11-14, but pipeline not constructed due to public opposition.
Raw water pipeline from Ohio River (Maysville) to Kentucky River (Beattyville)—103.8 miles long	Harza, 1991 (2.5.3)	Raw water delivery directly to Kentucky River. Design flow is 61.1 mgd, which was expected to meet the entire design deficit. Determined to be among most costly of considered pipeline alternatives.	Not implemented due to higher cost than other pipeline alternatives.
Raw water pipeline from Ohio River (Dover) to Lexington/Winchester, with branch pipelines to Beattyville and Richmond—84.8 miles long*	Harza, 1991 (2.5.3)	Raw water is discharged to Kentucky River just above Winchester's treatment plant. Design flow is 52.7 mgd. Meets the total water supply deficit. Third-least costly of considered pipeline alternatives. Retained for further consideration. The Harza report ranked this option third among its considered pipeline alternatives.	Not implemented due to higher cost than other pipeline alternatives.
Raw water pipeline from Ohio River (Dover) to Kentucky River (Richmond)—109.5 miles long	Harza, 1991 (2.5.3)	Design flow is 57.8 mgd. Determined to be most costly of considered pipeline alternatives.	Not implemented due to higher cost than other pipeline alternatives.
Raw water pipeline from Ohio River (Dover) to Lexington/Winchester, with branch pipeline to Richmond—84.8 miles long	Harza, 1991 (2.5.3)	Main pipeline designed for a flow of 52.7 mgd.	Not implemented due to higher cost than other pipeline alternatives.
Raw water pipeline from Ohio River (Dover) to Winchester—84.8 miles long	Harza, 1991 (2.5.3)	Design flow is 52.7 mgd. Determined to be among most costly of considered pipeline alternatives.	Not implemented due to higher cost than other pipeline alternatives.
Raw water pipeline from Ohio River (Dover) to KAWC's Jacobson Reservoir—78.8 miles long*	Harza, 1991 (2.5.3)	Would serve only the region covered by the Kentucky-American Water Company. Pipeline designed for a flow of 40 mgd. Second lowest-cost option of considered pipeline alternatives. Retained for further consideration. The Harza report ranked this option second among its considered pipeline alternatives.	Not implemented because only serves Kentucky-American Water Company customers.
Treated water pipeline from Louisville to Lexington (72 miles long) - operated only during drought*	Harza, 1991 (2.5.3)	Pipeline would also be tapped to provide treated water to Frankfort, which is located along the route. Design flow is 44.6 mgd. This option is premised on the assumption that Louisville would supply 44 mgd of treated water. Determined to be least costly of considered pipeline alternatives. The Harza report ranked this option first among its considered pipeline alternatives. It was retained for further consideration.	Not implemented due to public opposition.
Treated water pipeline from Louisville to Lexington - operated as primary water supply	Harza, 1991 (2.5.3)	Option eliminated because cost of operating the new system as the primary water source exceeds the cost of operating the existing system.	Not implemented due to excessive operating costs.

Ohio River Pipeline Alternatives (Continued)

Proposal	Source, Year	Discussion	Action Taken
Treated water pipeline from new plant at Dover to KAWC system (75 miles long) - operated only during drought	Harza, 1991 (2.5.3)	Pipeline would be designed for flow of 39.6 mgd.	Not implemented because only serves Pool 9 (Kentucky-American).
Treated water pipeline from new plant at Dover to KAWC system - operated as primary water supply	Harza, 1991 (2.5.3)	Operated as primary source of water supply for Kentucky-American service area.	Not implemented because only serves Pool 9 (Kentucky-American).

Demand Management			
Proposal	Source, Year*	Discussion	Action Taken
Demand management WITH low-level valves in Locks & Dams 9-14	KWRI, 1996 (2.1.4)	If all withdrawals from the Kentucky River are held at winter levels, the 2020 high demand condition deficit for Pool 9 can be reduced to 1.1 billion gallons. However, this represents an extreme demand management policy that would likely result in millions of dollars in damages, as well as adverse environmental impacts.	Strategy eliminated because it does not completely eliminate deficit. Demand management recommended as a supplement to another water supply alternative.
Conservation Pricing	KWRI, 1996 (2.1.4, Task V)	Represents a long-term demand management alternative. A supply option will still be required to meet reduced demands.	Not implemented because would not significantly address water supply deficit.
Short-Term Demand Management	KWRI, 1996 (2.1.4, Task V)	Could include strategies such as voluntary demand reduction, odd-even day lawn watering, mandatory rationing, etc. A supply option will still be required to meet reduced demands.	Will be implemented as needed during drought conditions.

Interbasin Transfers			
Proposal	Source, Year*	Discussion	Action Taken
Transfer from Cumberland Lake	KRB Technical Advisory Comm., 1989 (2.12.5)	Closest connection to Kentucky River Basin would be to Dix River or near Beattyville. Both distances are greater than that between Cave Run Lake and Kentucky River Basin.	Not implemented due to excessive capital and annual operating costs.
Transfer from Cave Run Lake to Red River	KRB Technical Advisory Comm., 1989 (2.12.5) and USACOE, 1978 (2.2.3)	Interbasin transfer from Licking River Basin.	Not implemented due to excessive capital and annual operating costs.

Other			
Proposal	Source, Year	Discussion	Action Taken
Reallocation of storage from Carr Creek Reservoir	USACOE, 1997 and 1978 (2.2.3 and 2.2.7)	1997 study estimated cost to be \$40 million for storage space allowing up to 12 mgd of combined releases and river flows to meet needs of North Fork region. An additional cost of \$11.2 million would be required to construct a 5 mgd treatment plant.	Not implemented as supply solution for central Kentucky region due to high unit cost of storage, high transmission and evaporation losses and insufficient storage. However, option is still being pursued by Carr Creek Water Commission to meet water supply needs of Knott, Letcher and Perry counties.
Lower the raw water intake at Nicholasville	KWRI, 1996 (2.1.4) and Harza, 1996 (2.1.3)	Enables water withdrawals from Pool 8 during low flow conditions.	Not yet implemented. Expansion and additional lower intakes planned for approximately 2004.
Lower the Beattyville intake	Harza, 1996 (2.1.3)	Enables water withdrawals during low flow conditions.	Not yet implemented. New plant planned for construction approximately 2004-2005 and may install lower intake in conjunction with this effort.
Reallocation of storage from Buckhorn Lake	USACOE, 1978 (2.2.3)	Existing multipurpose reservoir on Middle Fork of Kentucky River, serving flood control and low flow augmentation purposes. Has drainage area of 408 square miles. Was considered as sole supply source option, in combination with Station Camp Creek Reservoir, and in combination with Muddy Creek Reservoir.	Not implemented because was not as cost-effective as a single supply component. Other downfalls were the high cost of storage reallocation, excessive costs of relocating recreational facilities and Highway 257, and high transmission losses that occur during drought conditions.
Groundwater wells	USACOE, 1978 (2.2.3)	Insufficient groundwater supplies, except as possible supplemental source for small service areas.	Not implemented due to inadequacy of groundwater supplies.

KRA Schedule for Locks and Dams 9-

11:

* According to KRA's 2002-2008 Capital Plan*

(to achieve "Kentucky River Water Storage Enhancements" goal of increasing river storage by 3 billion gallons)

FY 2002

Leakage control buttress walls at Lock & Dams 8 and 9 completed
Valve installed in temporary buttress wall at Lock & Dam 9 completed
Geotechnical evaluation, design and environmental analysis at Lock and Dam 9 begins

FY 2003

Final design and environmental analysis of Lock & Dam 10 construction completed
Final design and environmental analysis at Lock & Dam 9 completed
Preliminary design and geotechnical evaluation of Dam 11 begins

FY 2004

Renovation of the auxiliary dam and bay at Dam 10 completed
Final design for Lock and Dam 11 completed
Construction of auxiliary dam at Lock & Dam 9

FY 2005

Main dam at Lock & Dam 10 to be stabilized and raised 4-6 feet
Dam abutments and cut-off walls at Lock & Dam 10 to be stabilized
Main dam at Lock & Dam 9 to be stabilized and raised 4-6 feet

FY 2006

Begin renovation of lock structure at Lock & Dam 10
Lock and abutment walls at Lock & Dam 9 to be stabilized

FY 2007

Renovation of lock structure at Lock & Dam 10 completed
Main dam at Lock & Dam 11 stabilized and raised 4-6 feet

FY 2008

Lock and dam abutments at Lock & Dam 11
stabilized