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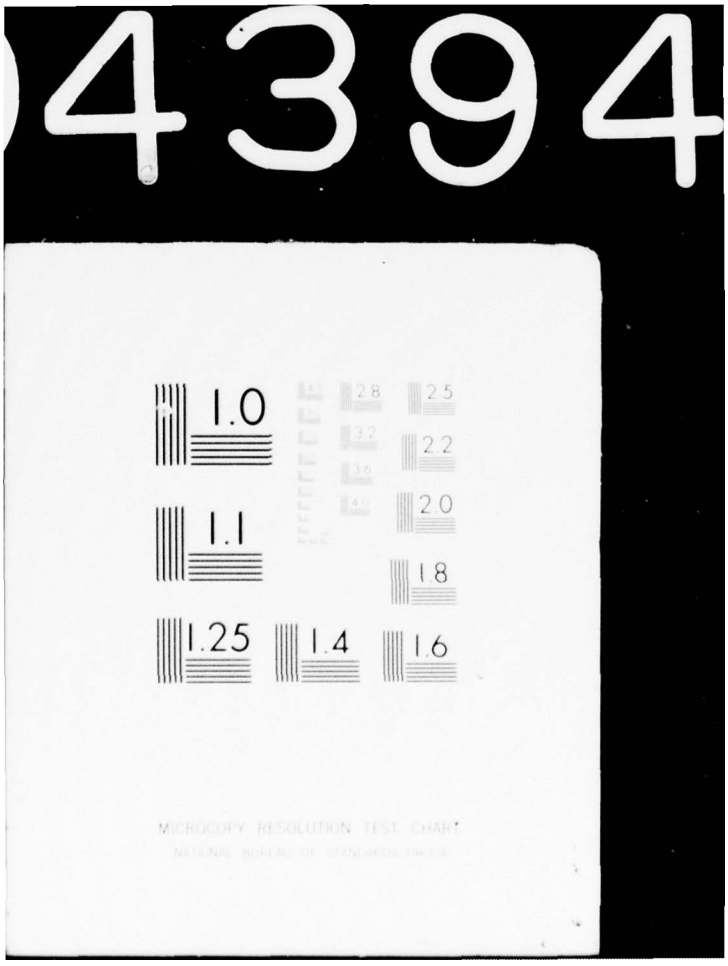
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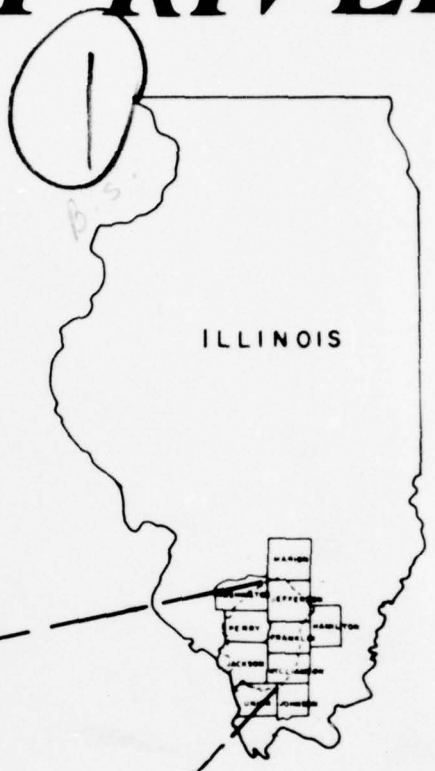
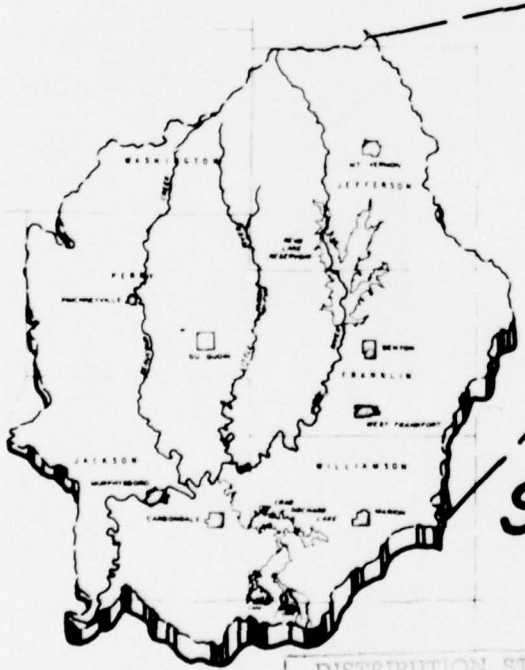
BIG MUDDY RIVER

Comprehensive Basin Study





Summary Report 1968

Draft No. 1

Prepared under supervision of
Muddy River Basin Coordinating Committee

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BIG MUDDY RIVER, ILLINOIS.
Comprehensive Basin Study.

9 SUMMARY REPORT.
~~DRAFT NO. 1~~

11 1968

12 198 p.

Prepared by
U. S. Army Engineer District, St. Louis

Coordinated with
BMRCBS Participating Agencies

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SECTION I - INTRODUCTION

1. AUTHORITY

The Big Muddy River Comprehensive Basin Study is one of the original Type II studies selected by the Interdepartmental Staff Committee of the Ad Hoc Water Resources Council. These comprehensive basin studies were planned to serve as the basis for authorization of specific projects and groups of projects. Subsequently, with the establishment of the Water Resources Council by the Water Resources Planning Act (Public Law 89-80), the administration and review of this study was placed under the Council's jurisdiction. It is the function of this Council to encourage the conservation, development and use of the water and land resources of the United States, with the Federal Government, States, localities and the private sector, all working in concert.

2. PURPOSE

The purpose of this report is to present a comprehensive plan of development that will provide for the best use or the combination of uses of water and land resources to meet the short and long-term needs of the basin. Specific objectives of the study made for this report were:

a. To determine the future direction and magnitude of the basin's economy at selected points of time;

b. To identify the demands for water and land-related products and services required to sustain the projected economy and maintain the area's socio-environmental well-being;

c. To develop possible solutions to meet these needs;

d. To formulate the projects and programs required to satisfy the immediate and long-range needs; and

e. To select the optimum plan of development based on engineering feasibility, economic justification, and social considerations

3. SCOPE

This report presents a general appraisal of the basin's over-all water and land resource potential based on the indentifiable needs and socio-environmental considerations. The recommended plan of improvement establishes a coordinated basis for the action programs of both Federal and non-Federal interests and serves as a common guide for future planning. Senate Document No. 97, 87th Congress, 2nd Session, "Policies, Standards and Procedures In the Formulation, Evaluation and Review of Plans For Use and Development Of Water and Related Land Resources," was used as a basic framework in studying and planning basin developments. Specific areas of investigation included:

a. Economic survey showing past trends and future projections of population and economic growth indicators such as employment and personal income;

b. Flood problems and their solution in the tributary watersheds and the headwater areas of the Big Muddy River above the Rend Lake Dam, presently under construction;

c. Current and projected municipal and industrial water supply requirements and the action programs currently underway to meet these needs;

d. Current and projected target flows and the action programs required to maintain acceptable quality standards for the major tributary streams.

e. Need for providing hydroelectric power generation and/or mine-mouth, at site power generation;

f. Potential and feasibility of improving Big Muddy River and Beaucoup Creek for modern barge transportation;

g. Recreational needs of the Basin and measures to meet these needs.

h. Fish and wildlife conservational requirements and the effects of resource development on the ecology and habitat;

i. The agricultural characteristics of the basin and the need to reorient and enhance agricultural productive output and efficiency;

j. Investigation of wetland problems and their drainage solutions;

k. The environmental quality, including preservation of unique historical and archaeological artifacts and aesthetic and sociological considerations;

l. Local and regional plans for development.

4. STUDY ORGANIZATION

Comprehensive planning for the Big Muddy River Basin Study was directed by a coordinating committee. Chaired by the Corps of Engineers, the committee was composed of representatives from U. S. Department of Agriculture; Army; Commerce; Health, Education, and Welfare; Interior; the Federal Power Commission; and the State of Illinois. The functions of the coordinating committee was to exercise overall managerial control of the study; provide a means for full and continuing exchange of views during the study; advise and assist all participating agencies regarding objectives, work assignments, and schedules; assist in resolution of study problems; and make periodic review of the progress being made on these studies. Small work groups or committees were formed to conduct studies in specific areas of interest.

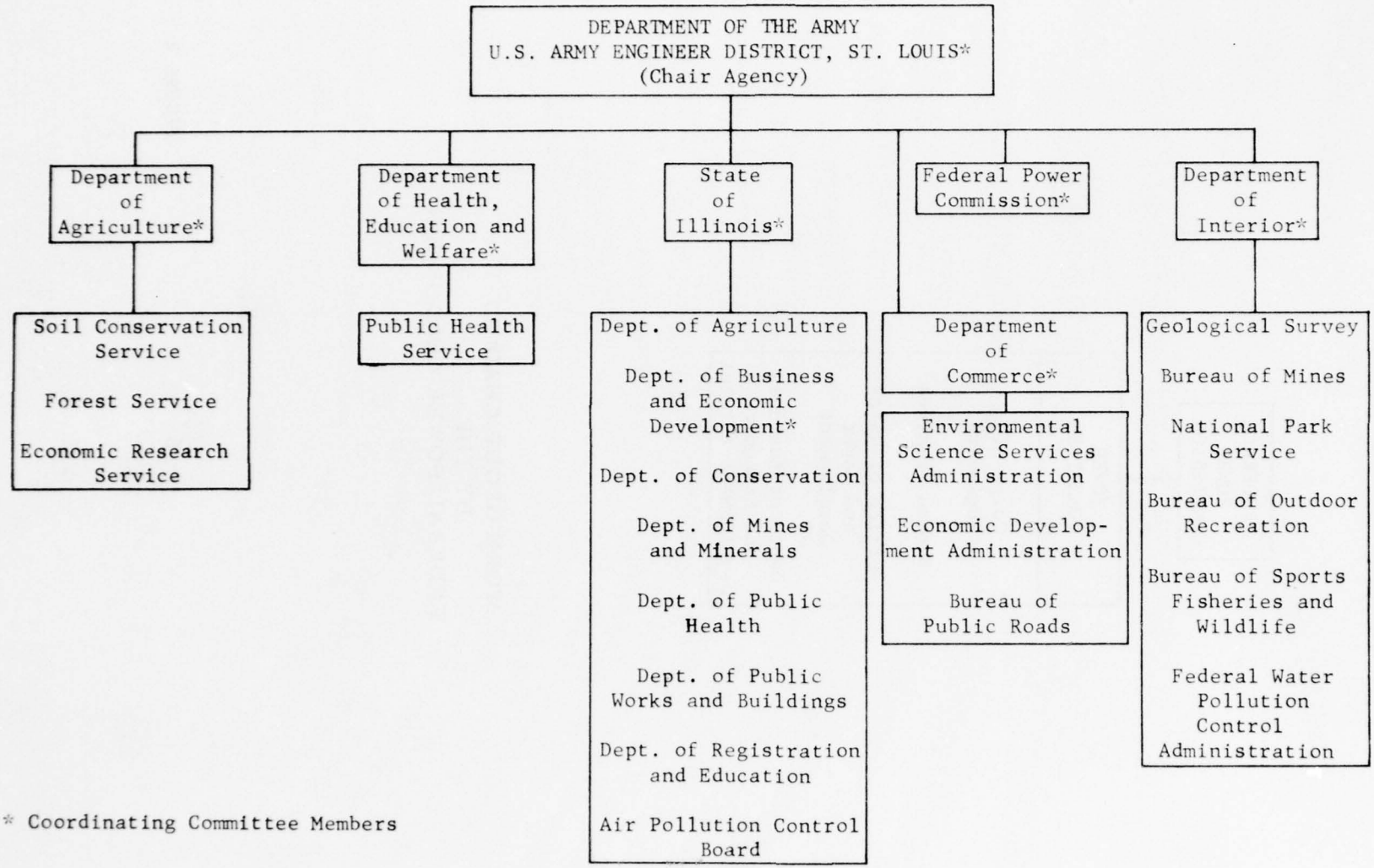
These work groups were chaired by the Federal agency having expertise in the particular subject. As the study progressed, it was realized that organization of a multi-agency work group was essential to achieve a truly joint effort in formulating the basin plan of development. Each department, having key responsibility in the various work committees, together with the State,appointed representatives to serve on a specially designated Plan Formulation Work Committee. This committee reviewed the various studies' conclusions; the formulation procedures used in establishing the optimum base plan; and the additions required to meet the basin's socio-environmental needs. The basic study organization is shown on FIGURE 1. Work group organizations are depicted on FIGURES 2 through 5.

5. DESCRIPTION OF INVESTIGATIONS

The coordinating committee participated in the control and coordination of the studies, the formulation of the basin plan of development, and the review of this summary report and its appendices. In addition, the individual agencies prepared the studies and reports listed below.

a. Department of Agriculture. The Soil Conservation Service, the Economic Research Service, and the Forest Service participated in the USDA part of the study. Participation of each agency was coordinated through a field advisory committee. This committee met on call of the chairman, the State Conservationist, to assure effective USDA coordination with studies of cooperating agencies. USDA agencies performed the following:

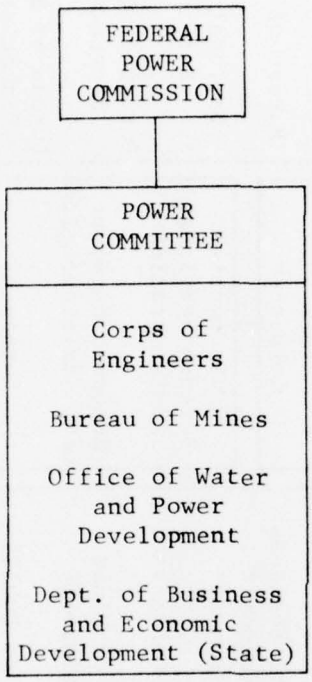
(1) Inventoried the natural resources for agricultural-related enterprises and identified future land-use, crop patterns and yields, and other economic factors.



* Coordinating Committee Members

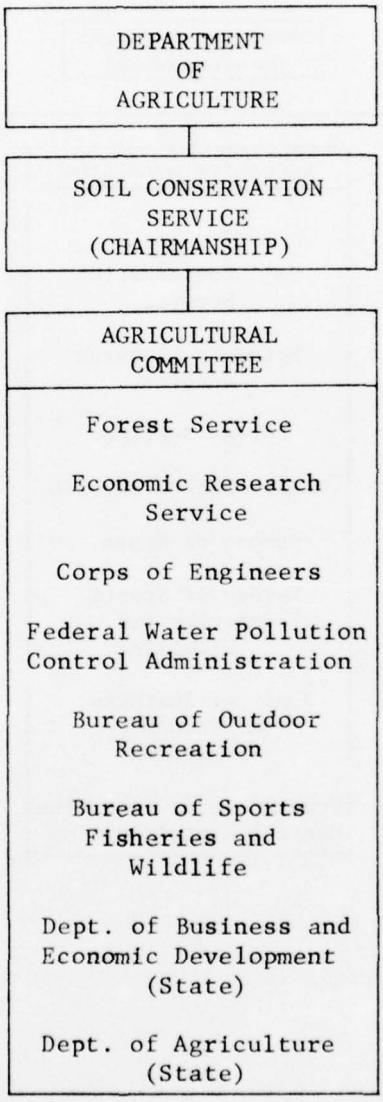
FIGURE 1

PARTICIPATING AGENCIES



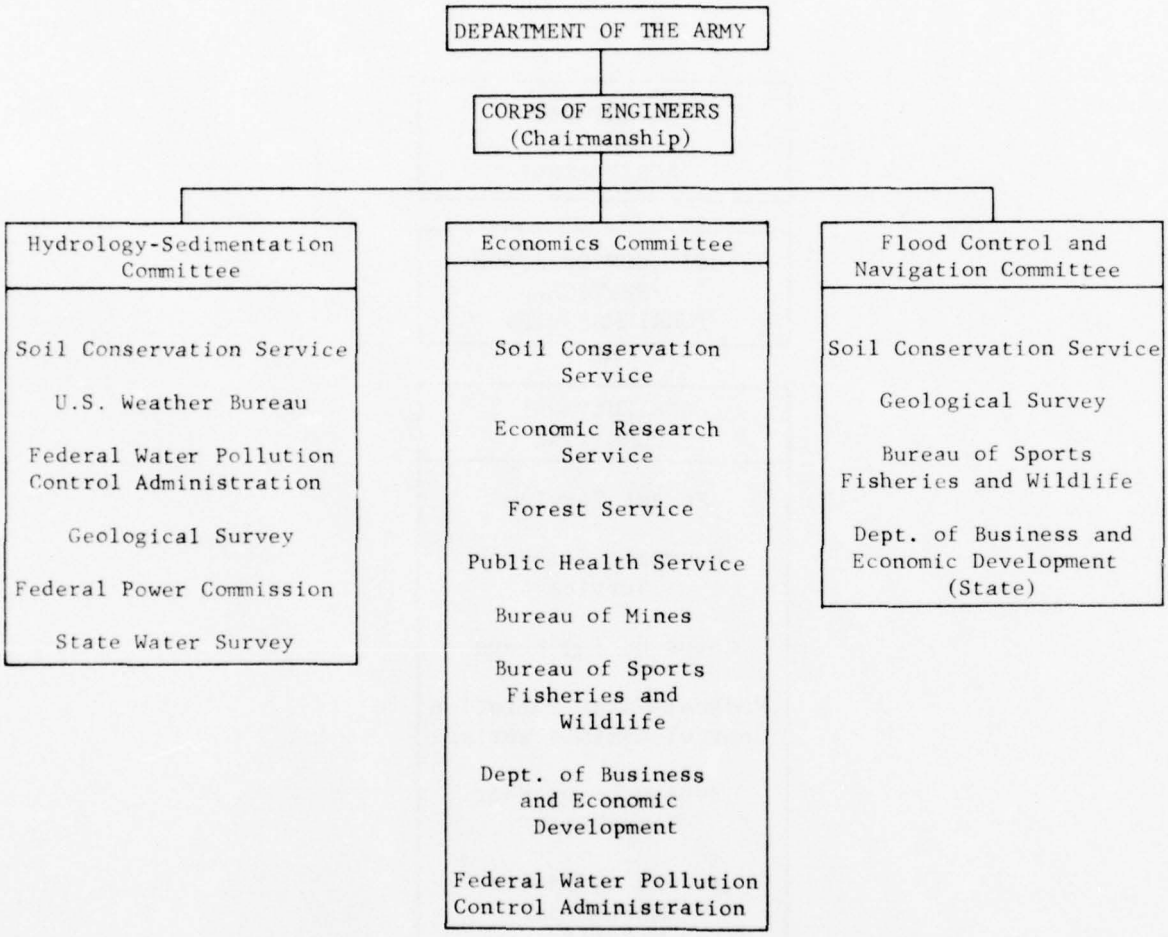
WORK GROUP CHAIRED
BY THE
FEDERAL POWER COMMISSION

FIGURE 2



WORK GROUP CHAIRED
BY THE DEPARTMENT
OF AGRICULTURE

FIGURE 3



WORK GROUPS CHAIRED BY
THE DEPARTMENT OF THE ARMY

FIGURE 4

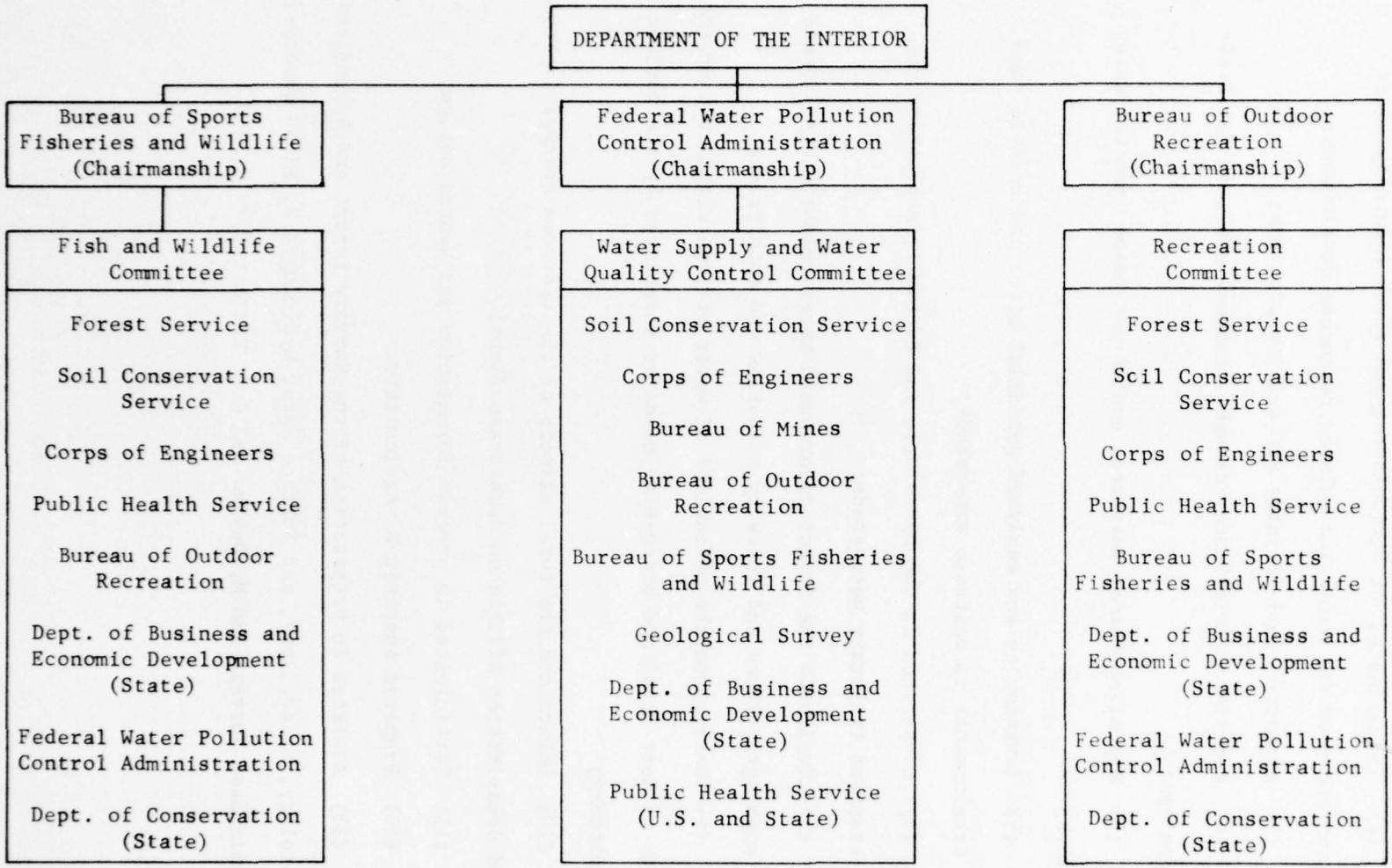


FIGURE 5

WORK GROUPS CHAIRED BY
THE DEPARTMENT OF THE INTERIOR

(2) Investigated of agricultural and rural community water problems and the need for water and related resources development;

(3) Appraised land-drainage and erosion problems;

(4) Appraised agricultural-drought problems and need for irrigation development;

(5) Appraised forest resources and forest-based industry water requirements;

(6) Inventoried and analyzed potential water and related land resource developments in upstream watersheds;

(7) Cooperated in the hydrologic and hydraulic evaluation for the main stem and tributary watersheds;

(8) Evaluated the impact of proposed water resource development projects upon agriculture and forestry resources and enterprises;

(9) Determined the potentials of water storage within the upstream watersheds to meet local and basin-wide needs as formulated by the various work committees;

(10) Determined the total effects of the upstream channel improvements and decapitation effects on downstream flows;

(11) Participated in program formulation and system design;

(12) Prepared Appendix K, Agriculture;

(13) Assisted in preparation of the Summary Report and Appendices: A, Climatology, Meteorology, and Surface Water Hydrology; F, Flood Damages; L, Economic Base Survey; and M, Design and Cost Estimates.

b. Department of the Army.

(1) Prepared Appendix L, Economic Base Survey, to determine the current and future economic development potential of the basin;

(2) Made engineering reconnaissance site inspections, topographic surveys, and subsurface explorations;

(3) Coordinated the establishment of flood profiles, current (with Rend Lake) and future conditions - with and without improvements in place, on the main stem of the Big Muddy River;

(4) Prepared Appendix G on the navigation problems and needs; made navigation economics studies and traffic analyses; and estimated the costs and benefits applicable to studied projects;

(5) Prepared Appendix D, Fluvial Sediment;

(6) Prepared Appendices: A, Climatology, Meteorology, and Surface Water Hydrology; F, Flood Damages; and M, Design and Cost Estimates, in coordination with the Soil Conservation Service;

(7) Prepared Appendix N, Benefit Evaluation, with appropriate assistance from all study participants;

(8) Prepared the Summary Report with appropriate assistance from all study participants;

(9) Evaluated the impact of proposed water resource development projects on all local and basin-wide needs, exclusive of agricultural related resources;

(10) Participated in program formulation and system design.

c. Department of Commerce. The Environmental Science Services Administration assisted in preparation of Appendix A, Climatology, Meteorology, and Surface Water Hydrology, and participated in the review of the various appendices.

d. Department of Health, Education, and Welfare. The Public Health Service participated in analyzing the potential health problems in the Carbondale area, where the stream flows were minimal relative to the vector population. It also participated in the review of the various appendices.

e. Department of Interior.

(1) U. S. Geological Survey prepared Appendix B, Ground Water Geology and assisted in the preparation of Appendix A, Climatology, Meteorology, and Surface Water Hydrology;

(2) Bureau of Sports Fisheries and Wildlife.

(a) Analyzed existing and projected demand-supply relationship for fish and wildlife resources;

(b) Determined where possible the effects of proposed developments on these resources;

(c) Prepared Appendix I, Fish and Wildlife Conservation.

(3) Bureau of Mines.

(a) Determined the nature and extent of mineral occurrences and the potential of the mineral industry in the basin;

(b) Evaluated the impact on the mineral industry by the proposed improvements;

(c) Prepared Appendix C, Mineral Resources, and assisted in the preparation of Appendix L, Economic Base Survey.

(4) Bureau of Outdoor Recreation.

(a) Developed the projected demands in terms of user-day attendance, water surface acreage and land acreage required for general recreation;

(b) Established design and cost criteria applicable for ascertaining and implementing the use potential for the reservoir developments considered;

(c) Prepared that portion dealing with personal recreation for Appendix H, Recreation.

(5) National Park Service.

(a) Contracted with the Southern Illinois University for preparation of that portion of Appendix H, Recreation, concerning archaeological, historical, and natural resources;

(b) Participated in the review of the various appendices.

(6) Federal Water Pollution Control Administration.

(a) Provided projections of target flows for critical tributary load points for water quality control purposes;

(b) Determined the value of supplemental storage required to maintain the selected DO level approved by the State of Illinois;

(c) Prepared Appendix E, Water Use and Stream Quality;

(d) Assisted in establishing governing design criteria for yield-storage capability of drainage areas.

(7) Federal Power Commission.

(a) Determined the projected power loads in the market area, feasibility of potential hydropower, and the potential of mine-mouth power generation in relation to the market load;

(b) Prepared Appendix J, Power;

(c) Participated in the review of the various appendices.

6. REPORT ARRANGEMENT

This comprehensive report is composed of a summary report and a series of supporting appendices covering specific areas of interest. Detailed technical information in the appendices is summarized and presented in the non-technical language in the summary report. Participating agencies were responsible for the preparation of any appendices relating to subject matter which came under their normal operating authority. All agencies were invited to contribute to the appendices. Table 1 lists the appendices and the agency responsible for their preparation.

7. PRIOR STUDIES AND REPORTS

a. Corps of Engineers.

b. Department of Agriculture.

c. Department of Interior.

d. State of Illinois.

e. Local.

NOTE: All agencies are to provide input for this paragraph.

8. PUBLIC HEARINGS

To be completed subsequent to acceptance of Summary Report by Coordinating Committee and holding of final public hearing. At that time, comprehensive plan of improvement will be presented to ascertain public acceptance.

TABLE 1

APPENDICES

Appendix	Title	Responsible Agency
A	Climatology and Meterology Surface Water Hydrology	Corps of Engineers
B	Groundwater Geology	Geological Survey
C	Mineral Resources	Bureau of Mines
D	Fluvial Sediment	Corps of Engineers
E	Water Use and Stream Quality	Federal Water Pollution Control Administration
F	Flood Damages	Corps of Engineers
G	Navigation	Corps of Engineers
H	Recreation	Bureau of Outdoor Recreation
I	Fish and Wildlife Conservation	Fish and Wildlife Service
J	Power	Federal Power Commission
K	Agriculture	Soil Conservation Service
L	Economic Base Survey	Corps of Engineers
M	Design and Cost Estimates	Corps of Engineers
N	Benefit Evaluation	Corps of Engineers

SECTION II - PLANNING ENVIRONMENT

9. BASIN LOCATION AND DESCRIPTION

The Big Muddy River Basin is located in the southwestern portion of the State of Illinois and includes most of the area between 37°30' and 38°30' north latitude and 88°40' and 89°40' west longitude. The Big Muddy River, which is part of one of 16 major tributary drainage areas in the Upper Mississippi River Basin, and embraces major portions of Franklin, Jackson, Jefferson, Perry and Williamson Counties and small portions of Hamilton, Johnson, Marion, Randolph, Union and Washington Counties. The basin contains some 2,375 square miles and is essentially rectangular in shape, having a median length of 72 miles and an average width of 33 miles. The topography of the basin is characterized by gently undulating hills in the north and west; low relief, wide valleys and well developed upland drainage system in the east; and more rugged, well-defined hills and valleys in the south. Local topographic relief seldom exceeds 100 feet, while elevations range from 320 to 860 feet above mean sea level. A map of basin is shown on PLATE 1.

10. GEOLOGY AND SOILS

Prior to the last glacial period in this area, the Big Muddy River cut a broad valley through the bedrock shales and sandstones found in the basin. Then, following the withdrawal of the glacial ice sheet, large quantities of melt water caused the Mississippi River to carry such large quantities of sediment that its capacity to transport them was exceeded. This, in turn, resulted in the Mississippi Valley being filled with sediment that closed the mouths of some of its tributary streams. The Big Muddy River was one of the tributaries that was unable to cut through these deposits as fast as

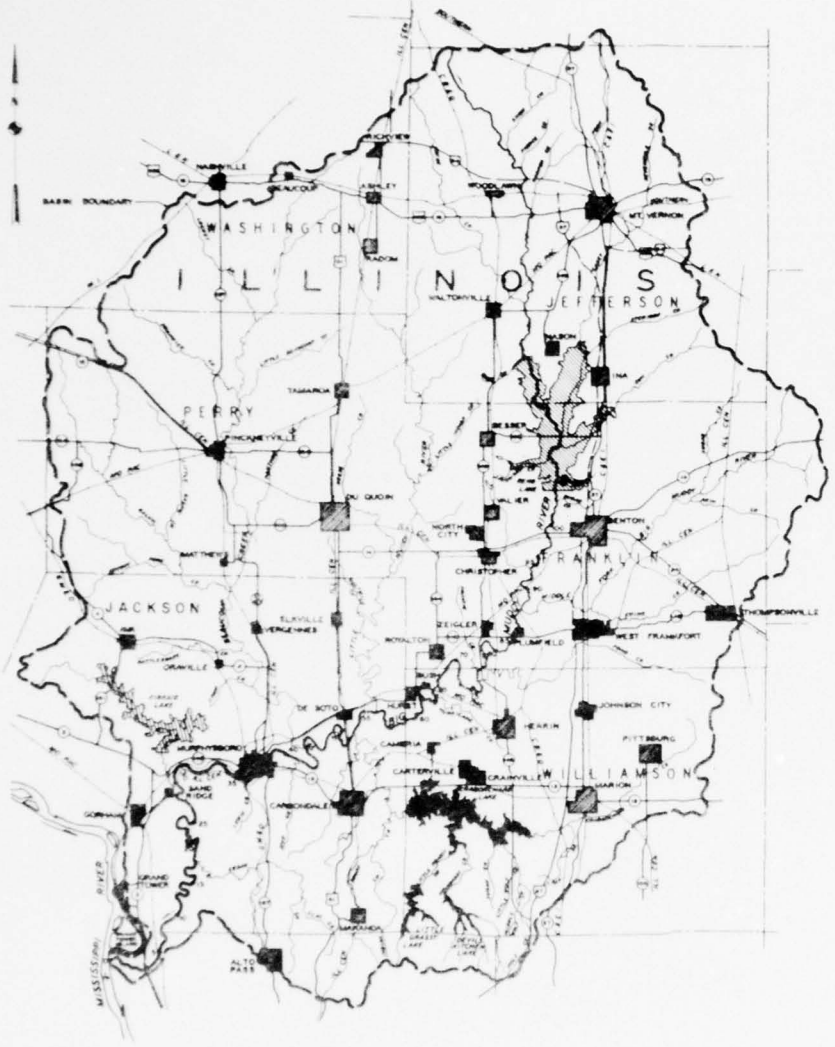
the Mississippi River laid them, and thus became impounded. This lake characteristic was probably intermittent in character, but well-defined terrace levels are evidence of at least two different periods of prolonged lake existence. When the Mississippi River was once more capable of transporting the sediment delivered to it, the natural process of cutting a deeper channel occurred and the ponded Big Muddy River, now nearly full of sediment, began to drain. Typical of a lakebed, the soils of the Big Muddy Valley consist of a series of clays and silts, interlaced with layers of very fine sands. The clay and silt composing the lake fill are relatively impervious, although they have been found to be saturated; ground water moves along the thin irregular layers of fine sand previously mentioned. Below this lake fill are coarser silts, sands, and fine gravels, which probably are remnants of earlier glacial deposits formed when the stream carried melt-water from the retreating ice edge. This lower portion varies in permeability and does not contain any significant ground water. Bedrock is 60 feet or more below the flood plain, with the deeper portion occurring on the west side of the valley in the Sesser area and primarily consists of sandstone underlain by shale.

11. CLIMATE, RAINFALL, AND RUNOFF

The basin area has a climate that is typical of the mid-Mississippi River region. The winters are relatively mild, while summers are commonly warm-to-hot and usually humid, with occasional temperatures of 100° Fahrenheit or higher. Mean annual temperature is approximately 60° Fahrenheit, with extremes of 114° to a -20° having been recorded. July is the warmest month and January is the coldest month, with mean monthly temperatures

CORPS OF ENGINEERS

U.S. ARMY



BASIN MAP

BIG MUDDY RIVER BASIN, ILLINOIS

PLATE 1

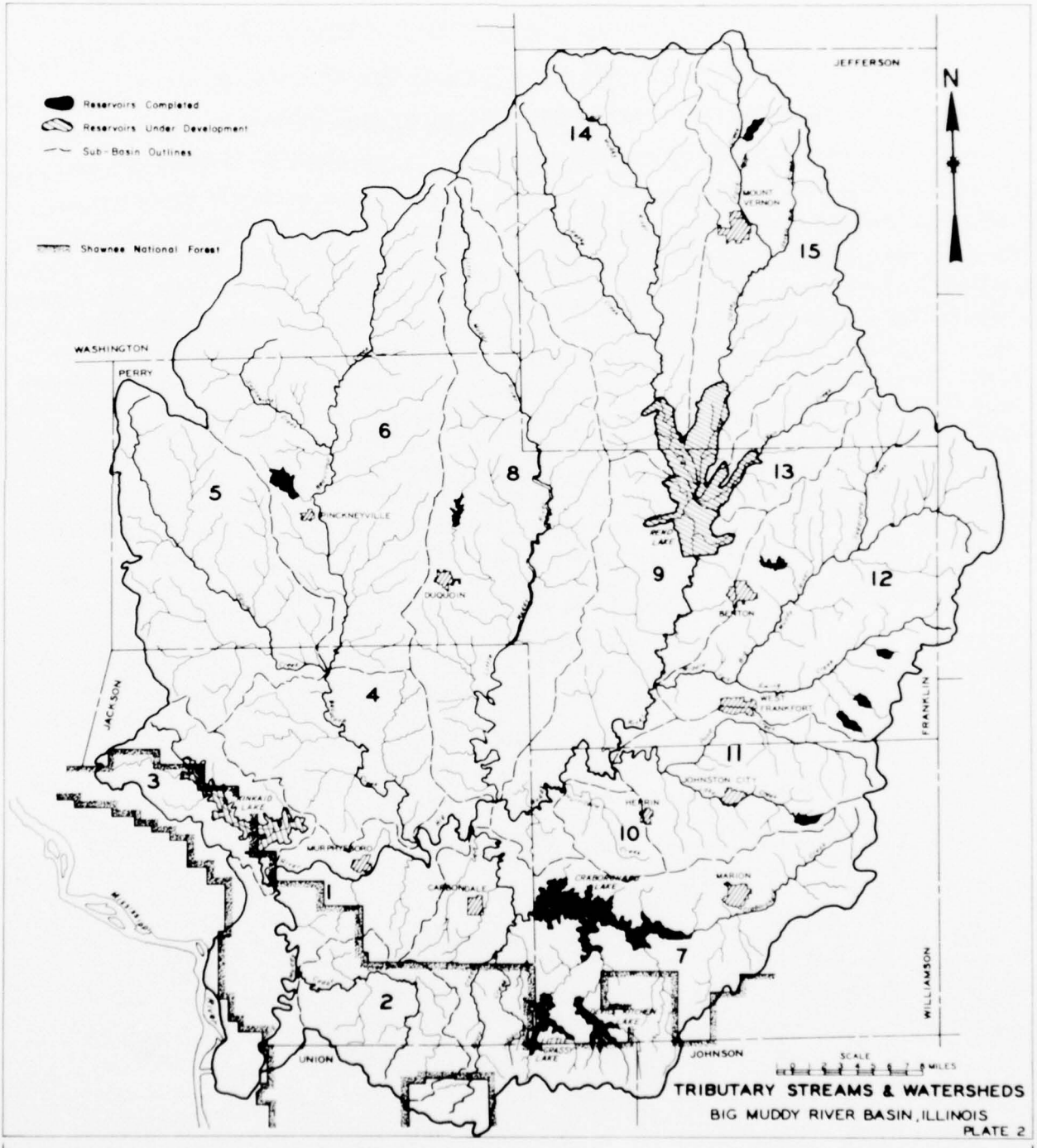
equivalent to 78° and 36°, respectively. The average daily temperature range is about 18° during the colder half of the year and about 22° during the warmer months. Due to this moderate temperature, the area has a frost-free growing season of some 190-200 days. Early April is normally the time of the last killing frost, while the first fall frost occurs usually late in October. Prevailing wind patterns move from the southwest to the northeast during the spring and summer, and from the northwest to the southeast during the winter. Maximum wind movement occurs in March and the minimum in August, with an average of about 10.3 miles per hour. The basin is subject to intense local rainstorms of short duration, usually in the summer, as well as widespread storms of lesser intensity throughout the rest of the year. The more notable storms of record are of the latter type and have been responsible for the major floods within the basin.

Average annual rainfall in the basin is about 42 inches, as compared to the United States average of some 30 inches, with extremes of 65 and 29 inches having been recorded. Average annual snowfall is about 20 inches. Distribution of precipitation is relatively uniform throughout the year, with the driest month being February and the wettest month being May. However, much of the total rainfall is lost because of evaporation, transpiration, rapid upland runoff rate, and the limited capacity of the surface soils to retain infiltration as ground water. Average annual runoff represents about 11.5 to 13.0 inches average depth over the drainage area, or about 1,500,000 acre-feet. Analyses of past flows indicate that the annual runoff at Murphysboro, which has a drainage area equal to about 92 percent of the total basin, exceeded 2,000,000 acre-feet for 7 years, with the greatest

annual runoff of 3,737,000 acre-feet occurring in 1950. In the same period of record, there were also 7 years in which runoff was less than 500,000 acre-feet, with a minimum of 95,000 acre-feet recorded in 1941.

12. HYDROLOGY AND HYDRAULIC CHARACTERISTICS

The drainage system consists of the main stem of the Big Muddy River and its five principal tributaries: Beaucoup Creek, Crab Orchard Creek, Little Muddy, Middle Fork, and Casey Fork. A breakdown of the basin's major tributary areas and watersheds, as defined by topographic and hydrologic limitations, is shown on PLATE 2 and listed in TABLE 3. These principal streams generally follow tortuous routes with directional changes abruptly taking place in many areas. Runoff is rapid in the northern half of the basin, with high-water crests occurring 2-3 days after the beginning of a rise, and being sluggish in the southern half with a 4-5 day crest lag. Recession after cresting is generally slow, particularly in the lower 43 miles of the main stem, which is affected by backwater from the Mississippi River. Stream flow data on the Big Muddy River have been collected intermittently from 1908 to date at three gaging stations on the main stem. Three additional stream flow gages are in operation on the major tributaries, but with only 20 years of record. The Plumfield gage on the main stem, which has a drainage area of 785 square miles, was selected as the controlling or reference gage because it has the longest period of record and was also representative of the basin's flow pattern and yield. During the period of record extending from 1916 to 1965, Plumfield has recorded a mean discharge of 713 cfs, with a maximum and minimum recording of 43,500 and 0, respectively. Low-flow characteristics indicate an annual critical 7-day



TRIBUTARY STREAMS & WATERSHEDS

BIG MUDDY RIVER BASIN, ILLINOIS

PLATE 2

Table 2
Major watersheds and principal tributary areas
Big Muddy River, Illinois, Comprehensive Basin Study

Watershed and principal tributary area	River mile - main stem, Big Muddy River	Drainage area (square mile) Individual	Total
14. Upper Big Muddy	103.1 - 160.5		276
15. Casey Fork	110.2		163
13. Gun Creek	109.3		49
9. Central Big Muddy	55.3 - 103.1		122
12. Middle Fork	87.8		236
Middle Fork		176	
Ewing Creek		60	
11. Lake and Pond	76.6		101
Lake Creek		34	
Pond Creek		67	
10. Hurricane Creek	65.4		24
8. Little Muddy	55.3		282
1. Lower Big Muddy	0 - 55.3		135
7. Crab Orchard Creek	52.3		288
Grassy Creek		27	
Little Grassy Creek		24	
Wolf Creek		18	
Drury Creek		51	
Local area		168	
4 & 6. Beaucoup Creek	43.5		404
3. Kinkaid Creek	28.4		64
5. Galum Creek	27.8		163
2. Cedar Creek	17.1		68
TOTAL			2,375 sq. mi.

low-flow, averaging 2 cfs or less per day in 25 of the 50 years of record. Yield in acre-feet for the Plumfield gage has equaled or exceeded 513,000 50 percent of the time; 170,000 90 percent of the time; and 63,000 95 percent of the time. Streams of the basin are characterized by high turbidity and sediment load, and a relatively low percent saturation (about 60 percent) of dissolved oxygen. In most stream reaches, especially those not near the headwaters, hardness, iron, and manganese are present in significant concentrations. Acid mine drainage is a major water quality problem in some of the areas, particularly in the Lake and Pond Creek sub-basin. Although little ground water is used for water supplies, approximately 10,146 million gallons per year are discharged into the basin, both naturally and artificially. On the basis of streamflow data, groundwater is discharged naturally into the streams about 25 percent of the time at an average rate of about 0.006 c/s per square mile. Excluding input from the Mississippi River flood plain, this amounts to 820 million gallons per year. More than three-quarters of the basin (excluding the southwestern portion) is classified as areas of low yield. In these areas, ground water supplies are difficult to obtain and are not dependable. Except for a few scattered pockets, the yield is estimated to be less than 5 gpm for individual wells. Thus over time, the available ground water has been used only for an individual domestic and farm supply. In the extreme southwestern part of the basin, exclusive of the Mississippi flood plain, ground water provides dependable supplies to a few towns and municipalities. Depths of the municipal wells range from 200 to 600 feet and yield from 25 to 190 gpm. Yields of more than 20 gpm from an individual well can be expected with an average yield of approximately 50 gpm. The Mississippi River flood plain is the only location

where the ground water is sufficiently abundant to permit installation of numerous wells that could supply a total of more than 60 mgd. However, to avoid excessive decline in water levels, pumping would have to be spread out over an area rather than concentrated at one or two centers. Excessive hardness and high iron content are the two most common characteristics of ground water found in the basin, and saline water may be encountered in wells with depths in excess of 1,200 feet. Two favorable characteristics are its temperature and its bacterial quality. Since the ground water has been filtered through so many feet of rock material, it is normally free of bacteria and should remain so if the wells are properly constructed and abandoned wells are properly plugged.

13. LAND USE AND NATURAL RESOURCES

a. Land use. There are approximately 1,510,400 acres within the study area, of which 65 percent is in croplands and pastures; 18 percent in commercial forestry lands, with an additional 4 percent in public ownership, and 13 percent is in other usages. A breakdown of land use and ownership in each of the basin's watersheds are shown in TABLES 3 and 4, respectively. About 21 percent of the basin acreage is located in flood plains, with 52 percent in agricultural production, and the remaining is basically timberland including some 3.7 percent of swamp lands.

b. Forestry. Twenty-two percent of the area is in forest lands, including 321,400 acres classified as commercial forest lands and some 13,300 acres still in timber but not in commercial production.

The types of species vary from oak,

TABLE 3

Land use by watershed
Big Muddy River Basin
Acres

Watershed	Crop-land	Pasture-land	Forest-land	Other Land 1/	Total
Casey Fork	54,000	18,900	11,800	20,300	105,000
Cedar Creek	15,100	4,800	18,100	11,000	44,000
Central Big	59,000	11,800	22,300	9,900	103,000
Crab Orchard	62,200	20,200	35,900	67,700	186,000
Calum Creek	62,300	13,600	15,100	14,000	105,000
Gun Creek	17,300	4,700	4,900	5,100	32,000
Hurricane Creek	7,900	2,300	3,400	2,400	16,000
Kinkaid	16,900	5,300	14,000	4,800	41,000
Lake & Pond	34,200	9,200	14,000	7,600	65,000
Little Muddy	106,600	23,500	30,500	20,400	181,000
Lower Beaucoup	31,400	9,900	21,200	3,500	66,000
Lower Big Muddy	21,700	7,500	21,600	24,200	75,000
Middle Fork	84,400	23,900	21,900	21,800	152,000
Upper Beaucoup	127,400	21,700	24,500	22,400	196,000
Upper Big Muddy	83,200	25,300	17,700	26,800	153,000
TOTAL: acres	783,600	202,600	271,900	261,900	1,520,000
percent	52	13	18	17	100

1/ Includes urban, industrial areas, State and Federal lands (including 63,030 acres of public-owned forests), farmsteads, roads, and other miscellaneous land.

TABLE 4

Land ownership
Big Muddy River Basin
acres

Watershed	Private	State	Federal		Total
			Shawnee National Forest	Crab Orchard Wildlife Refuge	
Casey Fork	104,300	700			105,000
Cedar Creek	35,700		8,300		44,000
Crab Orchard	136,700	4,500	1,800	43,000	186,000
Kinkaid	38,100		2,900		41,000
Lower Big Muddy	57,500	900	16,600		75,000
All others	1,069,000				1,069,000
TOTAL	1,441,300	6,100	29,600	43,000	1,520,000

gum, and cypress on the wet lowlands along the Mississippi River; to elm, ash, and cottonwood on the poorly drained uplands along the Big Muddy River; and to oak and hickory forests which make up the greater portion of commercial forest areas on the well drained uplands. Forest areas of Washington, Jefferson, Perry and Franklin counties range from 18 to 20 percent of the land in these counties. Because of its marked topographical relief, 30 to 45 percent of the total land areas in Jackson, Williamson, and Union counties are commercial forest lands and include part of the Shawnee National Forest, which was established in 1933. At present, the Shawnee National Forest comprises some 225,000 acres intermingled with 650,000 acres of private and other ownership. Of this amount, 29,560 acres of the national forest are within the Big Muddy River Basin and are under the management and administration of the U. S. Forest Service.

c. Mineral resources. The principal mineral resources found in the basin are coal, petroleum, sand and gravel, clay and shale, and stone. The first two commodities are actively under production and generally shipped to markets outside the basin. Sand, gravel, and stone outputs are generally limited to the needs of the local area in which they are produced. As far as is known, there has been no commercial mining of clay and shale since 1953. Illinois coals are highly volatile, with heat values generally ranging from 11,000 to 12,500 btu's per pound as received; sulfer content varying from 0.5 to 6.0 percent or more; and moisture content from 4.0 to 17.0 percent. Minable reserves of coal are extensive , with an estimated 16,713 million tons in the basin and 19,943 million tons in the adjoining counties. Strip and underground mining methods are both used in the basin. Strip mining began in the basin about 1910 and is still used today. With the

advent of improved design and development of large earth-moving equipment, strip mining accounted for some 33 percent of the basin's 1960 total coal production, and 44 percent of the coal output from the peripheral counties. Land reclamation in some form has been attempted since the early beginning of strip mining in the basin and, according to the U. S. Bureau of Mines, by 1961 approximately 57 percent of the strip mine lands had been restored and successfully reclaimed. Known oil fields are found in the northern and eastern part of the basin, in Jefferson and Franklin counties, and in the adjacent counties of Wayne, Hamilton, and Marion. Crude oil reserves in the basin total some 41,500,000 barrels with an additional 217,000,000 barrels in the peripheral service area. These estimates do not include oil which could be recovered by use of secondary recovery methods and which would increase these reserve estimates by some 50 percent or more.

Secondary recovery methods, involving pumping water under pressure through properly located input wells currently account for 23 percent of the basin's total crude oil production of 4,485,000 barrels in 1960. Illinois state laws and regulations require that proper procedures be followed to prevent salt water, oil, gas, or other wastes escaping from the wells to the surface or underground fresh water supplies. Regulations also govern construction or operation of salt water pits or oil field refuge pits so that wastes, liquid or oil field refuge may not escape in any manner except by evaporation or by burning. In addition, operators are required to restore the surface of the land surrounding all wells to its condition before drilling or upon abandonment by operators. The only commercially used

source of sand and gravel in the basin are those deposits located in the Mississippi River even though there are unconsolidated surface or near-surface deposits, some 10 to 30 feet thick, covering nearly three-quarters of the basin. The remaining resources, including sandstone and limestone, although found locally in the basin, are not the source of any significant commercial production other than meeting local needs such as agricultural limestone and road stone.

14. TRANSPORTATION

The basin is well provided with both railroads and highways. Two new interstate highways, currently under construction, as part of the nation's main network, will transverse the basin. When completed they will open up the area to new population centers and, based on a time-distance-travel concept, cause a secondary input effect on the basin's economy. Interstate Highway 57, connecting Chicago, Illinois, and New Orleans, Louisiana, crosses the eastern part of the basin for almost its entire length. Interstate 64 running east and west from St. Louis, Missouri, to Norfolk, Virginia, on the east coast, will be located in the northern part of the basin, crossing Interstate 57 near Mt. Vernon, Illinois, and continuing east. Rail transportation in and out of the basin is provided by: the Missouri-Pacific; the Louisville-Nashville; the Illinois Central; the Chicago, Burlington, and Quincy; the Gulf, Mobile, and Ohio; the Southern; and the Chicago and Eastern Illinois Railroads. Scheduled air transportation presently is limited to the airport at Carterville, with private runways and small municipal airports in operation at Carbondale, Benton, Mt. Vernon, and Little Grassy Lake, Illinois. In addition, the lower 37.5 miles of the Big Muddy River have been designated by law as navigable. However, in fact, it is not

developed or regarded as a commercially navigable stream and is not usable except during intermittent high-water periods and then only for short distances.

15. AESTHETIC AND ENVIRONMENTAL ASPECTS

a. Recreational season. There are sufficient changes in climatic conditions to sustain a range of recreational pursuits. Moderate temperatures in the spring and fall tend to create a recreational season extending from 1 April through 30 November, which is well beyond the traditional 3-month period common in the northern region of the state. Concentrated within this 8-month period are the peak demands for general recreation, fishing and selected hunting. While these pursuits are complementary and concurrent as to time, their peak demands are out of phase. Peak demand for general activities, such as boating, camping, picnicking, swimming, and hiking is from 15 April through 15 September; and for fishing from 1 April through 15 June and from 15 September through October. Hunting demand varies, dependent upon the species being sought, but it is generally the heaviest during the late fall and winter months, 15 October through February. Insufficient snowfall has heretofore precluded development of winter outdoor recreational pursuits in this basin. However, artificial devices are being used more extensively in this part of the country to supplement the annual snowfall so that over time the recreational season may be extended.

b. Ecological development. Because of its climatic make-up and its geographical location, the basin has mixed species of flora and fauna, representative of both northern and southern climates and which contributes to an environment conducive to outdoor pursuits. Especially significant are the numerous ecological communities found in the basin. Two of the most outstanding are the Pine Hills area south of Murphysboro and the scattered swamp lands that contribute an abundant cover to the area's wildlife. In addition, the natural aesthetic features have been supplemented by the geological actions that have occurred in the basin. Examples frequently noted are the extensive amounts of giant rocks and boulders, as well as geological bluff cleavage found in the Shawnee National Forest area, particularly the Giant City State Park. Traces of rolling prairie and bottomland in the north combine to give an interesting edge effect when contrasted with the hills and cliffs to the south. Historically, the northern three-quarters of the basin was covered by vegetation that was typical of the midwest prairies. The flora was dominated by five major varieties of grasses: Indiana, Wild Rye, Switch, Slough, and Big Bluestem. The latter variety was particularly noteworthy since it attained heights of between 6 to 10 feet and was the most prevalent of these grasses. Since then, these species, in the most part, have disappeared due to intensive agricultural pursuits, and extensive weed control programs. Bordering the prairie and separating it from the Shawnee Hills to the south are such shrubs as sumac, rough-leaved dogwood, and prairie crab apple. The dominant vegetation in the Shawnee Forest area are the Hill Prairie grasses of Little Bluestem, June grass

and Side-Oats Grama, which are typical of the cover native to the loess and the residual soils covering the limestone bluffs that underlie the forestry acreage. The Shawnee Hills Forest are composed of hardwoods that include: Beech, Tulip, and Maple in the bottoms; White, Red, and Black Oak together with several varieties of Hickory on the hill slopes; and Post Oak and Black Jack Oak interspersed with some Red Cedar on the hill crests. Also native to this basin is a remarkable array of animal life. Of the 59 species listed as native to Illinois, 46 can be found in the drainage area. The species range in size from the shrew to the white-tailed deer and include, among others, the raccoon, beaver, mink, muskrat, several varieties of fox, squirrel, and rabbit. Larger wildlife historically native to this area, but now no longer found, included the bison, elk, black bear, mountain lion, and wolves. Game birdlife found in the area consists of bob-white quail, morning dove, and limited amounts of pheasant and wild turkeys. A variety of migratory waterfowl, including the game species of geese and snow ducks, are native to this area which is part of the Mississippi Flyway. Due to sediment and pollution, most of the streams in the basin are populated by rough fish such as Drum, Buffalo, Carp, and Bullhead. However, where manmade impoundments are built, the predominant species include catfish, bass, bluegill, sunfish, and white crappie.

c. Manmade improvements. Facilities developed through the joint efforts of the Federal and State government and local interests have provided additional supplements to the natural resources. The Shawnee National Forest was created to take marginal farmland out of production and today is being managed by the U. S. Forest Service under a multiple-use program providing commercial forestation and recreational opportunities. The Crab Orchard

National Wildlife Refuge, maintained by the U. S. Fish and Wildlife Service, is currently being operated as a multiple-use wildlife management area. Three reservoirs, Crab Orchard, Devil's Kitchen, and Little Grassy, have been built and are managed for general recreation and, with the cooperation of the nearby Southern Illinois University, as an outdoor laboratory for biological studies, education, and research. Rend Lake, a multiple-purpose reservoir, is presently under construction by the Corps of Engineers and, in cooperation with the state and the local Rend Lake Conservancy District, will provide a range of recreational opportunities including parks, marinas and waterfowl refuges. In addition, the State of Illinois is purchasing land for development of Kinkaid Lake, a project jointly sponsored with the U. S. Forest Service. This lake, together with the previously mentioned 916-acre Giant City State Park, and the privately owned and operated DuQuoin State Fairgrounds, offer noteworthy contributions to the recreational and aesthetic value in the basin.

d. Archaeological findings. Significant Indian cultural remains have been found in the basin that are historically associated with the tribes that lived in this part of the country and that are of archaeological interest. Three types of sites have been found:

(1) open village or camp sites; (2) rock shelters and cave sites, which were used as habitation areas; and (3) burial sites dating from the period 300 B. C. to 900 A.D. and includes both bluff top or cliff-edge sites and river bottom sites. A fourth type, templetown or Indian mound site, which dates from the period 900-1500 A.D. and includes what was essentially an urban population concentration is possible but none have been

found in this basin to date. Other historical sites that are of potential public interest are stone forts and block houses. Stone forts are found throughout southern Illinois, with one located in the Giant City State Park. The sites consist of large elliptical stone walls constructed on tops of high bluffs. Opinions have varied as to their use, but generally they have been considered a form of wing trap for bison drives, or a defense stronghold. The block houses were built during the War of 1812 at the direction of the first Governor of Illinois territory. Constructed for the defense of the ten widespread communities, they were located in Jackson, Franklin, and Williamson Counties. Their reconstruction would enhance the recreational development of the basin.

SECTION III. ECONOMIC FRAMEWORK

16. GENERAL

To properly estimate the probable level of future economic development, it was recognized that the evaluation would have to include a geographical area larger than that encompassed by the basin's drainage area. The base, core or case, area includes major portions of Jackson, Williamson, Jefferson, Franklin, and Perry Counties which are located within the hydrologic boundaries of the basin. Final areal requirements were established by various land- and water-related need considerations. The result was the identification of an economic subregion, which included not only the five core counties, but also eight peripheral counties. Of the additional counties, Randolph, Washington, Marion, Hamilton, Johnson, and Union, have comparatively minor amounts of acreage located within the basin. The other two counties, Wayne and Saline, adjoin the basin on the northeast and east, respectively. Economic forecasts were developed from the analysis of three economic indicators: population, employment, and personal income, for which projections were developed for each decade in the study period, 1970 to 2020. Extrapolations to the year 2070 were also made, but only as an extension of the analysis and to validate the trends depicted for the study period. The population analysis included a study of such factors as migration rates, sex-cohart relationships, and urban, rural non-farm, and rural farm distribution. The employment analysis included the definition and classification of maximum possible labor force, participation rates of this segment of the population, and a forecast of anticipated unemployment rates. Employment projections were developed for nine divisions of the standard industrial

classification and for nine major group combinations of the manufacturing division. The employment analysis identified what percent of total employment will likely be filled by persons from within the basin area, and how many positions will be occupied by persons commuting from outside the basin. Because the standard industrial classifications were used, comparisons were easily made with other major regional sectors and trends in the national economy. Personal income, both total and per capita, was analyzed with particular emphasis paid to wages and salaries, and trends in this source of income. Within the total projected framework depicted by the three indices, adjustments by county were then made so as to depict the areas of influence for future economic growth from within the study area. These results were compared to those computed for the Upper Mississippi River Comprehensive Basin Study, Type I, and the sub-planning area, of which Big Muddy River Basin is part, to insure compatibility to the region and its relationship within the national economic framework.

17. HISTORICAL TRENDS

The basin has experienced an exodus of population in every census since 1930. As the employment effectiveness of mining and agriculture, the two principal industries at that time, was reduced, families found it necessary to move outside the area. By 1940, the out-migration was in full force and continued through the decade ending 1960. During the 1950-1960 decade, for example, out-migration ranged from 10.4 to 33.3 percent for many of the counties and was particularly severe among the post high school age group who was forced to move out of the basin in search of work. At

the same time, the continued reduction in the economic base of mining and agriculture created a secondary casual effect on this sub-region's economy. Manufacturing and the wholesale and retail trades became the major employers, not because of growth but due to the reduction in the other employment sectors. These manufacturing industries were mostly small, assembly-type operations, drawing from the available labor force. While the total labor market was dominated by unskilled and semi-skilled labor, the demand for the products could not create enough jobs to relieve the unemployment situation. Unemployment in the 1940's averaged 20-35 percent for the five counties. During the mid 1950's and early 1960's, many of the unemployed and their families left the area, reducing the unemployment rate to approximately 15-20 percent. Although there were fewer unemployed now, the labor force and population had been substantially reduced. Reflective of the basin's employment-industrial mix was the five counties per capita income of $1,213 for 1950 and $1,674 for 1960, far less than the respective national averages of $1,807 and $2,160. These economic characteristics are typical of an underdeveloped area.

18. CURRENT ECONOMIC CONSIDERATIONS

In the early and mid-1960's, this nation experienced one of the greatest economic booms of the century and with it came the opportunity needed by the residents of the Big Muddy Basin. Light industry moved into the area in search of the cheap, unskilled labor necessary for assembly-type operations, inexpensive land, and relief from a high municipal tax structure. This, in turn, created new job sources; and by 1963 the unemployment rate began to fall so that, while the estimated 1965 unemployment rate was still a high 8 percent, it was almost half of what it had been a decade before. Hence

for the first time since 1940, a real change in the aggregated decline of the basin was readily observed. Except for agriculture which has held its relative ranking, there has been a complete reversal in the industrial structure of the basin economy with manufacturing and services showing substantial growth. Manufacturing, in particular, experienced an exceptional growth, averaging an annual increase of some 3.3 percent during the decade 1950-1960, with the majority of this growth occurring in the latter 3 to 4 years. This new growth has been encouraged through the creation of industrial parks by the major communities within the basin, often with the financial and managerial assistance from sources such as the Public Works and Underdevelopment Act. Industrial parks, with emphasis on attracting light-to-medium industries, have been established: in the northeast part

of the basin at Mount Vernon, one completed and one under construction are each in excess of 100 acres; in the mid-east portion of the basin at Benton and West Frankfort, approximately 40 and 140 acres, respectively; and in the southeastern part of the basin near Marion, now in the preliminary stages of development. Noteworthy is the establishment of an air-industrial park between Carbondale and Murphysboro, located in the southwestern part of the basin. This park, presently planned to encompass some 130 acres, is being built around existing airport facilities and is an addition to the existing Carbondale industrial park of some 50 acres. Three industrial districts have also been established. These involve general areas of controlled, complementary, but mixed, land use, including selected sites for light-commercial industry. Two of these areas are located near Herrin in the middle of

the basin, and between DuQuoin in the west-central and Pinckneyville in the northeast part of the basin. The third area was one originally constructed during World War II at the east end of Crab Orchard Reservoir, which is now beginning to attract new industries after experiencing a period of decline. Just as significant as these industrial parks has been the establishment of supplementary manpower training programs, which have assisted in drawing labor to the area and particularly in the upgrading of the skill level of the workers. The Manpower Training and Development Corporation, Southern Illinois, has aided in this endeavor through such agencies as the Southern Illinois University Employment Service, Illinois Rehabilitation Service, and on-the-job training programs. At the present time, Southern Illinois University alone graduates approximately 3,000 individuals annually from its Vocational Training Institute, of which about 75 percent is being trained in industrial skills. In addition, action programs have been undertaken by both the State and local governments that will supplement the economic input to the area. Water resource developments, jointly planned and constructed by the Federal and State governments, notably Rend Lake and Kinkaid Lake, are specific examples. In addition, construction of the Federal Interstate Highway System and State improvements to the local road network have enhanced the accessibility of the basin to other markets. More will be said regarding this reorientation planning effort in later sections. Finally, during the mid-1960's, there has been a limited resurgence in coal mining activities. Recent new mine openings and land acquisitions undertaken by various large corporations have underscored this increase in certain parts of the 13 counties. It must be recognized, however, that with advanced technology, it is expected that the employment in mining

will still continue to decline while generating a greater unit productive output. Thus, the effect will be a gradual stabilization accompanied by greater real income to the basin.

19. PROJECTED ECONOMIC DEVELOPMENT

a. General. As light and medium industries continue their projected growth and as the recreational and educational sources approach their optimal potential, the economic standards of the basin will become more typical of those of the state and nation. By 2020, it is anticipated that the basin will have changed from an underdeveloped and relatively depressed region to one having an economic status nearly as high as the national average. Indications are that during the years 1970-mid 1980, the basin economy will show strong gains in employment, population, and personal income as the area begins its redevelopment. After the mid 1980's, the rapid rate of gains will inevitably slow down as an economic base is established, and, by the year 2000, the long-term pattern for a modified standard of living, as reflected by personal income, will have been established. Dramatic and conspicuous changes will no longer be observable, and the following two decades will show a growth, but in scope rather than in nature. Population will continue to grow, but at a lesser rate. Unemployment should continue to decline and approach the 4 percent level, accompanied by an equitable proportionality of the industrial mix. Wages and salaries will eventually constitute approximately 68 percent of total personal income around the year 2000, with property income realizing modest gains. Commercial and farm proprietors' income, as a percent of total income, will have stabilized with the relative percent gain or loss becoming

very subtle. It is anticipated that by the year 2020, the major portion of employment will still be of semi-skilled type, supplemented by both skilled and unskilled workers, as well as part-time and seasonal labor. As a result, the average annual unemployment rates may be slightly greater than the national average and the per capita income may remain slightly less than the national level.

b. Population trends. The exodus of people from the basin has already begun to reverse itself and should result in a long-run increase in net in-migration of population. Although a lag is anticipated in the early years of development, through 1980, the gap between desirable employment opportunities and inflow of people into the area will eventually narrow The major transition from the rural farm to the urban and rural non-farm sectors will be completed, as manufacturing and service industries become more dominant in the economic framework, reflecting the change in the socio-economic characteristics of the population. Projections indicate that a relatively modest increase in population will occur between the mid 1960's through the 1990's. Then, as unemployment reaches a minimal level and personal income approximates the national average, substantial growth in population is anticipated with in-migration as a predominant factor. Finally, growth and social changes will be reflected by where the people reside. The population is expected to gravitate towards larger towns and cities now in existence, as well as centering around recreational facilities and major highway networks where industries are more likely to be attracted. The population in the rural farm category will continue to decrease during the study period, as farms become larger and more efficient. Projections of population and rate of increase are shown on FIGURE 6.

c. Employment. A definite shift in the industrial mix of the area will be observed over the 50-year study period. It is anticipated that by the year 2020 manufacturing, service, trade, agriculture, and mining will be the relative order of industrial ranking, based on the number of people employed. This is almost a complete reversal of that found in the basin in 1950. Except for agriculture, which has held its relative ranking within the structure of the basin's economy, selected employment will continue its gradual growth, started in 1960, through mid 1980, after which time an even greater growth is anticipated. A general leveling-out period is anticipated by the year 2010. Unemployment will continue to decline as it has since 1960 until a relatively modest 4 to 5 percent rate of unemployment is achieved by 1990. Thereafter, a very gradual decline to a 4 percent level is expected throughout the following decades. The analysis recognized those workers which are expected to commute to jobs from outside the basin. This net inflow will grow so that during the decades following 1980, approximately 12 percent of the employment in the basin will be met by persons living outside the area. Trends in agricultural employment will continue to show the declines as farms become larger and fewer. Labor input per acre will continue to decline, as productivity increases are obtained through improved technology and greater mechanization. This increased productivity per employee will hasten the decline in agricultural employment up to the year 2000, when a leveling out is expected. Conversely, this production increase will provide greater real returns to the farm proprietor, making it more attractive to devote full time to agricultural pursuits and eventually stabilizing the employment figure. Projections of total employment are shown on FIGURE 6.

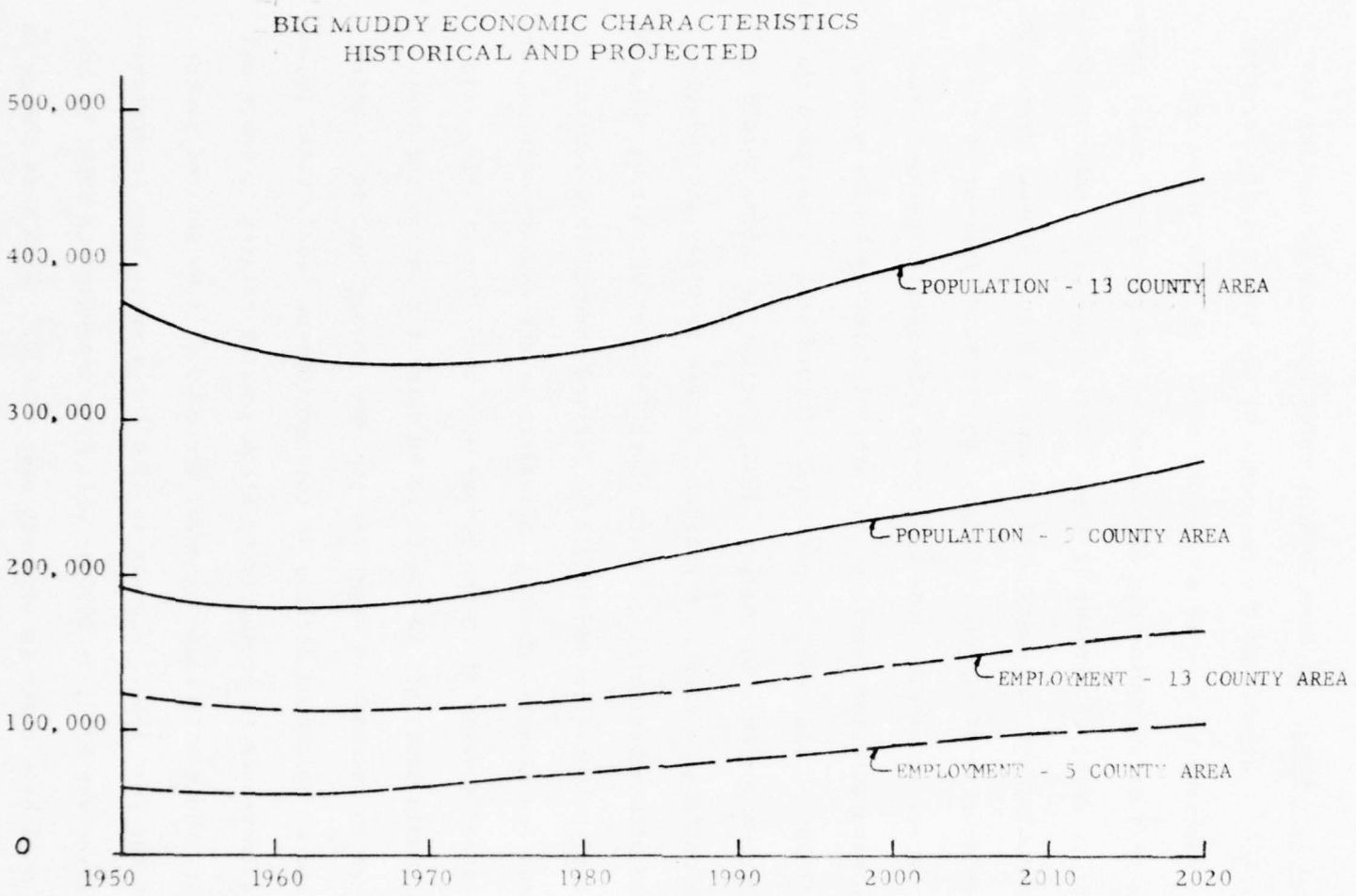

BIG MUDDY ECONOMIC CHARACTERISTICS
HISTORICAL AND PROJECTED
500,000
400,000
300,000
200,000
100,000
0
1950
1960
1970
1980
1990
2000
2010
2020
POPULATION - 13 COUNTY AREA
POPULATION - 5 COUNTY AREA
EMPLOYMENT - 13 COUNTY AREA
EMPLOYMENT - 5 COUNTY AREA

FIGURE 6

d. Personal income. As unemployment rates continue to decline and more jobs are made available to the residents of the basin, total personal income should continue to grow at a moderate rate. In 1950, wages and salaries consisted of approximately 62 percent of the residents' total personal income, rising to about 65 percent in 1960. This trend will continue, since the growth in employment and wages will advance at a much greater proportion than the other sources of personal income. By the third quarter of the 1970 decade, better industrial jobs will bring even greater gains in real income. With manufacturing services and other industries becoming more firmly established, these gains in per capita income will be realized throughout the projection period. By the year 2030, per capita income should be very near the national average. A general increase in wages and salaries is anticipated with substantial gains to about 1990, at which time about 68 percent of total personal income should be derived through this source. Modest declines are expected shortly thereafter as the economy becomes more affluent and other sources of income become more readily available. Wages and salaries should level off in the 67 to 68 percent range by the year 2020. Although an increase in wages per employee in agriculture is anticipated because of continued decline in this employment level, total income will climb as increases in productivity allow greater returns to labor and the proprietor. This anticipated gradual increase will be noticed, particularly after the year 1980. Whereas in 1960 the average wage in agriculture per employee was $328, by 1990 it will have increased to $910; by the year 2101 it will have risen to slightly over $1,400.[1] With this change in

1. Constant dollars.

farming and the increase in productivity, farmers' operational needs will also increase. This, in turn, generates a secondary demand, much of which will be fulfilled locally. Consequently, less revenue will leave the area, and the basin will be better able to maintain the balance of payments relative to its consumer needs. While this is true for all sectors of the basin economy, the scale applicable to agriculture, and its related generated demand is often greater than those in many other industries. The trend in personal income on a per-capita basis is shown on FIGURE 7.

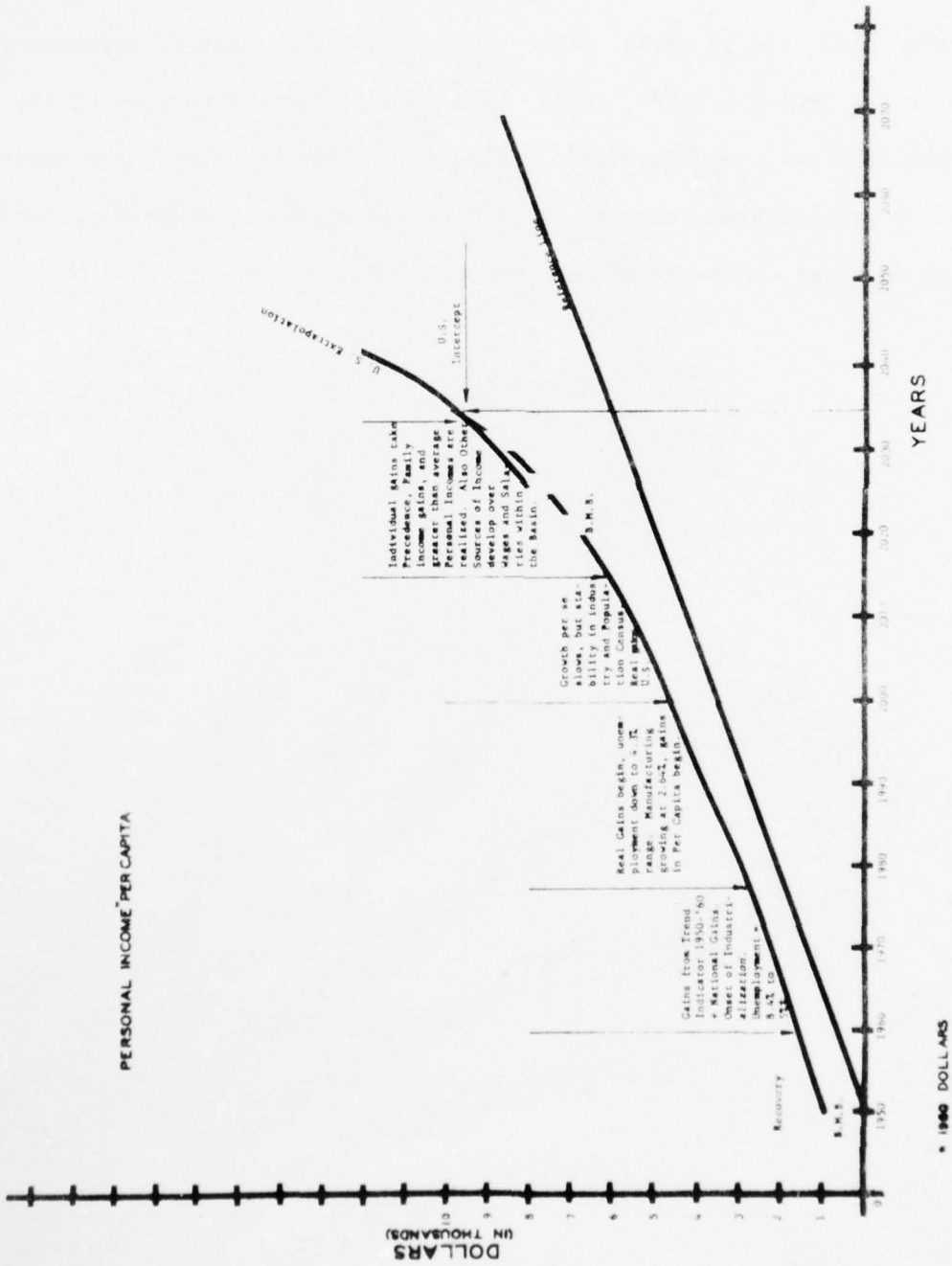

PERSONAL INCOME PER CAPITA
DOLLARS
(IN THOUSANDS)
YEARS
* 1960 DOLLARS
U.S. Extrapolation
U.S. Intercept
Individual gains take
Precedence. Family
income gains, and
greater than average
Personal Incomes are
realized. Also Other
Sources of Income
develop over
wages and Sala
ries within
the Basin
Growth per se
slows, but sta-
bility in indus-
try and Popula-
tion Census
Real Gains begin, unem-
ployment down to a fi
range. Manufacturing
growing at 2 or 3 gains
in Per Capita basin
Gains from Trend
Indicator 1940-'60
+ National Gains
Onset of Industri-
alization.
Unemployment -
8.43 to
Recovery
B.E.A.
B.E.A.
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100

FIGURE 7

SECTION IV - DEMANDS FOR PRODUCTS AND SERVICES

20. FRAMEWORK FOR EVALUATION

The short and long-range demands associated with the basin's resources were determined by the various participating Federal and State agencies, together with local planning entities. Recognizing that each area of concern or demand for service would have an inherent uniqueness, the analysis and presentations have been separated to distinguish between demands on water-related resources, land-related resources, and the socio-environment considerations. The evaluations of these demands were predicated on the project future economic conditions, depicted in Section III and detailed in Appendix L, and the social resource input needed to sustain the area's environment and well-being.

21. WATER-RELATED DEMANDS

a. Floodwater damage. Approximately 9.5 percent of the basin or some 144,400 acres, are located in the flood plain and are subject to flooding. This acreage is inundated on the average of once every 50 years. Of the total flood plain acreage, approximately 41,700 acres are afforded some degree of flood damage reduction from multiple-purpose reservoirs, either completed or under construction. Included in this category are 37,300 acres on the main stem of the Big Muddy River below the Corps' Rend Lake Reservoir; 5,200 acres on the lower Crab Orchard Creek downstream of the Crab Orchard Reservoir operated by the U. S. Fish and Wildlife Service; and 200 acres on Kinkaid Creek below the State of Illinois' Kinkaid Reservoir presently under construction. The 37,300 acres below Rend Lake Dam excludes that

acreage located in the flood plain common to both Big Muddy and its tributaries. While the reservoir will effect some reduction in the main stem backwater to the tributaries, the flood problem still exists in those tributaries due to local runoff. Hence, these areas have been included in those acreages identified as subject to flooding for each of the tributary watersheds. A breakdown of the present land use in each of the main tributaries and subwatersheds, including the remaining 101,700 acres is shown in TABLE 5. Major portions of the developed areas, including urban and rural property, as well as some agricultural lands and farmsteads, are located at elevations subject to less frequent flooding while the bottomlands are primarily agricultural and timbered. Flooding of the tributaries occurs on an average of once every year, frequently resulting in moderate to severe damage to agricultural acreage. Flood problems are further intensified by extended periods of inundation and the frequencies of minor floods that occur during the growing season. It is estimated that 31 percent of the gross value of crops and pastures are damaged annually. This damage consists of reduced crop yields, lowered crop quality, and increased costs of production. Seeding beyond optimum dates and delayed harvesting are examples of the manner in which flood damage reduces crop yields and quality. Increased costs are also incurred when additional tillage operations and other agronomic practices are required to counteract the effects of flooding. In addition, timber management and harvest operations are also delayed by frequent flooding. Damage to other agricultural property is principally to fences, with some damage reported to livestock and machinery during the greater floods. Urban floodwater damage in the upstream watersheds is mainly caused by underdesigned stormwater disposal systems. This results in flash flooding in the City of

TABLE 5

Flood plain land use and damages

Damage area	Acreage: Cropland, pasture and idle land	Acreage: Forest and miscellaneous	Acreage: Total	Estimated average annual damage
Big Muddy(1)	14,100	23,200(2)	37,300	$ 174,100(3)
Casey Fork	6,400	1,400	7,800	178,600
Cedar Creek	400	1,000	1,400	8,500
Crab Orchard	3,500	3,800(4)	7,300	60,600(5)
Galum Creek	4,400	3,700	8,100	93,500
Gun Creek	800	100	900	28,600
Hurricane Creek	400	400	800	4,600
Kinkaid Creek	100	100	200	3,400
Lake and Pond	1,500	1,100	2,600	18,800
Little Muddy	11,200	15,400	26,600	190,500
Lower Beaucoup	900	1,000	1,900	26,400
Lower Crab Orchard	2,500	2,700	5,200	27,400
Middle Fork	10,200	10,500(6)	20,700	228,000(7)
Upper Beaucoup	6,300	6,800	13,100	169,000
Upper Big Muddy	7,000	3,500	10,500	253,800
TOTALS	69,700	73,700	144,400	$1,465,800

(1) Big Muddy River flood plain downstream Rend Lake Dam and includes estimated average annual damage.
(2) Includes approximately 70 acres of urban area.
(3) Includes some $27,300 urban damage to Murphysboro, Blairville, Hurst, Herrin, and Royalton.
(4) Includes approximately 20 acres of urban area.
(5) Includes some $15,400 urban damage to Marion.
(6) Includes approximately 10 acres of urban area.
(7) Includes some $700 urban damage to West Frankfort.

Marion, which is drained by two branches of a tributary to Crab Orchard Creek. Flash flooding also is caused by inadequate channel capacity and restrictions at culverts and bridges. Damage to roads and bridges throughout the basin is principally to secondary and unimproved roads. These crossings are more susceptible to damage because the approaches to most bridges are near elevations of the flood plains. Many of these bridges and culvert openings are limited in capacity and flood flows must overtop the road in order to pass. Accumulated damages at these locations can become significant when frequent flooding causes repeated replacement or repairs. In addition to the direct flood damages, there are other losses which are directly related to flooding even though the area itself may not have been flooded. These indirect damages consist of interruptions to travel and rerouting of traffic, temporary dislocation of persons from work, extra time and travel required for delivering farm products, and other social aspects involved. A summary of the average annual flood damages presently experienced in each of the 15 watersheds is shown on TABLE 5.

b. Water supply. The demands for future municipal and industrial water supplies were evaluated based on the projected increase in population, standard of living, and industrial and commercial development. It was assumed, as indicated in APPENDIX L, that basin industry would be dominated by light manufacturing and commercial industries of the general type now present which are not heavy water users. It was noted that because of the limited ground water all significant municipal water systems use surface water; and, except for several impoundments constructed to supply railroad and coal processing plants, most of the industrial water is obtained from these municipal water

supply systems. Therefore, it was assumed that in the future industries will continue to obtain their water from these municipal systems, and that the estimates of municipal and industrial water demands should be derived based on the individual evaluations of domestic and industrial usage with special allowances made for the mineral industry. The present water use, including the population served, was the base for projected demands. This information was obtained from the State data on municipal water supplies, including treatment plant records. The domestic water usage was computed as equal to the population served times the gallons-per-capita-day water use (gpcd). The projected increase in non-rural farm population was used as the measure of increase in population served, with gpcd rates adjusted to reflect anticipated increases in the standard of living. Since one measure of the increase in standard of living was the change in personal income, the gpcd rates were adjusted by rates of change in personal income. Estimates of industrial water usage were based on the premise that present needs would increase in relation to the rate of growth in industries. Since manufacturing and services are expected to continue as the leading employers in the basin, the projected increase in manufacturing employment was used as the measure of increase in industrial water use. The only significant self-supplied industrial water use is that of the mineral industry, particularly the coal mining industry which uses large amounts of water for washing coal. However, since most of the water used by the mineral industry is recirculated, the consumptive use is comparatively small. A llowances were determined for self-supplied water use, based on projected commercial mineral activities in the basin. Future municipal water usage, as well as industrial, was first

estimated for each of the five basin counties. These figures were then disaggregated to obtain estimates of use for the individual municipalities so as to identify the predominant demand centers. Since county projections involve greater areas, they are inherently more accurate than the projections for individual municipalities. Therefore, when the sum of projected water use for municipalities in the county did not equal the county projections for municipal and industrial water usage, the difference was assumed to have been caused by other urbanization and industrialization that can be expected to occur. A summary of the water supply demands for each of the five counties, including a breakdown by major municipalities and mineral industries, is shown in TABLE 6. Subsequent to the foregoing evaluation, an inventory of existing impoundments and firm commitments for providing future water supplies was undertaken. Construction of the Rend Lake Dam and Reservoir will provide approximately 40 million gallons per day to meet future municipal and industrial water supply requirements. This storage, coupled with an intercity pipeline now under construction, will assure a dependable source of water supply in excess of the 2020 needs projected for those areas and individual communities located in the middle and northeastern part of the basin. The projected municipal usage of the intercity pipeline system which served as the basis for commitments and justification (sale of treated water) of that project is shown on TABLE 7. As a result, the only areas of possible municipal and industrial water shortages would be in the southeastern and western parts of the basin. The town of Marion will not be supplied by the Rend Lake intercity system, and has indicated that it is

TABLE 6

Projected municipal and industrial water supply needs (MGD)

	1970	1980	2000	2020
JEFFERSON COUNTY				
Ashley (Washington County)	.07	.09	.13	.18
Mt. Vernon	1.25	1.55	2.65	3.59
Subtotal	1.32	1.64	2.78	3.77
Increment for other urbanization & industrialization	-	.15	.88	1.39
Total municipal use	1.32	1.79	3.66	5.16
Self supplied mineral industry	1.16	1.53	1.80	1.64
Total county demand	2.48	3.32	5.46	6.80
FRANKLIN COUNTY				
Buckner	.02	.02	.03	.05
Benton	.69	.83	1.16	1.68
Christopher	.33	.39	.55	.79
Royalton	.15	.17	.23	.33
Sesser	.24	.28	.41	.58
West Frankfort	1.07	1.30	1.83	2.63
Ziegler	.26	.33	.55	.85
Subtotal	2.76	3.32	4.76	6.91
Increment for other urbanization & industrialization	-	-	.08	.62
Total municipal use	2.76	3.32	4.84	7.53
Self supplied mineral industry	.41	.54	.63	.57
Total county demand	3.17	3.86	5.47	8.10

TABLE 6 (Con't)

Projected municipal and industrial water supply needs (MGD)

	1970	1980	2000	2020
WILLIAMSON COUNTY				
Carterville	.30	.37	.54	.66
Herrin	1.95	2.39	3.48	4.30
Johnston City	.25	.30	.41	.50
Marion	.90	1.10	1.59	1.96
Subtotal	3.40	4.16	6.02	7.42
Increment for other urbanization & industrialization	.08	.26	.87	1.37
Total municipal use	3.48	4.42	6.89	8.79
Self supplied mineral industry	1.17	1.54	1.81	1.64
Total county demand	4.65	5.96	8.70	10.43
PERRY COUNTY				
Coulterville (Randolph Co)	.09	.12	.18	.24
Du Quoin	.87	1.11	1.79	2.44
Pinckneyville	.44	.57	.93	1.26
Subtotal	1.40	1.80	2.90	3.94
Increment for other urbanization & industrialization	.03	.08	.39	.68
Total municipal use	1.43	1.88	3.29	4.62
Self supplied mineral industry	3.72	4.92	5.78	5.24
Total county demand	5.15	6.80	9.07	9.86
JACKSON COUNTY				
Carbondale	2.81	3.76	5.73	7.12
Elkville	.05	.07	.10	.13
Murphysboro	.82	.109	1.66	2.05
Subtotal	3.68	4.92	7.49	9.30
Increment for other urbanization & industrialization	-	-	-	-
Total municipal use	3.68	4.92	7.49	9.30
Self supplied mineral industry	1.71	2.26	2.70	2.41
Total county demand	5.39	7.18	10.19	11.71
TOTAL BASIN DEMAND	20.84	27.12	38.89	46.90

TABLE 7

Water supply needs - Rend Lake Intercity System *

	1970	1980	2000	2020
Jefferson County				
Mt. Vernon	1.25	1.55	2.64	3.59
Urban./Indust. Increment	-	.15	.88	1.39
Franklin County				
Buckner	.02	.02	.03	.05
Benton	.69	.83	1.17	1.68
Christopher	.33	.39	.55	.80
Royalton	.15	.17	.24	.33
Sesser	.24	.29	.41	.59
West Frankfort	1.07	1.30	1.83	2.63
Ziegler	.26	.33	.55	.85
Urban./Indust. Increment	-	-	.08	.62
Williamson County				
Carterville	.30	.37	.54	.66
Herrin	1.95	2.39	3.48	4.30
Johnston City	.25	.30	.41	.50
Urban./Indust. Increment	.08	.26	.87	1.37
Perry County				
Du Quoin	.87	1.11	1.80	2.43
Urban./Indust. Increment	.03	.08	.39	.68
TOTAL	7.49	9.54	15.87	22.47

* Requirements for McLeansboro are not included since community is located outside basin. Estimated water use (2020) is 0.6 mgd.

proceeding with plans to enlarge its present water supply storage reservoir sufficiently to carry it through the study period. The only communities outside intercity pipeline system's area that would be of sufficient size to justify concern over future water are Murphysboro and Carbondale. The State of Illinois is including municipal and industrial water supply storage in its proposed Kinkaid Lake Reservoir sufficient to meet the future needs of the town of Murphysboro. This left Carbondale as the only community that could have a definite future water supply problem. Carbondale is presently obtaining its water needs from both Crab Orchard Lake and its own municipal reservoir. The community has an existing contract with the U. S. Fish and Wildlife Service for obtaining some of its needs from Crab Orchard until June 1970, at which time the contract would be terminated. Discussions with the Bureau of Sports Fisheries have indicated that it would most likely consider extending the same emergency standby services to Carbondale as are presently offered the towns of Marion, Herrin, and Carterville. However, before any final determination could be made, an engineering evaluation of available storage would have to be undertaken by the Bureau, with the final decision largely contingent upon Carbondale's success in obtaining other sources of water supply. Presently, the community of Carbondale is negotiating with the Soil Conservation Service for provision of municipal and industrial water supply storage in the Cedar Creek watershed, for which a work plan is currently being prepared under Public Law 566. Since these projects would be capable of meeting Carbondale's projected requirements, it was concluded that there was no need to consider provision of additional supplemental water supply storage for that community. For the remaining

individual communities, existing storage was found to be sufficient to meet projected requirements, excluding any consideration of extended drought periods. Consequently, it was concluded that provision of future water supplies would not be required unless the State was interested in purchasing additional storage beyond the study period 2020. The State, by letter, concurred that the basin's water supply storage, both existing and under development, appeared adequate to meet all foreseeable needs and that there was no interest on the part of the State to invest in long-range water supplies at this time.

c. Stream quality. Waste assimilation is one of the most important water uses in the basin, but because of the poor quality of surface runoff and low stream flows it is one of the uses for which many streams in the basin are least suited. Municipal and industrial waste residues are discharged to every major tributary stream in the basin. Urban centers within the basin have located on lateral tributaries or small drainage areas rather than on main waterways, and many of these waste discharges are at or near stream headwaters where waste assimulative capacity is the lowest. The result is many areas of low water-quality at times of low stream-flow, even when conventional secondary treatment is provided. Previous studies, particularly those undertaken in connection with the Rend Lake Reservoir, have underscored this existing problem; and because of this, Congress authorized low-flow augmentation for that reach of the main stem below the dam to its confluence with the Mississippi River. To identify possible requirements for flow regulation in controlling stream quality, analysis involved the process of counteracting the waste discharge, Biochemical Oxygen Demand (BOD) loads, imposed on a stream. This included consideration

of the receiving water, the reaction rate (deoxygenetion) and reaeration factor - each temperature sensitive and variable per month. These factors, together with the effects of geology, land-use, and the characacteristics of the hydrologic regimen, were identified by sampling of present stream flow during the early stages of the study. Since low-flows directly affect the stream quality, time-of-travel data and velocity profiles of low-flow conditions were estimated to route pollution loads and to position oxygen sags along the stream. Since all significant oxygen-consuming industrial waste loads presently are discharged into municipal treatment plants, it was assumed that this practice would continue. Applicable water quality criteria were determined, based on the projected land-use activities and regulations established by the Illinois Sanitary Water Board. Because of the expressed desirability of enhancing the streams' recreational, environmental, and ecological characteristics, a dissolved oxygen (DO) level of five milligrams per liter (mg/l) and maximum permissible stream temperature of 85°F for the time period April through November were established as two prime considerations in the goal of maintaining acceptable stream quality. Therefore, the estimates of municipal waste loads included both the domestic and the industrial waste discharges projected for the basin. In each subbasin or watershed, emphasis was placed on the load points where the greatest stream flow for waste assimilation was required. Both effluent waste concentration and percent removal were used in estimating the quantity of waste discharge. In general, the procedure for estimating the municipal waste load was based on obtaining an estimate of the population served, the gallons per capita per day waste load, and the per capita pounds

per day of 5-day BOD. The waste flow was then computed as equal to the population served times the gpcd of waste flow and the quantity of untreated waste. Secondary treatment was assumed to provide 85 percent reduction in 5-day BOD, and tertiary treatment 95 percent; however, to allow for the waste carried by urban storm drainage, these were reduced to 80 and 90 percent, respectively. The present sewered population is 126,000 and is expected to increase to 201,000 by the year 2020. The future population served was assumed to increase at the same rate as the non-rural farm population. The rate of increase in gpcd domestic return flow was adjusted in relation to the increase of personal income. Hydraulic routings were then undertaken in each of the major watersheds, and five critical load or oxygen sag points were identified as sources of pollution requiring remedial measures.

d. General recreation. The basin's natural aesthetics and environment, moderate climate of extended duration, together with the Shawnee National Forest, and Federal game refuge, combine to provide a significant potential for recreational development. Completion of Interstate Highways 57 and 64, by virtue of the time-distance-travel relationship, will afford the residents in the outlying areas an opportunity to enjoy any recreational development provided in the basin. Projections of the demands for general recreational pursuits recognized a circle of demand or zone of influence encompassing the population of the five core counties, the eight peripheral counties surrounding the basin, together with potential draw from eight surrounding standard metropolitan statistical areas. These latter areas included: St. Louis Metropolitan Area; Springfield, Decatur, Peoria, and Mattoon, Illinois; Terre Haute and Evansville, Indiana; Paducah, Kentucky; as well as the transient

travellers passing through the basin via the interstate highway system. Based on the population projection in the circle of demand, the anticipated user-day attendance for water-oriented and associated recreational pursuits were determined for the years 1970, 1980, 2000, and 2020. This gross demand was then reduced by the usage that would be met by Federal and non-Federal projects, both existing and under construction. This inventory of existing projects included only those resources available for public use, and considered applicable optimum-use saturation levels that would assure a quality environment. This adjusted difference between the total demand and existing supply established the magnitude and projected growth of the net recreational demand. The gross and net demands, together with their respective time-phasing, are shown in FIGURE 8

e. Fishery aspects. Inventory of present water resources has indicated that the opportunities for fisherman activities, within the basin zone of influence, more than adequately meet the projected needs for the study period. While any water resource development built to meet other needs would, because of its availability, develop fisherman use, the usage would essentially be a shifting of fishing opportunities from one area to another. This would constitute a new and additional source of supply that would merely add to the existing surplus. However, both the State and the U. S. Fish and Wildlife Service have indicated that there is a need to improve the qualitative aspects of the basin streams. The present ecology of the stream is conducive only for rough fish population. Before game fish production is possible, steps must be taken to reduce the stream's turbidity and acid content, increase the stream's dissolved oxygen content, and maintain sufficient flow to offset the adverse effects of induced pollutants.

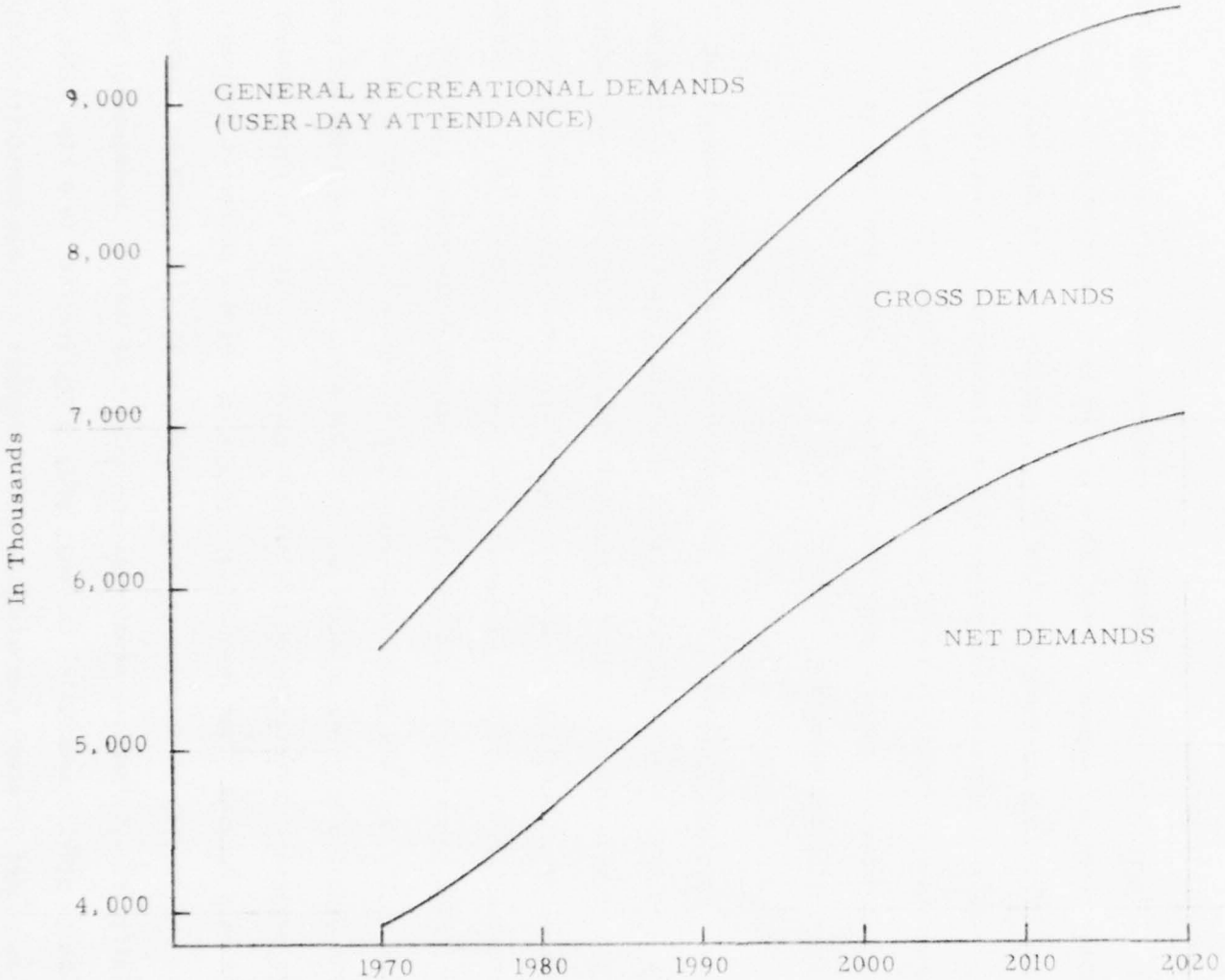

GENERAL RECREATIONAL DEMANDS
(USER-DAY ATTENDANCE)
In Thousands
9,000
8,000
7,000
6,000
5,000
4,000
GROSS DEMANDS
NET DEMANDS
1970
1980
1990
2000
2010
2020

FIGURE 8

f. Hydropower generation. There are no existing hydropower developments within the area. Natural conditions, such as stream flow and topographical static head, are such as to preclude development of hydroelectric power in amounts sufficient to be economically competitive in the present and foreseeable market.

g. Navigation. The potential and economic feasibility of improving the Big Muddy River and Beaucoup Creek for modern barge transportation was investigated. There are adequate reserves of good quality coal in the basin that are available for existing and prospective market areas. However, the required improvements were found not to be economically justified. Thus, the advisability of improving the basin's waterways was deferred until such time as economic conditions warrant.

22. LAND-RELATED DEMANDS

a. Wet-land drainage. There are approximately 671,000 acres of wet soil in the basin today. Contributing to this condition are such factors as the type of soil and the lack of topographic relief. According to the Department of Agriculture, this basin is the most undeveloped area with respect to drainage improvements in the State of Illinois. That agency has identified some 294,000 agricultural acres that are in need of some drainage improvement. All are located in the upstream areas, with about 101,800 acres in the bottom lands and 192,200 acres in the area adjacent to the flood plain. The Big Muddy and most of its principal tributaries do not provide adequate outlets in their present condition. However, some channels do provide an adequate degree of drainage, and rehabilitation of existing drainage systems is all that would be required. Generally, though, channel capacities are considered totally inadequate. The failure to provide controlled drainage outlets has resulted in a high water table and has caused inherent economic losses. Inadequate drainage prohibits development of the crops and pasture lands, restricts the choice of crop distribution and rotation, delays optimum planting, and increases production costs because of frequent replanting

and often delayed harvest. As a consequence, yields on present crop lands are substantially below what could be obtained if adequate drainage was provided. TABLE 8 is a listing, by watershed, of the agricultural acreage requiring some form of remedial works for drainage improvements.

b. Erosion-sediment damage. Erosion can be divided into two separate processes; namely, sheet erosion and channel erosion, including gullies. Both are active in varying degrees in all areas of the basin, with the rate and type being dependent upon local conditions. Sheet erosion is a movement of a relatively uniform depth of soil from an area by over-land runoff, or from precipitation without the formation of channels or gullies. Channel erosion is the removal of soils and other material in and along the stream channel. This includes gullies, stream bank cutting, slumping, and degrading of the channel itself. The intense rainfall and rolling topography combine with the present land use to cause serious erosion. Sheet erosion is the dominant type affecting some 586,100 acres, while gully erosion affects only 16,100 acres. Of this amount, about 303,000 acres require some immediate and corrective action. Stream bank erosion is comparatively minor, since stream gradients, water velocities, and the erodability of the stream bank soils are low. Erosion damage from scouring of flood plains is not extensive. However, approximately 5,900 acres have been damaged; 65 percent of the affected area has slight damage, 30 percent moderate damage, and 5 percent severe damage. Flood plain scour causes an estimated average annual damage of $34,300. This soil erosion, and its eventual deposition as sediment, is a source of major concern in the basin. Sediment in streams has reached

TABLE 8

Maximum needs for drainage improvement

Watershed	Flood plain (acres)	Nonflood plain (acres)
Casey Fork Creek	7,810	13,080
Cedar Creek	1,390	2,710
Central Big Muddy		36,480 1/
Crab Orchard	7,260	24,190
Galum Creek	8,040	7,010
Gun Creek	960	6,710
Hurricane Creek	860	4,120
Lake and Pond Creeks	2,530	12,280
Little Muddy	26,590	20,690
Lower Beaucoup	1,930	12,990
Lower Big Muddy		1,970 1/ 2/
Middle Fork	20,670	23,880
Upper Beaucoup	13,160	15,060
Upper Big Muddy	10,550	11,070
TOTAL	101,750 3/	192,240 4/

1/ Includes flood plain.

2/ Adjusted to correspond with Conservation Needs Inventory.

3/ Includes 46,040 acres of forest which will not require drainage in its present use.

4/ Includes 87,360 acres of forest which will not require drainage in its present use.

the point where these fine particles held in suspension create a turbidity that is one of the major pollutant sources in the basin. The damages due to sediment are extensive, complex, and costly. Beginning with the original movement of material, usually the removal of valuable top soil, it continues through the state of transport (turbidity) and accumulates at the final deposition as infertile overwash. Damage from sediment deposition on the cultivated flood plain is not a serious problem, since most of the sediments are clays and silts. However, the resulting deposition is frequently lacking in organic matter and the cost of restoring productivity is a major cost problem. It is estimated that over 290,000 acres have been damaged by overbank deposition. In terms of reduced productivity capacity, as affected by sediment deposition, approximately 77 percent of the areas affected have slight damage, 13 percent moderate damage, and 10 percent severe damage. The value of the damage from infertile overwash is estimated to be $14,400 annually. Sediment deposition also forms levees along stream banks and subsequently disrupts natural drainage, affects the functioning and maintenance of a drainage system, and raises water tables. Damage occurring as a result of swamping is considered very severe, with an estimated 20,400 acres affected. This has resulted in lower intensity of use in some areas and abandonment of use in other areas. Approximately 30 percent of the area affected by swamping has slight damage, 25 percent moderate damage, and 45 percent severe damage. Total damage from swamping alone approximates $175,900 annually. In addition to the foregoing, the sedimentation occurring in surface impoundments is a principal concern to the basin's municipalities which

have incurred considerable expense in plant facilities and equipment to overcome losses from sediment. Damages due to reservoirs from sedimentation are estimated to be approximately $30,000 on an average annual basis.

c. Irrigation. A survey of acreage presently in agricultural production served as the basis for estimating the extent of any future demands. The survey indicated that irrigation is practically non-existent. Discussions with the University of Missouri Agricultural Department have indicated that there will not be any extensive organized irrigation undertaken in this general part of the country until about the year 2000. There are three basic variables in optimizing agricultural production: the hybrid seed, fertilizer, and controlled moisture content of the soil. It is believed that advances in technology for the first two variables will account for all of the production increases up to the year 2000. Thereafter, irrigation will be undertaken on an organized basis to increase the yields and quality of the crop.

d. Mine-mouth power generation. The electric load of the basin and the electric systems serving the area are included in the part of the Federal Power Commission's Power Supply Area (PSA) 40 located within the Upper Mississippi River Basin. The basin is presently served by five electric utility systems, all of which have their plants located outside the study area. Two of the utilities are privately owned, Central Illinois Public Service Company and Illinois Power Company, and are the principal suppliers of electrical energy to the basin, serving the municipal requirements of the area. The three remaining systems which serve the rural areas are the Southern Illinois

Electric, Tri-County Electric, and Egyptian Electric Cooperatives. As part of the economic resource demand evaluations, consideration was given to the possibility of electric power being generated in stream plants located at the mineral source of its fuel (coal). For purposes of this study, the electric power requirements and supply characteristics within PSA 40 were considered to be indicative of the power situation of the basin. In 1960, the portion of PSA 40 in the Upper Mississippi River Basin required about 7,144 million KWH of electrical energy. Of this amount, about 470.5 million KWH, or about 7 percent, was required to serve loads in the Big Muddy River Basin portion of the PSA. Based on a study of this power area, the basin's electrical power requirements are expected to grow at a decreasing annual rate, or from 7.3 to 3.4 percent, during the period 1980 to the year 2020. In light of the past trends of supplying the basin's electrical requirements by imports, the transmission system serving the area, and the reported plans of the systems now serving the basin to increase their generating capacity, it is anticipated that the future electrical energy requirements will continue to be met by generation located outside the basin. Therefore, it was concluded that there would be no demand on the basin's water resources for mine-mouth power generation.

e. Hunting demand. The wildlife habitat in the basin is good-to-excellent, with numerous scattered tracts of wildlife habitat sufficient to support farm-game species attractive to the hunter. Deer habitat is most abundant in the southern part of the basin, with hunting in and adjacent to the Crab Orchard National Wildlife Refuge in Shawnee National Forest accounting for the substantial portion of the deer kill. In addition, there

are approximately 19,000 acres of permanent water of significance to the waterfowl found in the thirteen-county area, with the main concentration of waterfowl management occurring on the Crab Orchard National Wildlife Refuge. While accessibility to hunting area is just as important as game supply in determining hunting pressures, and even though the basin is predominantly a rural area under private ownership, there are enough acres of public-owned land to insure hunting supplies exceeding the demand. There are approximately 20,000 acres of land and water area on the Crab Orchard National Wildlife Refuge and 29,500 acres of Shawnee National Forest that are open to public hunting. In addition, there are more open uplands and cultivated portions of the flood plains that receive moderate upland game hunting pressure. While the continued expansion of the urban and industrial areas and the anticipated growth in cropland and pasture acreage will reduce the woody cover required for the terrestrial wildlife species, it is anticipated that the wildlife surplus will be more than adequate to absorb the future needs. The total surplus of hunting opportunity in the five-county core area is estimated to increase from 156,000 man-days in 1960 to 291,600 man-days in 2020.

23. SOCIO-ENVIRONMENTAL CONSIDERATIONS

a. Stream environmental problems. As had been noted earlier, urban centers have tended to locate on lateral tributaries of small drainage areas; and as urban growth had progressed, water problems appeared in those locations because the demands for all water uses had approached the ultimate yield capacities of the applicable drainage area involved. During the studies regarding stream quality, special consideration was given the reach of Crab

Orchard Creek flowing through the environmental area of Carbondale in recognition that this community was the area with the greatest growth rate in the basin. Hydrologic analysis had indicated that the yield from the drainage area between Carbondale and the upstream Crab Orchard Reservoir was incapable of sustaining sufficient flows to maintain an acceptable water quality standard. As a result, it was apparent that there was a potential need to provide low-flow augmentation for the express purpose of maintaining a base flow and preserving the area's environment and public health. Of particular concern was the fact that, in time, this particular reach of Crab Orchard Creek will experience septic conditions, particularly from the large volume of various types of pollution that will be induced into the stream from storm runoff. The problem of maintaining a minimum base flow for flushing action was further underscored by Crab Orchard Reservoir's inability to provide and maintain any dependable downstream releases. Furthermore, concern was expressed by the Public Health Service that maintenance of a base-flow over and above any return flow (treated wastes) should be guaranteed to avoid the potential hazards to the local residents from vector problems and other health and social nuisances. Based on the foregoing, and with the obvious need to improve the urban area's aesthetics, it was decided to supplement natural stream flows sufficient to maintain a minimum base flow equivalent to three mg/l DO 100 percent of the time. Routings indicated hydrologic feasibility, requiring minimum base flows ranging from about 7 cfs average annually in 1970 to 22 cfs in 2020. Another environmental problem area was identified in the Lake and Pond Creek Watershed, with a specific pollution problem primarily caused by induced mining wastes and acidic runoff.

b. Preservation of fish and wildlife habitat. With the advent of future socio-economic growth, changes in land-use can be expected. These will range from conversion to higher economic usage, industrial and residential, to a more intensified land-use, agricultural. All of these changes eventually will result in a smaller wildlife habitat base with possible adverse effects on the wildlife and fishery ecology. Consequently, there is a need to enhance the management and environment of the remaining conservation resources. Public ownership is so widely scattered, particularly within the Shawnee National Forest, that providing intensive management practices and action programs will be a problem. Increased effort is needed to consolidate these lands for management purposes with adequate, but controlled, public access. Water development projects will offer real opportunities to improve the hunting and fishing opportunities in the basin. Such improvements may result in greater opportunity or higher quality experience, or both, if the projects are planned to effectively utilize all natural resources. It is in this framework that management of upland areas and waters should be stressed, with a program seeking wider application of land-use practices that safeguard both soils and land cover, with particular emphasis on land rehabilitation measures, especially in strip mine areas, and reforestation of badly eroded and other problem areas.

c. Archaeological considerations. As man expands into his surrounding natural environment, there is an inherent potential of losing part of his archaelogical artifacts that make up his culture and history. With this in mind, it is imperative that an action program be developed to preserve and

restore the basin's archaeological remnants as supplement to other recreational activities that could be offered the recreationist and tourist. In particular, there is a need to incorporate Indian cultural remains as attractions that would be protected by both land and scenic easements. The site requirements would be dependent upon the type of site to be preserved. For open villages or camp sites, fee purchase of lands generally one-half to 3 acres in size would be required to safeguard the river orientation that is general to the site, plus the surrounding ecological zone. For rock shelters or cave sites, development would normally require an average purchase of from one-half to 2 acres. Land acquisition would essentially be oriented to the river, safeguarding the water- and land-related environment historically basic to the original selection and development of the cave as a habitat. For the burial mound sites, development would be dependent upon the particular type involved. Those located on the bluff tops or edges would lend themselves primarily to scenic considerations and would require only about one-half an acre in fee purchase. However, those located in the river bottoms, particularly representing the Hopewelliam phase, would warrant a more elaborate development requiring purchases of at least one to 5 acres, so as to safeguard all facets of its cultural features. In this latter case, emphasis would be primarily on the cultural remains rather than scenic. At the present time, there are no known temple-town sites, but if found, emphasis should be concentrated upon the development of these sites, since they are well suited to extensive commercial development because of their uniqueness and inherent tourist interest. To preserve these sites, land acquisition should be considered in two phases. Initially, purchase

should include enough land to encompass the Indian mounds, together with sufficient circumvential access and natural setting approximating 10 acres in depth. Subsequent to determining the scope of the site's development, consideration should then be given to the purchase of additional land for the complete integration of the major geological and geographical features that dictated the original site selection. Once this is done, the amount of land required will probably lend itself to providing an adequate base for total park development. In many cases, these archaeological sites are river-oriented so that low-flow augmentation will provide a total site enhancement that should encourage Federal and State participation. In addition to the foregoing, consideration should be given the restoration or rehabilitation of other historical sites such as the stone forts and block houses that were native to this area. Restoration of historical sites as a tourism attraction has been well justified in various parts of the country, and reconstruction of these facilities should be integrated in any recreational development planned for this area.

d. Economic reorientation. Both the Federal and State governments, together with local governmental agencies and local interest groups, have shown concern over the economic situation as it has existed in southern Illinois, particularly in the Big Muddy River Basin. As a specific example of Federal input to the area's economic reorientation, the United States Congress authorized construction of the Rend Lake Dam and Reservoir by the Corps of Engineers. The Rend Lake project was designed and planned on a coordinated basis with the then Area Redevelopment Administration of the Department of Commerce, and the State of Illinois. The evaluation of the Rend Lake project recognized area redevelopment as a legitimate purpose of

the project and construction works. The project promises to contribute significantly to the improvement of the economic conditions in southern Illinois. Local political entities have also proceeded to provide essential inputs to the socio-economic redevelopment of the basin. The Rend Lake Conservancy District, a co-sponsor of the Rend Lake Dam and Reservoir, has instituted studies for land use and development on the peripheral areas outside the Rend Lake project. Plans have been drawn up to provide a proper framework for attracting capital investment which would change the economic structure of that part of the basin. Concurrently, the Rend Lake Conservancy District has also co-sponsored the planning and initiated construction of an inter-city pipeline system that will furnish treated water from the authorized Rend Lake storage to most of the communities in the middle and eastern portion of the basin. Heretofore, many communities have not been competitive in attracting industry, due to their inability to provide a guaranteed supply of water, particularly because of extended droughts. Storage purchased by the State and Conservancy District exceeds the need projections of the system for well beyond the next 50 years and should now afford those communities a competitive economic advantage in this part of the midwest. At a higher political level, the five core counties located in the basin have joined together to form a regional planning group known as the Greater Egypt Regional Planning Commission. Four of the five have already established and adopted a land-use plan that will insure a proper framework for development. Preparation of a land-use plan for the fifth county, Jefferson County, is being initiated and should be completed during 1970. All these

attempts reflect the local concern in providing the proper framework for a planned economic reorientation.

e. State recreational planning. The State in its report "Water for Illinois - A Plan for Action," published in March 1967, provided a framework for long-range planning and construction commitments of both land and water-related developments. In the section of the report on water-related recreation, the State recognized a major deficiency in outdoor opportunities. It stated that Illinois has the lowest ratio in the nation of total State park acreage to its population, having 5.6 percent of the nation's population, but only 0.05 percent of the country's recreational land. Consequently, existing facilities are overburdened and over half of Illinois' residents vacationed out-of-state, with the resulting loss to the state's economy of more than one-half billion dollars per year. The report recommended an accelerated program of extensive public land acquisition to meet future open-space needs (700,000 acres by 1980; 2,000,000 by 2020) with the qualification that about 75 percent should be associated with the existing or potential public water surface and that major parkway systems and recreational corridors also be developed for public use. Furthermore, their report stresses the advantage of combining the two resources, land and water, to complement each other under planning control to greatly increase the value of both for recreational use. With this in mind, emphasis was given to the development of recreational corridors with the recommendation that 40 percent of the state's streams and lakes should be available for public use by 1980. To accomplish this over-all goal, fundamental changes in the Illinois law regarding riparian rights were recommended, complemented

by a program requiring the preservation and protection of valuable open-space land by zoning and land-use regulations. This latter program would be phased: first, seeking dedication of open-space lands for public use by easement; and second, acquiring land to be leased until it can be developed for public recreation. The State in specifying use of river corridors planned them as a linear water-related recreational resource that served as connecting scenic routes between major landscape recreational resource areas. This same concept was expressed in the Greater Egypt Planning Commission's land-use plan, which called for establishment of specific recreational river corridors as part of the counties' attempt to establish specific public-use acreage. Some of the same acreage was shown in the State's report, which attempts to establish a parkway corridor in the Big Muddy River Basin connecting the Shawnee National Forest in the south to the adjoining Kaskaskia River Basin and its Corps' reservoir complex of Carlyle and Shelbyville in the north. It should also be noted that subsequent to authorization of the Rend Lake Project and prior to publication of the state's report, the State of Illinois in cooperation with the Economic Development Administration, U. S. Department of Commerce, funded a study to analyze the economic potential of tourism and recreation in Southern Illinois. The report prepared by Checchi and Company of Washington, D. C., published in February 1966, included a recommendation for expanding tourism and recreation in Southern Illinois; identified the type and magnitude of benefits that could result; and discussed how to organize and finance the expansion. The State of Illinois, through its participation in this study and subsequent actions, has indicated that development of Southern Illinois

as a state and regional recreational center would further serve to supplement the state's recreational deficiency and the area's economic base. Furthermore, the State has initiated specific action programs in this basin to provide an enlarged State recreational base. The State is cooperating with the U. S. Forest Service in the construction of Kinkaid Lake, with special emphasis on cooperative recreational planning. It also is working with the Corps in providing basic facilities and diversified recreational opportunities on project lands of the Rend Lake Reservoir. Federal facilities would provide the essential services required for public enjoyment and access to the water. The State will supplement this by operating a waterfowl refuge area for migratory water fowl on 5,600 acres of both project lands and subimpoundments on the upper part of the reservoir and, in addition, develop a 2,900-acre state park.

f. Regional plans. Two projects of regional significance presently are under consideration and, if fully developed, will have an indirect impact on the basin. The first is the Great River Road. The basic plan of action for this development is outlined in a report published in 1958 by the U. S. Bureau of Public Roads and National Park Service. This plan calls for total development of a Mississippi River corridor as a linear parkway for boating, motoring, and general recreation. Serving as a specific master plan for regional development of the Mississippi River corridor, it would create attractive parkways for those portions which pass through urban areas, develop the boating potential by establishing mooring facilities and boating harbors, and incorporate archaeological and historical developments fully within a master plan for lands that are presently located in the Mississippi flood plain. Located on both sides of the river, it offers

local basins, counties, and cities a valid potential source for meeting their recreational needs, particularly through zoning and participation in development of facilities. This socio-economic input will have a great impact on all parts of the Mississippi River. The second project is located within the Shawnee hills and is called the George Rogers Clark Recreation Way. As a recreation corridor, it will connect many of the Southern Illinois recreational facilities located along the Mississippi and Ohio Rivers. Visualized as a major recreational attraction of national significance, it is the subject of proposed legislation now pending before the U. S. Congress, House Bill No. 3933 and Senate Bill No. 479. Creation of the recreation corridor as a linear development is dependent upon provision of a scenic road system supplemented by rest stops, picnic areas, and marked exits to points of interest and accommodations. This would be supplemented by a series of water impoundment structures that will provide diversified recreational input. The project would require public acquisition of land, land-use rights, scenic easements, and zoning restrictions. It should be noted that as part of this long-range plan, the Forest Service is now acquiring acreage along the right-of-way in its development of the Shawnee National Forest.

SECTION V - BASIN NEEDS

24. GENERAL

Based on the previously cited demands for products and services, the scope of water - and land-related resource needs was established. This evaluation establishes a framework identifying the type of water and related land resource developments that should be considered as necessary input to sustain the basin's socio-economic growth. The scope of goods or services that would be provided by a proposed resource use or development was directly related to projections established by the participating Federal and State agencies. However, the nature and extent of these physical requirements depend upon the basin's natural resources. Proper evaluation insures that all needs involving significant resource use will be given equal recognition for the purposes of development and provides a proper basis for evaluating alternative combinations reflecting different basic choice patterns for providing such uses and purposes. There is presented in the following paragraphs the basis for the physical need evaluations.

25. FLOOD CONTROL

The economic projections and evaluations contained in APPENDIX N, AGRICULTURE, part of the Upper Mississippi River Comprehensive Basin Study (Type I), indicate that a decline in farm population and related employment can be anticipated. Inferred is the additional trend concept that the land presently in agricultural use would be capable of meeting the projected food and fiber production allocated to the Upper Mississippi River, and hence, the Big Muddy River Basin through the year 2000 without the need for any additional water resource improvement. Beyond this period, more

land will then be required to overcome an anticipated lag of some 15 percent in production versus projected requirements. However, as stressed, in the Upper Mississippi River Comprehensive Basin Study and APPENDIX K to this report, there is a corollary need to enhance the economic efficiency or the comparative economic standing of the farmer. The farmer's real income and comparative income standing have declined to the point where various types of water resource developments are required to help increase his production efficiency. This, in turn, will improve his monetary competitiveness by reducing losses in production costs and increasing his profit margin. Preliminary hydrologic and hydraulics studies indicated that tributary decapitation of flood flows by reservoirs would be effective only in the headwater reaches. Flood flow decapitation by reservoirs located on the tributaries' main stem would affect only minor reduction in depth and duration of floods on that tributary's main stem. Hence, the need analysis was concentrated in the headwater areas where water-related resource developments would result in the most efficient regulation of water and land resources for the basin's agricultural enhancement. Prototype reach analyses concerning hydraulic and damage evaluations indicated that damage reduction would result primarily from a reduction in area flooded rather than from reduction in depth of flooding. In analyzing the acreages inundated on the tributaries, flood profiles were first established for each of the tributaries. With the authorized Rend Lake assumed in place and in operation, stage-elevation curves for various flood frequencies were established on the main stem and, from these, adjusted flood-frequency profiles were established for the tributaries. Preliminary hydrologic evaluations in the prototype reach analysis have established the economic inadvisability of

attempting to decapitate major peak flows. Rather, it was determined that the main beneficial flood damage reductions could be obtained by retention of the more frequent floods, particularly those flows having frequency of occurrence ranging from 1 to 3 years; furthermore, that any effective reduction in flooded acreage would require a completely controlled water regimen. This would require control structures strategically located so as to control local flood runoff, rephase time of concentration, and reduce peak flows. Successive hydrologic screenings eventually identified the optimum plan of improvement as one that would control a minimum of 25 percent of the watershed area and maintain a maximum controlled release rate of from 10 to 15 cfs per square mile. The controlled release rates were established to reduce the peak flows, with excess flood runoff being retained equivalent in storage to 2.6 inches, or 5-year frequency.

26. DRAINAGE IMPROVEMENTS

Present land use, as well as soil types, was used to evaluate the potential drainage improvements that should be considered in determining the amount or scope of improvements to be considered. After establishing the optimum hydrologic plan for reducing the more frequent flood flows, an analysis was made of the needed improvements that would increase the agricultural efficiency and permit drainage of selected wet-land acreage. Once the rate of participation was determined for both flood plain areas and non-flood plain areas, a preliminary economic evaluation was undertaken to determine the inducement that drainage improvements could have to the local farmers. Subsequently, the scope of drainage improvements made feasible by the system-induced reductions of the more frequent floods was established for

each watershed, with adjustments made to recognize the backwater effects from the main stem. These adjustments involved deleting the tributary acreage affected by the 2-year frequency main-stem flood from consideration for drainage improvement. Channel improvements were concentrated in those areas where sufficient lands could be benefited and on acreage that would be benefited by flood reduction. Shown in TABLE ___ is the extent of the improvements, including main laterals and sublateral channels for each of the watersheds. The result was a revised system, with essentially the same reduction in flood flows but with a modified regimen effected by the main channel and lateral improvements. The combined systems maintained the previously established flood flow reductions, but changed the times of concentration and stage-elevation relationship of peak flows on the tributaries for the downstream areas. Routings were made to evaluate the induced effects of the selected drainage improvements on the mainstem, Big Muddy River, and new area-frequency curves were developed from the resultant profile. The results indicated a general increase in flood heights for the more frequent floods but comparatively very little effects for the rarer floods. This adverse effect would negate to some degree the benefits accruable to the Rend Lake Project.

27. LAND TREATMENT (HOW MANY ACRES)?

It was recognized that while the primary incentive for proper land use and adequate treatment has increased upland productivity and reduced production costs, the effects of improved upland agriculture also can be measured in the bottomland areas. Improvements in the quantity and quality of ground cover tend to decrease runoff. Improved cropping patterns and high fertility minimize upland silt production. Proper land use and

TABLE 9

Potential channel improvements for flood damage reduction and agricultural water management

Watershed	Miles of potential improvements
Casey Fork Creek	140.2
Cedar Creek	43.6
Central Big Muddy	302.2
Crab Orchard Creek	189.7
Galum Creek	69.4
Gun Creek	51.6
Hurricane Creek	34.8
Lake and Pond Creeks	112.2
Little Muddy River	208.0
Lower Beaucoup Creek	116.8
Lower Big Muddy	68.3
Middle Fork Creek	210.6
Upper Beaucoup Creek	169.6
Upper Big Muddy	120.3
TOTAL	1,837.3

improved land treatment are the first increments in flood damage reduction. Furthermore, it was recognized that to control the silt problems in the streams, which was a causal effect of erosion, a comprehensive effort must be made to encourage proper agricultural improvement and land treatment measures. Reforestation is an example of this approach, as is contouring and grading. Success in controlling runoff rates and effecting erosion-preventive measures is directly dependent upon the type of soil and the involvement of local interests in proper action programs.

28. LOW-FLOW AUGMENTATION

a. Stream quality.

(1) Procedure. The study for low-flow augmentation in the interest of water quality control was based on the needs of the individual sub-basins that comprised the total watershed of the Big Muddy Basin. The need analysis assumed that secondary treatment, with a minimum removal of 85 percent BOD, was provided all discharged effluent at existing load points. Water quality supplementation was then computed, based on the target flow furnished by FWPCA as being necessary to maintain specified standards of dissolved oxygen for the critical points in each of the sub-basins. Variable monthly target flows were established for five, four, and three milligrams per liter (mg/l) dissolved oxygen stream quality levels. Based on the projected land-use activities, commercial and municipal growth, and the present location of population centers, only one critical (maximum water requirement) point was established as the control point for the monthly flow that is necessary to sustain the various DO levels in each of the individual sub-basins. The exceptions to this procedure were on Crab Orchard Creek and the main stem, where critical points were also established

relative to the waste load that is carried by the main tributaries. Total supplemental flow for low-flow augmentation was predicated on first evaluating the base that is required for sustaining a specified level of DO for 95 percent of all low-flow events, the event being defined as those deficient periods (historical basis, period of record) when the natural flow is less than the required target flow established by FWPCA. Further evaluation was then made to determine the additional increment of supplementation required to insure that for the remainder of the critical period of record the stream would be maintained at a minimum standard of three milligrams per liter dissolved oxygen. This implies a rule curve for all reservoir operations, with phase supplementation of natural flows. Releases would maintain target flows at the desired standard of DO level within the availability limits of the basis storage block. Subsequent to depletion of the base storage, releases then would be reduced, maintaining the minimum 3 DO target flows for the balance of the deficient period and/or until the base reservoir storage is once more available.

(2) Need evaluation. Once the target flows were established for various DO levels, a preliminary analysis was undertaken to determine the hydrologic feasibility of maintaining these required monthly flows for each of the critical load points. Since augmentation of natural flows involves those deficient periods when the natural flow is less than the target flow for the specific DO level, it was apparent that the size and yield capability of the drainage area above the critical point would be the basic design and control consideration. Using the mass flow records of the six gaging stations, comparative yield parameters were established for the various parts of the basin. Thus, to depict either the daily or monthly flow variations,

or establish a hydrologic trace, or to determine the yield capability, a percent relationship of the mean discharge (dfs) for any size drainage area under study to that of Plumfield was used as a multiplier of the Plumfield gage flows. Based on the foregoing yield relationships, computerized routings were made by FWPCA to ascertain the probability of maintaining selected seasonal target flows for a five DO level at the load points. In addition, computerized reservoir routings were run for a series of variable-size drainage areas or reservoirs that were selected by the Corps to determine the minimum size drainage area for which a reservoir could be considered in augmenting low flows. The preliminary hydrologic analysis undertaken by FWPCA, Washington Office, was based on monthly flows at Plumfield, adjusted to the point (load center or reservoir) under consideration. The probability analysis was based on an annual capability without regard to extended low-flow durations. This was indicative of the recharge capability of a drainage area and the successful assurance of maintaining the depicted flows by natural runoff. A two-way matrix was used to analyze success or failure on both a water year and monthly basis. Based on the success-or-failure analyses, a limit was established in the size of drainage area and changes in DO levels at load points were made. The degree of failure in maintaining a 5 DO level at Mount Vernon, Herrin, and Marion (also Carbondale) load points were in excess of 50 percent and indicated the need to reevaluate and ascertain what DO standard could be maintained in these areas. Subsequent detail routings undertaken by the St. Louis District, Corps of Engineers, in cooperation with FWPCA, Chicago Regional office, resulted in identification and establishment of reduced standards. Analysis

of variable-size reservoir drainage areas indicated that for the smaller drainage area, demands in terms of cfs-per-square-mile versus yields in terms of cfs-per-square-mile tended to become asymptotic. Based on the ratio of total load-point deficiency to the adjusted mean annual storage equivalent for the reservoir and the percent of failures, it was concluded that a drainage area of 7 square miles should be established as the minimum size for which a reservoir could be considered in augmenting low flows. Utilizing established target flows, final DO level for each load point and the amount of supplementation required were determined. The results are shown in TABLE 10. Included is information relative to the watershed, main load contributer and control point, applicable drainage area of control point, yield factor adjustments for the Plumfield gage, selected DO standards and the time-phase amount of supplemental flow required at the load points. This information was furnished to the State of Illinois for review and comments. By letter dated 28 September 1967, the State replied that the summarized results generally confirmed its appraisal of the water quality at the points indicated, and that the dissolved oxygen-water quality standards, as presented, were satisfactory.

b. Stream environment. Based on the target flows established by FWPCA to maintain a minimal base flow and to provide the equivalent of a 3/DO level, the amount of supplementation required at a load point in Carbondale was determined. The results of this analysis are shown in TABLE 10. However, provisions of these flows did not alleviate the concern regarding the treatment and disposal of wastes in the Carbondale area. Since augmentation is solely to provide and to maintain a minimum base flow for the protection of the public health and enhancement of the aesthetic and beautification of the metropolitan environment, there is still a need

TABLE 10

Water quality hydrologic analysis

Sub-basin	Main load contributor and control point	Applicable drainage area of control point (sq. mi.)	Yield factor	Supplemental storage requirements			Remarks
				Time of demand	Duration (1) (months)	Storage(2) (acre-feet)	
Beaucoup Crk.	Pinckneyville; Pinckneyville on Beaucoup Creek	222	0.245	1965	5(6)	1,300	DO level of 5 mg/l attainable.
				1970	5(6)	1,600	
				1980	5(6)	2,000	
				2000	6(12)	3,600	
				2020	6(13)	5,200	
Little Muddy Creek	DuQuoin; Confluence Reese Creek and Little Muddy Creek	208	0.225	1965	5(6)	2,900	Yield of drainage area above DuQuoin's sewered outfall insufficient to maintain desired standards. DO level of 5 mg/l attainable for adjusted control point (confluence)
				1970	5(6)	3,400	
				1980	6(12)	4,600	
				2000	17(18)	8,700	
				2020	17(21)	13,200	
Upper Big Muddy	Mt. Vernon; Confluence Casey Fork and Seven-Mile Creek (tertiary treatment)	76	0.073	1965	5(6)	1,500	Yield of DA above Mt. Vernon outfall insufficient to maintain desired standards. DO level of 4 mg/l for adjusted control point (confluence) attainable based on tertiary treatment provided at Mt. Vernon.
				1970	5(6)	1,700	
				1980	5(8)	2,100	
				2000	17(19)	4,600	
				2020	17(20)	6,700	
Middle Fork	West Frankfort; West Frankfort on Middle Fork	231	0.256	1965	6(11)	4,500	DO level of 5 mg/l attainable.
				1970	6(11)	4,600	
				1980	6(12)	5,900	
				2000	17(18)	9,100	
				2020	17(19)	15,300	

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COMPREHENSIVE BASIN STUDY. BIG MUDDY RIVER, ILLINOIS.(U)
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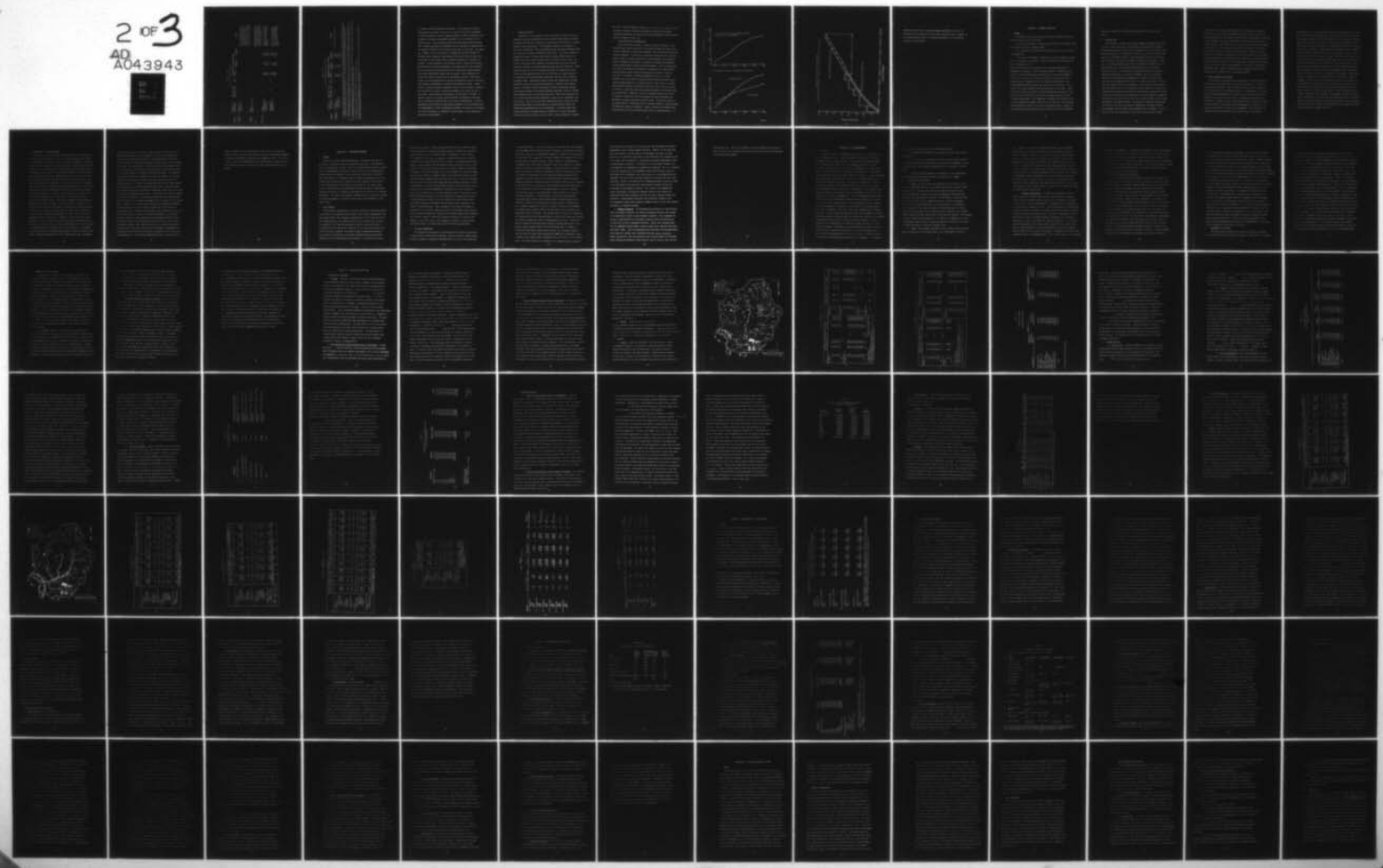

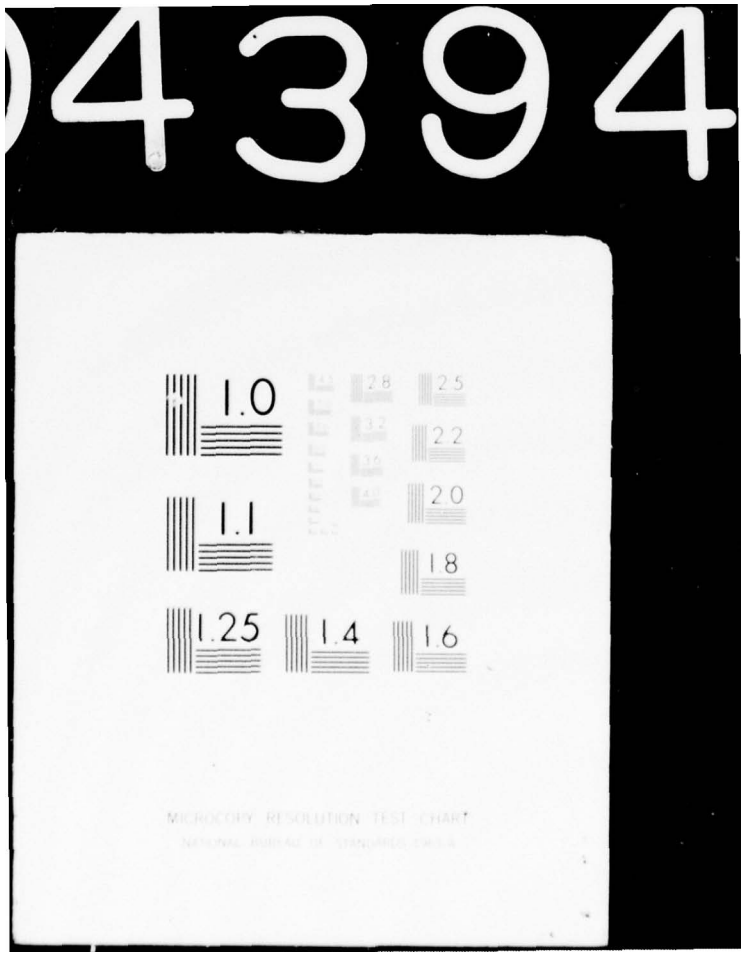
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

TABLE 10 (cont'd)

Water quality hydrologic analysis

Sub-basin	Main load contributor and control point	Applicable drainage area of control point (sq. mi.)	Yield factor	Supplemental storage requirements: Time of demand	Duration (1) (months)	Storage (1) (acre-feet)	Remarks
Lake and Pond Creeks	Johnston City; Johnston City on Lake Creek	17					Pollution problem is primarily one of induced mining waste. Experience has proven that low-flow augmentation is not an acceptable solution. Consequently, any analysis has been deferred subject to local action to alleviate the basic problem.
Hurricane Creek	Herrin; Herrin on Hurricane Creek						Drainage area of sub-basin and above load point (Herrin) insufficient in terms of size and yield capability to warrant investigation. Control point moved to main stem, Big Muddy.
Crab Orchard	a. Marion; Confluence Buckley Creek and Crab Orchard Creek	49	0.049	1965	5(8)	1,000	DO level of 4 mg/l attainable. Predicated on present tertiary treatment being provided Marion discharge.
				1970	5(8)	1,300	
				1980	16(18)	1,700	
				2000	17(19)	2,900	
				2020	17(20)	3,800	
	b. Carbondale;(4) Carbondale on Crab Orchard Creek	71(3)	0.070	1965	5(6)	3,800	DO level of 3 mg/l attainable (100% of events). Restricted operation of Crab Orchard Reservoir limiting factor restricting yield available for supplementation.
				1970	5(6)	4,800	
				1980	5(6)	6,600	
				2000	17(18)	11,500	
				2020	17(19)	16,600	

TABLE 10 (cont'd)

Water quality hydrologic analysis (cont'd)

Sub-basin	Main load contributor and control point	Applicable drainage area of control point (sq. mi.)	Yield factor	Supplemental storage requirement: Time of demand	Duration(1) (months)	Storage(2) (acre-feet)	Remarks
Lower Big Muddy River	Carbondale; Confluence(5) Crab Orchard and Big Muddy River	1,544	1.690	1965	4(5)	6,300	DO level of 5 mg/1 attainable
				1970	4(5)	8,100	
				1980	5(6)	11,200	
				2000	5(6)	19,000	
				2020	5(6)	24,700	

(1) Duration of the critical period at the selected control point, based on the target flows established by FWPCA and the natural flows of record adjusted to the control point. Two durations are shown: the first identifying the time increment involved between the initial supplement and maximum accumlative flow deficiency; and the second, in (-), the total time span between initial drawdown to reservoir recovery.

(2) Based on the storage required for satisfying a specific level of DO for 95 percent of all low-flow events plus that additional increase required to insure that, for the remainder of the critical period of record, the stream would be maintained at a minimum storage of 3 mg/1 DO.

(3) The 270-square mile drainage area above the control point has been reduced by 199 square miles of drainage area control by Crab Orchard Reservoir to reflect that reservoir's operational inability to provide dependable releases.

(4) Supplementation requirement to maintain standard of 3 mg/1 DO 100 percent of the time.

(5) Key control point for low-flow augmentation in that reach of Big Muddy River below Rend Lake. Other control points not shown are Benton (downstream of Rend Lake Dam), Herrin (Hurricane Creek), and Murphysboro.

to prevent a pollution problem in this area. Since sufficient dilution flows cannot be provided, there will be a need for the City of Carbondale to either increase its level of sewage treatment or pump its effluent to the Big Muddy, if primary and secondary treatment is to be continued at its existing plants. Since Rend Lake Project will eventually augment the main stem, effluent discharged by Carbondale into the Big Muddy is possible without adversely affecting the DO level in that reach of the stream. See TABLE 10. However, if the city elects to discharge its effluent through its existing plants located on Pyles Creek and Little Crab Orchard Creek, both tributaries of Crab Orchard Creek, advanced treatment must eventually be provided. As was indicated in the previous section, concern also had been expressed over the stream environment in the Lake and Pond Creek Watershed due to an existing pollution problem that is essentially mining-oriented, with acidic wastes being induced into the stream. Since experience has proved that dilution flows are not an acceptable solution to this type of problem, it was concluded that no further consideration be given to solving this problem by development of specific water-related resources. Rather, this is a problem requiring cooperative action by local citizenry, industry, and the State in an effort to solve the problem at the source and not in the stream. This decision was concurred in by the State of Illinois. In addition, there is a corollary need to preserve or enhance the land adjacent to the basin's stream as part of the social considerations. Low-flow augmentation will enhance the recreational potential of the surrounding area and establishment of river recreational corridors, as called for in the State, and local plans should be considered in establishing a truly comprehensive basin plan of development.

MUST CONSIDER SOLUTION - CAN'T IGNORE

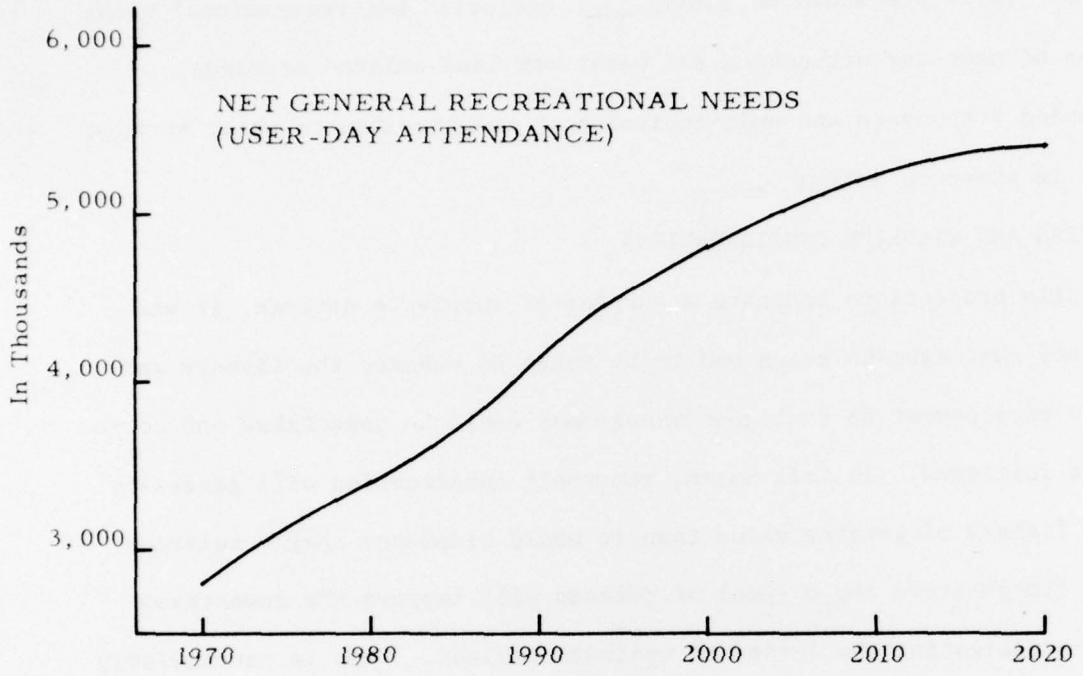
29. GENERAL RECREATION

Subsequent to the evaluation of the net demands in terms of user-day attendance, further adjustments were made in these demand figures to reflect recommendations that would involve the construction of facilities on projects presently under construction. The adjustment replaced a pre-emption, or allocation of potential user-day attendance which was assigned Kinkaid Creek, with additional increased visitation for Rend Lake. This latter allocation recognized the need to change that project's existing master plan and to upgrade, over time, certain unzoned lands to a higher priority public use. As part of the total need evaluation, the water surface and land acreages required to satisfy the user-day attendance need also were determined. These needs were based on a total requirement adjusted for inventories of both Federal and non-Federal projects, with the resultant net needs determined by comparing the existing projects' capability with each of the projected time-phase needs. Recreational design criteria were established, relating applicable visitation and optimum development to available water surface acreage. The design criteria recognized a variable relationship between water surface acreage and accruable visitation potential, based on a reasonable saturation limit for peak recreation days. Within this framework, the cost of the facilities was then expressed in terms of unit development cost per user-day. The unit cost was kept sufficiently high to insure that the physical plant would be in good quality to provide adequate service and diversified opportunities for the recreationist. To provide lands, both project-associated and single-purpose, sufficient for capital development and use per type of activity, a ratio of land to water acreage of 67 percent

was used. There are shown on FIGURE 9 projected net recreational needs in terms of user-day attendance and water and land-related acreages. Recommended attendance and unit-capital-cost relationship to water surface acreage is shown on FIGURE 10 .

30. FISH AND WILDLIFE CONSIDERATIONS

While projections indicate a surplus of supply to demands, it was recognized that certain steps had to be taken to enhance the fishery and wildlife environment so that good management could be undertaken and action programs initiated. In this basin, reservoir construction will generally support fishery of greater value than it would displace; that regulatory control (temperature and oxygen) of release will improve the downstream fisheries mitigating the losses of upstream habitat. This is particularly true since the present fish population is essentially of rough fishery, whereas improved stream quality will encourage the growth of sport or game fish. In addition, wildlife conservation tracts are so widely scattered that any proposal for water and land-related development would provide acreage beneficial to wildlife habitat. While losses to certain species would naturally be incurred in the river bottom lands, they would be offset by a beneficial return to waterfowl production and improved hunting opportunities. Generally, the loss of hunting opportunities caused by reservoir construction would be mitigated by proper development and management of project-associated land and waters. Shore areas created in the upper reaches of impoundment could be intensly managed to provide greatly increased food supply for waterfowl. Aquatic wildlife would benefit from increased shore line and stabilized water levels in downstream areas. In



NET RESOURCE NEEDS - GENERAL RECREATION

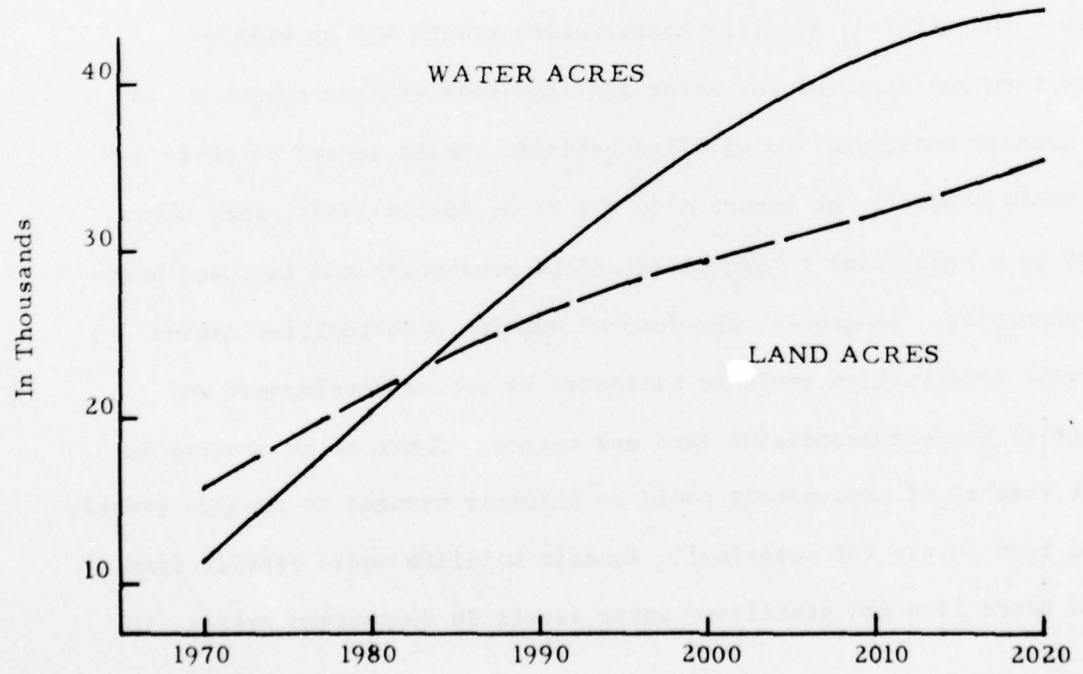


FIGURE 9

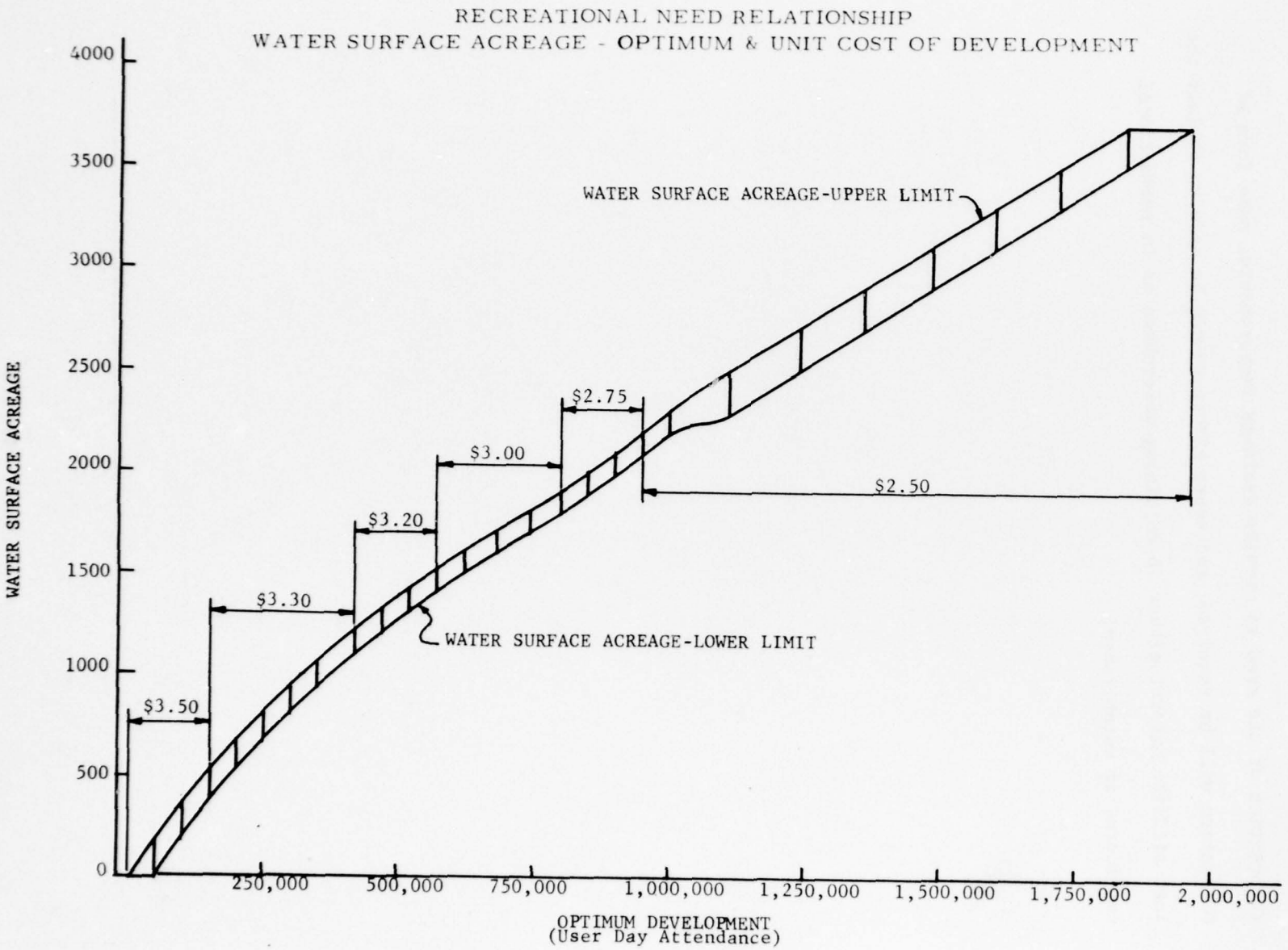

RECREATIONAL NEED RELATIONSHIP
WATER SURFACE ACREAGE - OPTIMUM & UNIT COST OF DEVELOPMENT
WATER SURFACE ACREAGE
4000
3500
3000
2500
2000
1500
1000
500
0
WATER SURFACE ACREAGE-UPPER LIMIT
$2.75
$3.00
$2.50
$3.20
$3.30
WATER SURFACE ACREAGE-LOWER LIMIT
$3.50
250,000
500,000
750,000
1,000,000
1,250,000
1,500,000
1,750,000
2,000,000
OPTIMUM DEVELOPMENT
(User Day Attendance)

FIGURE 10

recognition of the need to provide drainage improvements, some form of mitigation will be required, and every effort should be made to replace the lost wildlife habitat either in adjoining watersheds or in recreational corridors, if established.

SECTION VI - PLANNING OBJECTIVES

31. GENERAL

In defining the resource planning and ultimate development required, a three-fold objective was established:

a. To help in providing the necessary land and water development needed to sustain the projected economic growth;

b. To encourage the preservation and enhancement of the area's natural environment; and

c. To assist in developing a framework for social development, stressing the well-being of the people so that the growth and living conditions will be beneficial to all.

The social well-being of the people was the overriding determinant in planning the development of water and land resources. Planning for this objective involves balancing the distribution of resource development to assure that all parts of the basin will share in the projected socio-economic growth. Towards this end, the land-use plan prepared by the Greater Egypt Planning Commission was used as a basic guideline. Utilization of the local planning report was justified by two reasons. First, the plan has similar objectives and contains proposals regarding the same types of needs established by this study as regards land use and socio-economic considerations. The Commission's proposals were time-phased over a period extending from 1985 to 2025 and are the basis for achieving maximum development by control of the area's main growth inputs. Second, the plan, which was formally adopted early in 1965 by the four participating

counties, is considered an expression and commitment of the local residents.

32. LAND-USE PLAN

What follows is a summary of the Greater Egypt's planning concepts that serve as a basic guideline in establishing the framework for development. Minor modifications were made to make it applicable to the five-county rather than four-county area. Formulation of the over-all plan of development was based on the framework concept of concentrating the resources of the basin into five major areas which show maximal potential for development. These are: the Mount Vernon-Rend Lake area; the Benton-West Frankfort area; the Marion-Herrin area; the Murphysboro-Carbondale area; and the DuQuoin-Pinckneyville area. This principle of concentration offered the greatest opportunity for success in economic development, and at the same time, scattered the potential points throughout the region so that the direct influence of development would be felt in more than one location. In addition, this approach offers the possibility of specialization within each of the major areas so that each area would in effect complement each other and eliminate much duplication of function. This procedure recognized that while each area of the region has its own sphere of the urban-industrial-commercial development, each is still tied to the other through economic activity, highway patterns, and common problems. This pattern of dispersed concentration utilizes as a core that area bounded by Murphysboro, Carbondale, Marion, West Frankfort, Benton, Mount Vernon, Pinckneyville, and DuQuoin. It is in this core area that the majority of the basin's population and economic

activity are to be found. This places the urban communities essentially in the center of an outlining environmental area of agricultural and recreational activities. The land-use plan envisions a phased growth, controlled so that urbanized areas would concentrate in those areas presently semi-urban; and future semi-urban areas will develop in acreage where development is now scattered. The land-use plan specifically minimizes the land area that would be developed to meet the urban needs and maximizes the amount available for greenbelt and open space, as well as agricultural development. The plan underlines the important fact that residential development should occur in the areas adjacent to the existing larger communities, and touches on the use of waste lands and establishment of public-use (recreational or greenbelt) areas. Specific planning concepts regarding these latter considerations are presented in the following paragraphs.

33. RIVER RECREATIONAL CORRIDORS

To encourage the preservation and enhancement of the natural environment and at the same time provide an additional increment to the basin's recreational development, special consideration was given the possibility of establishing river recreational corridors. As recommended by the State and local planning commissions, location of these corridors would be concentrated in the center of the core area containing the major portion of population. In addition, it was deemed feasible that the location of these corridors should be in relation to major impoundments, if possible, or at least in streams whose low flow would be augmented. The potential of enhanced stream flow would provide a dual facet return: the potential

transformation of the fish population from rough to game fishery, as a tourist and recreational attraction; and a cleaner stream that would encourage public usage and protect the public health. Since the increased flow would enhance the adjoining land acreage, providing a dual enhancement of both land and water, specific separation of recreational and conservation developments would be required. Acreage selected for wildlife habitat and general recreation would be controlled by zoning, either spacial or time. Three areas were identified as having the greatest potential for this type of use: the main stem of the Big Muddy below Rend Lake; and the lower portions of the two major tributaries, Little Muddy River and Beaucoup Creek. These three reaches of streams were selected by the local planning commission which recognized the existence of several thousand acres of unused land that were the least suitable for cultivation or development. These lands consist of swamp and other wet-land acreage that is subject to periodic flooding, or land located in hilly areas too steep for any specific use. The Commission felt that many of these lands should be retained in their natural state and incorporated into the total recreational plan for the basin, since their location is near areas of future development and concentrated growth that need this type of environment to balance their social needs. In addition, it was felt that any extensive mitigation of wildlife habitat could be concentrated in these areas to provide a more manageable acreage and serve as a basis for a comprehensive action program to preserve the area's natural ecological resources.

34. DEVELOPMENT OF TOURISM INDUSTRY

To meet the recreational needs of the basin and at the same time aid in the economic reorientation of the area, special planning controls were established relative to water related recreation developments. The Checchi report, which investigated the economic potential of developing tourism and recreation in the southern part of the State, identified the main centers of competition for the kind of recreational development and attraction that southern Illinois can develop. Existing competitive centers are the Lake of the Ozarks in Missouri, Kentucky Lake area, and the many natural small lakes in the Wisconsin-Michigan area. Two areas whose future development seems readily assured through State and Federal participation are the Wabash River Basin in southern Indiana and the Meramec River Basin in southeast-central part of Missouri. To insure the development of this part of Illinois, it was recognized that a strong effort must be made to provide extensive water-based projects. The report recommended that approximately 48,000 surface acres be provided in the southern part of Illinois as an initial base for long-term development of tourism and recreation facilities in Illinois. In essence, the water surface acreage analysis implied the need to establish individual impoundments, the sizes of which range from approximately 500 to 9,000 acres. Corollary to this approach, the study attempted to select reservoir sites that would provide impoundments within this range. It was felt that the size of impoundments was a critical factor in attracting private development to the area, and would be a predominant factor in attracting the economic capital required to provide quality development. Long-range planning for the area redevelopment, which encompasses

tourism and recreation as a definite economic input to the area, will be predicated on Rend Lake being developed as the base for providing extensive public recreational opportunities. Present planning is already involving a protective zoning and development in depth on the land surrounding that project. The comprehensive recreation plan presently envisions extensive development of basic facilities and diversified recreational opportunities on project lands by the Federal and State Governments. To complement these basic recreational developments, several local entities are developing plans for construction of major luxury-type resorts and convention center facilities, all located on adjacent non-project lands. Most significant are the plans of the Rend Lake Conservancy District, which would provide controlled and zoned development of restaurants, night clubs, motor inns, and an 18-hole championship golf course. In addition, other plans are underway to locate the campus of the newly established Rend Lake Junior College District as part of an intensive development center contiguous to the project lands. Included in this complex would be high-rise buildings and shopping areas that will serve both the campus residents and total tourist and recreational influx. Based on the foregoing, it was concluded that the location of any reservoirs selected for study in development for recreation should, in addition to being located near the anticipated centers of area development, ring the Rend Lake project and be satellite to that project's recreational complex. Thus, Rend Lake will serve as a major attraction in the basin, and the satellite reservoirs will be planned to supplement the basin water-related activities that would be required for the total recreational demand area. This in-depth planning will allow a restricted use in

terms of opportunities and will provide a stable base in the satellite reservoir area so that the State and local counties can encourage permanent residential development and industrial and commercial growth. The result will be a plan of development that will permit complete integration of all input factors necessary to provide for a stable and diversified base for growth.

SECTION VII - SOLUTIONS CONSIDERED

35. GENERAL

As part of the plan-formulation procedure, consideration was given to all types of alternative means for meeting the basin needs. The importance of this evaluation was two-fold. First, it objectively identifies all possible ways of accomplishing an objective or service other than the standard water-related resource development of local reservoirs; and, second, evaluating these alternatives on a comparable basis in terms of equivalent services and economic worth provides data required for project formulation and selection of the basin plan when the alternative cost governs the true worth of the service. This procedure also established the possible range of supplementary measures that should be considered in providing for the basin's socio-economic development. The range of alternatives considered and the review and rationale involved in acceptance or rejection of these types of developments are discussed below.

36. FLOOD CONTROL

The alternative possibilities to reservoir storage for protection against flood flows in the tributary areas included levees, channel improvements, and flood plain zoning. The alternative consideration of local levee protection was eliminated because the length and size of levee required were too great in comparison to the benefited acreage per reach of stream, and because of the prohibitive cost that would be required for the levee and interior water course diversion or pumping. The need for channel improvements primarily was related to alleviation of the on-farm drainage problems and was found feasible only as a last-added project increment to a reservoir system that

provides flood control. Channel improvements would require extensive channel size and excavation to provide sufficient gradient to contain the controlled runoff volume of the more frequent floods. Consequently, it was rejected on a comparative cost basis, as opposed to detention reservoirs in providing equivalent flood decapitation per reach of stream. In considering flood plain zoning, it was recognized that this non-structural alternative is not a water control or flood height reduction measure, but rather a means of controlling development. Flood plain zoning is a way of living with the overland flooding situation and attempts to minimize losses by restricting the physical development and resulting damage within the flood plain area. It was also recognized that care must be exercised when suggesting flood zoning regulations in order to assure that those activities and pursuits which require waterside sites, or which enjoy a net economic advantage by locating in the flood susceptible areas, are not denied use of the flood plain area itself. The primary usefulness of this method appears to be in the prevention of unwarranted increase in flood damages and losses to the area, region, and nation normally associated with uninformed development activities which ensue subsequent to provision of flood protection. Since planning for flood plain development is predicated on an open-space usage, (agricultural developments) which normally has an economic advantage when located in the bottoms, zoning as an alternative was rejected. However, flood plain zoning was retained as a potential supplement, if both flood control and drainage are justified, to insure proper flood plain usage in accordance with the selected plan of improvement.

37. LOW-FLOW AUGMENTATION

The alternative possibilities to providing dilution flows in the interest of water quality include advance treatment, tertiary treatment, single-purpose reservoirs, pipeline transfers of effluent within the basin, and restrictions

on stream and land use. In the early stages of the basin study, water samples taken for FWPCA indicated pollution from an intermix of sources such as mining, agriculture, municipal, and industrial components. Quality had deteriorated to the point where the streams were no longer acceptable for domestic use or fish ecology without increased treatment. Urban, industrial, and agricultural developments were sufficiently concentrated and too far advanced to consider restriction of water use and land zoning as a practical method of control. However, the State of Illinois is studying the need for legislation relative to treatment of mining waste and has issued regulations governing stream standards and quality controls of the municipal waste treatment effluents. Advanced treatment was selected as the one alternative with the basic criterion of equivalent service or function to that provided by dilution flows; hence, it was retained and used as the equivalent measure of service. Tertiary treatment was studied, but discarded when it was concluded that it was not equivalent in function to dilution flows. Even with tertiary treatment (polishing ponds) provided, some dilution flows of reduced amount would be required to maintain an acceptable goal of water quality. Dilution flows are a necessary supplement to tertiary treatment to prevent the development of nuisance aquatic growth caused by the high nutrient in the effluent discharge from tertiary treatment. The economic worth of this latter combination of treatment and dilution flows was found to be more costly than just providing the necessary supplemental flows by single-purpose reservoirs. Intra-basin pipeline transfer of municipal waste treatment effleunts was studied in progressive steps, pumping effluent from the discharge point to reaches of streams with increasing drainage areas and flow. The hydrologic analysis indicated that the target flows established by FWPCA were sufficiently large to require some, though reduced, supplementation in all parts of the tributary areas. The result was that the economics of the combined system of pipeline

and reduced dilution flows would be more costly than providing the necessary supplemental flows by single-purpose reservoirs. However, if the load point were close enough to the main stem of the Big Muddy River where dilution flows are to be provided by Rend Lake, it was found that use of pipeline would be the least costly alternative to providing the necessary supplemental flows by single-purpose reservoirs. In addition to the intra-basin transfer, use of groundwater for supplementary streamflow was considered. The U. S. Geological Survey has indicated that the groundwater yields from all areas, except the Mississippi River flood plain, within and adjacent to the Big Muddy Basin are inadequate for any use other than water supply for individual and small municipalities. However, the practicality of pumping groundwater from well points in the Mississippi flood plain was rejected when the design factors were established for preliminary evaluation. The variable flow, pumping head (static and dynamic), and pipeline lengths resulted in cost factors for construction and annual operation that were too high to warrant further consideration. Single-purpose reservoirs, with sufficient storage to meet the time-phased target flows furnished by FWPCA, proved to be the most feasible alternative to advanced treatment.

a. General recreation. In determining the alternative to local developments for general recreation, the needs and planning objectives were assumed to be essentially related to water-oriented recreation. This recognized the surplus of opportunities for land-based recreation within the basin and is in line with the State's expressed objectives. Hence, the alternative must have the comparable effectiveness of water surface acres, physical facilities, and project lands. Since the planning process identified the adjoining Wabash River basin as a similar area, essentially serving a similar recreation market (population), data were extracted from an interim report on the Wabash basin, permitting estimates of base reservoir costs by use of a unit cost per

water-surface acre. Thus, the alternative value was computed as being equivalent to the sum of the reservoir cost plus the cost of the specific recreational facilities and land charges.

SECTION VIII - PLAN FORMULATION

38. CRITERIA

The basic objective in formulating a basin plan is to provide the best use or combination of uses of water and related land resources to meet all foreseeable short and long-term needs. In accordance with Senate Document No. 97, 87th Congress, 2nd Session, all viewpoints, national, regional, state and local are to be fully considered in establishing the needs of the basin. These needs then serve as the basis for formulation of a plan that includes all units and purposes which satisfy a quantitative economic evaluation based on tangible benefits and costs expressed in comparable terms. Once this baseline has been established, the effects of intangibles or other considerations warranting acting programs should first be identified. Then, any modification required to meet these socio-economic or environmental needs should be included in the proposed scale of development, if the plan of improvement is to be truly comprehensive. In terms of tangible benefits, basin formulation is based on the principle that the selected project or projects should be the most economical means of accomplishing their specific purposes. Thus, each development or increment thereof included as an integral part of the system is developed to the scale producing the maximum excess of benefits over costs. However, where long-range water needs are forseeable only in general terms and where alternative means for meeting these needs are not available, consideration has been given to including additional storage in reservoirs where it can be accomplished at a significant savings over the cost of subsequent enlargement. Alternatives, including phased and sequential construction, were also considered in determining the level of development which would provide the maximum benefits over costs as related to the basin needs. The procedure for determining the optimum plan of development for the basin's

water resources was comprised of three broad planning steps:

a. Definition and location of both present and future water resource related needs;

b. Use of successive evaluation in terms of cost and accrued benefits to provide the needed goods and services by alternative developments, assuring a balanced plan of water resource development which is consistent with the needs;

c. Analysis of each increment of development to insure maximization of net benefits while meeting the needs for multiplicity of demands.

39. FACTORS AFFECTING ANALYSIS

a. Time. The time of needs was recognized at the outset as a major factor in determining the plan of development that would be required to meet the basin needs. A period of 50 years was selected for analysis of the economic trends and to establish the type and magnitude of water and land needs that could be expected to develop. The requirement for the first need increment (1980) was used to establish the nucleus of basin development. Once this base had been established, the long-term needs, as indicated by the requirements for the latter increments of time (2000 and 2020), would be met whenever possible to insure that the project formulation was directed towards achieving the best possible use of the resources employed. This planning procedure provides for consideration of all factors in determining the scope of development that will meet the needs and maximize net benefits on the basis of factors measurable in quantitive economic terms.

b. Area. The geographic distribution of the problems associated with water resources was an influencing factor in the development of the basin

plan. Location of the various prejected need centers clearly indicated that an analytical division for each of the main watersheds was the only practical approach. The need for flood control and water quality augmentation for the major portion of the main stem, Big Muddy River, will be provided with the completion of the Rend Lake Dam and Reservoir, scheduled for 1973. Therefore, the location and scale of development that would be considered in meeting the remaining needs dictated an individual-tributary watershed analysis. Topographic limitations and yield capabilities relative to supplemental storage requirements for low-flow augmentation precluded utilization of many potential sites or structures in the headwater areas. Planning for major recreational developments was concentrated in those areas in and around the major growth centers, as defined by the economic base study and Greater Egypt's land-use plan.

c. Economic reorientation. To further the governmental efforts to enhance the basin's economic structure and to help reorient its economic growth, particular emphasis has been placed on the enhancement of the agricultural industry and the establishment of an adequate base for development of a tourism and recreational industry. Needed improvements for agricultural enhancement have been evaluated in a framework beyond the normal institutional procedures as have been indicated before. The plan of improvement for flood control will be based on a definite hydraulic evaluation of a systemized decapitation of flood flows within the individual watersheds. This requires that the participants at all levels, particularly the local residents and farmers, commit themselves to a total implementation of the land treatment measures and multi-facet resource developments. Obtainment of the agricultural enhancement cannot be a piece-meal affair, and to insure proper results requires

total resource management. To encourage establishment of the tourism industry, selection of reservoirs for recreational development was essentially limited to those projects that would provide a usable water surface acreage of 500 acres or more in size. As has been previously indicated, this was the minimum or lower limit of water surface acreage that is conductive to attracting capital into the basin and attracting the tourist to partake of the various water-related pursuits that can be developed.

40. DESIGN AND PLANNING CONSIDERATIONS

To satisfy the present and foreseeable future needs of the basin, it was decided that each reservoir site should be carefully analyzed for total site development, i.e., that the limited number of good sites should not be committed to partial development when past experience has subsequently proven that full-site use is economical and, from a conservation standpoint, most desirable. Hence, the scale of development for total reservoir storage was maximized, limited either by topography or incremental cost-benefit analyses which indicated that the extension of the scale of development would require expenditures in excess of benefits added. For purposes of project analysis, the recreational facilities costs were based on an initital level of development, with installation of the remaining facilities time-phased over the rest of the study period. This phasing of development was determined from analyses of existing reservoirs and their history of development, and from discussions with various Federal, state, and local agencies. Of the optimum capital investment necessary to meet the total recreational potential at each of the reservoir studies, a general parameter ranging from 40 to 80 percent of the optimum was selected as a level of

initial development reasonable of attainment. The percent factor selected was dependent upon the size and optimum development potential of the reservoir and its location relative to the main growth centers. Whenever possible, recreational development was planned for those reservoir sites located near the low-flow critical-load points. This procedure resulted in a good distribution throughout the basin and insured that the reservoir location was close enough to the main growth centers to enhance the project's recreational potential and its value for the area's economic redevelopment. It was recognized during formulation that provision of a pool for recreation, a non-consumptive use, would permit time-phased conversion to meet the concurrent and consumptive demands of low-flow augmentation, with only minimal adverse effects on the reservoir's recreational potential. In reservoirs with multiple-purpose joint-use pools, the expected level of optimum use was predicated on an analysis of the drawdown effects caused by releases for low-flow augmentation. The resultant in water surface acreage that would be available, generally for at least 75 to 80 percent of all historical low-flow deficient periods, was used to establish the optimum potential for reservoir and the applicable user-day attendance and development cost. A unit charge of 20 cents per user-day was used to determine the specific operation and maintenance and replacement cost. This unit charge was recommended by the Bureau of Outdoor Recreation and thought to be representative of costs that would be experienced in this part of the state.

41. ASSIGNMENT OF FUNCTIONS

The water purposes served by the individual reservoirs were based on the services assigned the project in meeting the basin needs. Subsequent

to determining the storage required for providing flood control, each reservoir was studied to determine its capability for meeting the individual watershed needs for low-flow augmentation and the concurrent basin need of recreation. Since any reservoir considered would have to be considered part of a system for decapitating flood flows, the storage for the other two purposes would be analyzed as incremental to that need. Sizes of the joint-use pools were based on the objectives of meeting the immediate 1980 needs and the concept of full-site utilization. Within this framework, storage dedication was first predicated on allocating the storage necessary to meet the 1980 low-flow augmentation needs. To this base, a second increment was added, equivalent to that storage required to meet the supplemental low-flow augmentation needs for the year 2000 and 2020. This storage was included as a dual-purpose block, initially dedicated to recreation but subject to subsequent selective and progressively greater incremental conversion to low-flow augmentation, while still satisfying essentially the same recreational needs. For those reservoirs whose site potential was not fully utilized, a third storage block was added, dedicated to the single-purpose need of recreation. This storage would have the added value of enhancing the project's contribution to the reorientation of the basin's economic structure by increasing the water-surface acreage and adding to its potential as a tourist attraction. Thus, project formulation and analyses recognize that the larger reservoirs would have an increment of joint-use storage, possibly involving a multiplicity of use on a time-phased basis.

42. CONVERSION OF DUAL-USE POOL

a. Rationale. The concept of a time-phased conversion for any increment of joint-use storage is based on the assumption that the projected needs will become a reality; that storage will be converted from an interim and compatible use to meet these needs: and that, together, the dual, or combination of, uses will not only provide the maximum excess of benefits over costs, but will obtain the full advantages of multiple-purpose developments. Implied is the recognition of a restricted, yet multiple, usage of the same storage based on two requirements. They are: (1) to identify the costs necessary to modify the basic project (exclusive of specific facilities), each block of storage has at least two governing parameters: volume of storage and time, and (2) to determine the eventual economic justification of a project purpose, the project cost applicable to each (added) block of storage must be distributed equitably among the purposes served. Hence, there are the additive requirements of specific identification and compatability evaluation of the multiple services or functions provided.

b. Application. Based on the foregoing, the joint-use pool in each of the reservoirs studied was divided into individual storage blocks defined in terms of (1) controlling or consumptive uses, (2) scale of project modifications and (3) time. Recreation, essentially non-consumptive in water use, would be compatible even on an incidental basis. However, the degree of compatibility would be a subject of separate analysis ascertaining the effects of project operation (drawdown for consumptive use) on recreation. Scale of project modifications is the ultimate storage need of

each controlling purpose at the end of the analysis period (50 years, 1970 - 2020). Time is the controlling variable for phasing the magnitude and availability of storage needs, and is the basis for computing the relative value (present-day worth) of each service or function provided. These relative values, in turn, serve as a basis for eventual distribution of project costs. Hence, interim usage is reflected only in terms of identifying project purposes involved in each storage block and the relative values of those functions. Specific costs may or may not be involved.

c. Operational effects on reservoir recreation. To verify the compatibility of dual use, an analysis was made to determine the effects of downstream releases for low-flow augmentation on the recreational potential of each reservoir. First, the storage required to supplement natural flow was determined. Storage requirements were evaluated on the basis of probability of low-flow events, as defined by FWPCA target flows for the selected quality standards. Since the water surface acreage that would be available for at least 75 percent of all low-flow events was used to establish the optimum recreational potential of each reservoir, a further analysis was undertaken to determine the average surface acres that would be available for recreational pursuits. Unlike the planning criteria, no allowances were made for evaporational losses in this analysis, since the duration of drawdown is comparatively short and the evaporational losses would be comparable, whether either dual-use or single-purpose is involved. Since these storage requirements and average surface acres were predicated on "low-flow events," the drawdown events, if calculated on an average annual basis, would tend to indicate an even greater recreational potential (i.e., less severe reduction in recreational potential).

Thus, to insure a proper evaluation, analysis of the drawdown effects was on a monthly basis, which indicated that the reductions in surface acres available for usage during the recreational season were within acceptable design tolerances. Planning for reservoir recreation recognizes that there will be a drawdown of varying magnitudes depending on the severity of drought conditions, since it is predicated on a "normal pool" rather than top of joint-use pool. Use of average annual attendance figures is indicative of this generalized approach in recognizing year-to-year variations dependent upon the weather cycles. Design and location of recreational facilities have to be based on a range of surface acres of a joint-use pool. The hydrologic conditions, and the increased usage and regulation of water by man, require a coordinated approach and recognition of compromise in the ultimate aims of each water purpose with realistic assessment and coexistence in planning for each project purpose. The withdrawal for water quality will also enhance the recreational aspects of the downstream reaches and provide the base for the ultimate development of recreational parkway and river corridors recommended by the State of Illinois.

SECTION IX - SELECTION OF BASE PLAN

43. ALTERNATIVES CONSIDERED

a. General. Analysis of the needs for water-related developments involved separate studies for flood control, drainage, low-flow augmentation in the interest of both water quality control and maintenance of base flow, and general recreation. It was found that the needs of the individual watersheds can be satisfied by a system of reservoirs impounding and regulating the surface runoff. It was also apparent that because of economical or physical constraints the optimum plan of development may be incapable of completely satisfying all the water-and land-related needs of the basin. As part of the plan formulation effort, joint coordinated planning was undertaken by the construction agencies to identify the various need centers and within that framework to establish various alternative proposals in meeting these needs. The need centers for low-flow augmentation were established by the Federal Water Pollution Control Administration. The need centers for flood flow decapitation and drainage of wet-lands were determined by the system requirements for tributary and lateral drainage areas. The need centers for recreation were centered around the communities and environmental areas of Mount Vernon, West Frankfort, Benton, Herrin, Marion, Carbondale, Murphysboro, DuQuoin, and Pinckneyville.

b. Soil Conservation Service-proposed plan of improvement. To meet the primary needs of the basin, the Soil Conservation Service studied some 130 headwater sites for reservoir development in 13 of the 15 watersheds. The remaining two watersheds, Cedar Creek and Kinkaid Creek, were not studied since comprehensive plans of development had already been established and

were in various stages of development. Preliminary screening based on hydrologic and economic justification of flood flow decapitation, subsequently reduced the 130 sites to 80. In addition, the preliminary economic evaluation indicated that development in watersheds number 1 - Lower Big Muddy River, 4 -Lower Beaucoup Creek, 9 -Central Big Muddy River and parts of watershed 7 -Crab Orchard Creek, could not be justified in terms of agricultural enhancement. Each of the 80 reservoir sites was then evaluated relative to its potential for additional storage and multiple usage. Further hydrologic screening established that five reservoirs had sufficient storage-yield capability, either individually or in combination with another reservoir, to meet the low-flow augmentation needs for four out of the six load points. Eleven reservoirs were initially selected as having a recreational potential, However, application of the minimum water-surface acre criteria, together with the need for area distribution and the net remaining recreational needs, reduced this number to five for final basin consideration. In addition, the need for drainage channel improvements was established in seven watershed areas. These channels would require development of laterals and sub-laterals for drainage improvements to wet areas in and adjacent to the flood plains. Some 350 miles of main channel improvements were identified and costed for development along the principal tributaries. These improvements would supplement the detention structures in encouraging the agricultural enhancement of the protected areas. In addition, these main channel improvements would permit a secondary development of approximately 875 miles of laterals and sub-laterals to provide drainage outlets for an additional 163,000 acres adjacent to the flood plain. Of the 80 reservoirs selected by the Soil Conservation Service to

meet the net remaining needs of the basin, there is a potential storage of 143,100 acre feet for flood reduction including sediment storage, with an additional 92,400 acre-feet that was selected for potential development to meet other multiple-use needs of recreation and/or low-flow augmentation. Total cost of the reservoirs were estimated at $23,046,000. Total cost of channel improvements are estimated at $12,200,000 of which $7,100,000 is required for installation of the main channels. Total cost of the plan of improvement, as recommended by the Soil Conservation Service is estimated at $35,246,000.

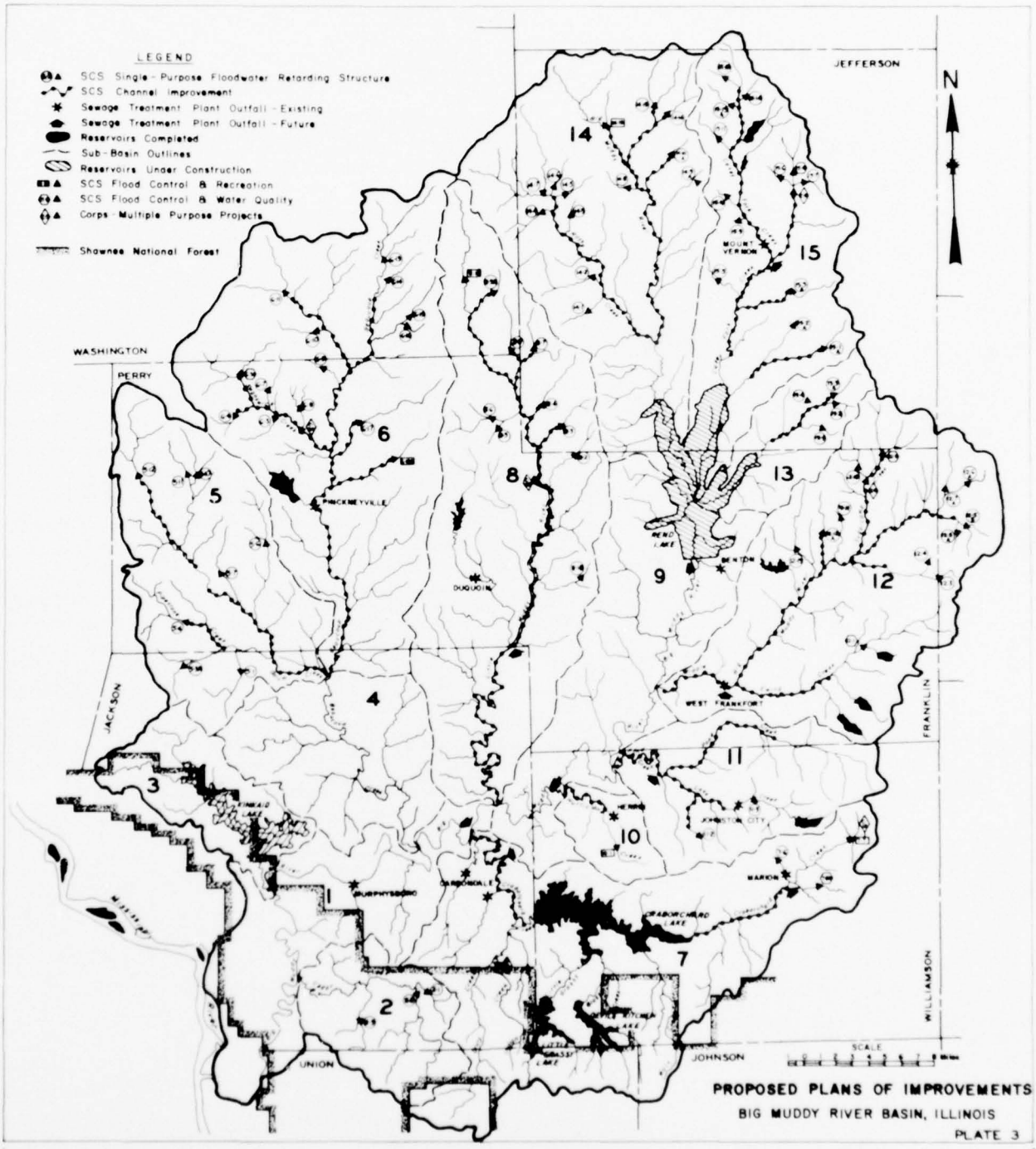
c. Corps of Engineers-proposed plan of improvement. In analyzing the needs and their inherent characteristics, it was concluded that the interest of the basin would be best served if conflicts with the Soil Conservation Service's headwater reservoirs were minimized. This would be required if the concerted effort to reorient and enhance the local agricultural productive output and efficiency is to be achieved. Local involvement would be facilitated and maximum enhancement of agricultural development assured under Public Law 566 with its supplemental land treatment program and channel improvements. Hence, the Corps purposely restricted its study to those watersheds where low-flow augmentation was a definite water need. This procedure automatically insured selection of reservoirs with a good basin distribution pattern. Furthermore, the site would be close to the main growth centers, and the project's recreational potential and its value to the area's economic reorientation would be enhanced. Since the hydrologic analysis indicated that, installation of channel improvements would be a last-added increment to the flood decapitation; and because drainage provisions would have to be directly related to the proposed land-use and land treatment programs, it was decided that the drainage system should be developed under the Public Law 566 program. It was felt that interjection of multiple Federal agencies should be

minimized in what essentially should be a single Federal-local sponsor relationship. Otherwise planning could become too complex and lead to haphazard phasing and development in each of the watersheds. Consequently, it was concluded that the Corps' responsibility should be restricted to investigation and construction of reservoirs to meet a multiple water-resource need. On this basis, preliminary studies involved consideration of 57 reservoir structures, 6 of which were retained for detailed analysis. Screening was confined essentially to the individual sites capability and efficiency in meeting the water-related requirements. Design of these reservoirs provided a total storage equivalent of 177,700 acre-feet, of which 27,900 acre-feet were provided for flood control decapitation, 20,700 for sediment retention, and the remaining 129,100 for multiple usage, both low-flow augmentation and recreation. Total cost of the 6 projects was estimated at $61,020,000.

d. Summary. TABLE 11 lists the reservoirs in each watershed proposed by the Soil Conservation Service and the Corps of Engineers as alternative plans of improvement. TABLE 12 presents the channel improvements recommended for installation in the selected watersheds. PLATE 3 shows all of the improvements proposed by the two agencies.

44. BENEFITS

a. General. Benefits attributable to the reservoirs and channel improvements are based on the services or functions provided by those projects formulated to meet the basin needs. Two types of benefits, primary and secondary, have been evaluated. Primary benefits represent the net value of goods or services directly resulting from the project under consideration, less any associated costs incurred in the realization



PROPOSED PLANS OF IMPROVEMENTS
BIG MUDDY RIVER BASIN, ILLINOIS
PLATE 3

TABLE 11
Alternative Plans of Improvement - Reservoirs

	Sediment storage ac-ft	F.C. storage ac-ft	Multiple-purpose storage ac-ft	Total storage ac-ft	Cost ($)[4]
Watershed No. 5					
Galum Creek					
SCS					
5-1	800	2,100		2,900	142,000
5-3A	300	1,600		1,900	140,200
5-4	1,200	3,400		4,600	220,900
5-6	900	3,000		3,900	234,700
5-7	620	2,100		2,720	117,200
5-10	600	1,600		2,200	142,600
5-11	200	800		1,000	73,600
5-12	1,200	3,800		5,000	430,700
Corps		N O N E			
Watershed No. 6					
Upper Beaucoup Creek					
SCS					
6-3*	500	1,600		2,100	191,800
6-4*	300	1,000		1,300	87,400
6-5A*	2,000	6,800	8,200[2]	17,000	839,800
6-7*	400	1,100		1,500	94,500
6-8	400	800		1,200	93,600
6-9	300	800		1,100	117,000
6-10	400	1,100		1,500	136,000
6-11	1,400	4,700		6,100	216,800
6-13	1,400	4,500		5,900	331,700
6-14	500	1,800		2,300	126,600
6-15	400	1,200		1,600	121,800
6-16	300	900		1,200	86,400
6-17	1,400	4,600		6,000	316,600
6-18A	900	2,100	6,600[1]	9,600	1,029,800
Corps					
-34*	4,900	7,200	22,800[3]	34,900	12,229,000

(1) Recreation only.
(2) Low-flow augmentation.
(3) Dual use - recreation and low-flow augmentation.
(4) Project costs include discounted (present-worth) of future (2000 and 2020) recreational time-phasing development where applicable.

*Alternatives for meeting the total or portions of the basin's needs.

	Sediment storage ac-ft	F.C. storage ac-ft	Multiple-purpose storage ac-ft	Total storage ac-ft	Cost ($)[4]
Watershed No. 7					
Crab Orchard Creek					
SCS					
7-6	300	1,000		1,300	102,800
7-7*	600	1,800	6,400[1]	8,800	1,327,700
7-8A*	1,000	2,000	5,550[2]	8,550	640,000
Corps					
-12*	1,500	1,200	6,100[3]	8,800	5,753,000
-16A	1,800	---	19,000[3]	20,800	7,503,400
Watershed No. 8					
Little Muddy River					
SCS					
8-1	300	1,000		1,300	122,500
8-2*	400	1,100		1,500	105,100
8-3*	600	1,800		2,400	151,100
8-4*	600	1,800		2,400	159,800
8-5*	200	600		800	83,200
8-6*	700	2,300		3,000	175,600
8-7*	400	1,300		1,700	173,400
8-8*	600	1,600		2,200	189,000
8-9A	300	800		1,100	95,800
8-10	1,200	4,000	4,200[1]	9,400	1,408,100
Corps					
-35*	7,900	14,500	25,700[3]	48,100	17,215,000
Watershed No. 10					
Hurricane Creek					
SCS					
10-1	700	2,200	11,600[1]	14,500	926,800
Corps		N O N E			
Watershed No. 11					
Lake and Pond Creek					
SCS					
11-2	200	600		800	64,800
11-3	1,000	4,400		5,400	397,400
Corps		N O N E			

TABLE 11
Alternative Plans of Improvement - Reservoirs (cont'd)

	Sediment storage ac-ft	F.C. storage ac-ft	Multiple-purpose storage ac-ft	Total storage ac-ft	Cost ($)(4)
Watershed No. 12					
Middle Fork Creek					
SCS					
12-1*	1,700	5,600	17,000(2)	24,300	2,154,000
12-3	400	800		1,200	148,900
12-4	100	400		500	73,500
12-5A	300	800		1,100	105,900
12-5B	300	1,100		1,400	100,100
12-6A	300	1,500		1,800	151,000
12-7A	500	1,600		2,100	158,800
12-9*	1,200	3,400	4,500(2)	9,100	654,000
12-10*	400	1,300		1,700	175,000
12-11	200	700		900	60,600
12-12A	200	500		700	158,600
12-13	700	2,400		3,100	242,500
Corps					
-7*	2,800	3,700	40,900(3)	47,400	11,854,000
Watershed No. 13					
Gun Creek					
SCS					
13-1	200	600		800	114,800
13-2	200	500		700	110,800
13-3A	400	1,200		1,600	158,700
13-4	200	700		900	171,900
Corps					
		N O N E			

(1) Recreation only.
(2) Low-flow augmentation.
(3) Dual use - recreation and low-flow augmentation.
(4) Project costs include discounted (present-worth) of future (2000 and 2020) recreational time-phasing development where applicable.

*Alternatives for meeting the total or portions of the basin's needs.

	Sediment storage ac-ft	F.C. storage ac-ft	Multiple-purpose storage ac-ft	Total storage ac-ft	Cost ($)(4)
Watershed No. 14					
Upper Big Muddy River					
SCS					
14-1	600	1,900		2,500	204,600
14-2	1,000	3,000		4,000	360,200
14-3	200	600		800	104,500
14-4	200	600		800	115,900
14-5	200	500		700	116,600
14-6	500	1,600		2,100	165,700
14-7	2,800	9,100		11,900	581,200
14-8	200	700		900	117,900
14-9A	200	600		800	123,800
14-10A	300	800		1,100	197,000
14-12	1,800	5,100	18,000(1)	24,900	1,099,700
14-14	500	1,400		1,900	219,600
14-15	800	2,100		2,900	288,700
Corps					
		N O N E			
Watershed No. 15					
Casey Fork Creek					
SCS					
15-1A	600	2,000		2,600	209,400
15-2A	200	600		800	145,700
15-3A	600	1,500		2,100	205,200
15-5	300	1,000		1,300	159,300
15-6	100	100		200	38,700
15-7	100	100		200	40,700
15-8*	1,200	2,900	10,400(2)	14,500	1,511,100
15-9	200	600		800	90,000
15-10	100	300		400	125,300
15-11	400	1,100		1,500	171,900
15-13A	300	1,000		1,300	244,600
15-14	200	500		700	134,700
15-15	200	600		800	127,200
Corps					
-5*	1,800	1,300	14,600(3)	17,700	7,978,000

TABLE 12

Channel Improvements

Big Muddy River Basin

Watersheds	Mains		Laterals & sublaterals	
	Length of improvements (miles)	Installation cost ($)	Length of improvements (miles)	Installation cost ($)
Casey Fork Creek	51.0	666,500	89.2	417,200
Cedar Creek	----	-------	----	-------
Crab Orchard Creek	9.8	203,900	99.0 1/	529,300
Gun Creek	5.9	89,600	45.8	241,200
Hurricane Creek	6.7	117,000	28.1	110,600
Lake and Pond Creeks	28.5	632,000	83.7	475,000
Middle Fork Creek	47.8	1,388,400	162.8	839,300
Upper Big Muddy	44.8	768,500	75.5	686,100
Galum Creek	21.6	381,900	47.8	273,900
Little Muddy River	66.9	1,684,200	141.0	872,000
Upper Beaucoup Creek	66.9	1,167,800	102.7	655,900
Total	349.9	7,099,800	875.6	5,100,500

1/ Area above Crab Orchard Lake.

of benefits. Secondary benefits represent those net increases in the value of goods and services which indirectly result from the project, under conditions expected with the project as compared to those without the project. Primary benefits accruable to the reservoirs include the applicable values for flood control, low-flow augmentation in the interest of water quality or maintenance of base flow, and general recreation. Primary benefits creditable to the channel improvements are the increased value of agricultural enhancement obtained from drainage of wet lands. Secondary benefits may include the indirect monetary returns that add economic inputs helpful to area redevelopment or economic reorientation and that are the direct result of project construction. These area redevelopment benefits are usually divided into two general categories:

employment of unskilled and semi-skilled labor presently on relief, representing savings in umemployment compensation; and

new economic activities and developments that would be attracted to the area as a result of the project. Benefits expected to accrue at varying rates in the future have been discounted to the base year (1970) and distributed as an equivalent uniform annual value over the period of economic analysis. The Federal rate of 3.25 percent was used to discount to present (base) worth.

b. Primary benefits

(1) Flood control. Benefits creditable to the reservoirs include the difference between damages expected to occur in the absence of the reservoirs and those expected even if the reservoirs are constructed, plus increased utilization benefits that will result because of the reservoir system. Flood damages prevented are currently estimated

at 2,010,200 annually. Benefits for increased returns are presently estimated at 1,156,600 annually. Average annual flood control benefits creditable to the reservoirs are estimated at 3,166,800. A breakdown of these benefits, by watershed, is shown in TABLE 13.

(2) Drainage. Channel improvements were designed to provide adequate outlets for drainage systems on the individual farms or groups of farms. Only land acreage afforded some degree of flood flow decapitation and not already drained was considered. Considered also was approximately 350 miles of main outlet ditching and 875 miles of lateral and sub-lateral outlet ditches. Gross benefits measured in increased yields were discounted for delay in attainment and for less than full participation. These benefits were then further reduced to account for the non-project costs associated with drainage improvements. In the course of the benefit evaluation it was recognized that improved drainage channels may contribute to a reduction in depth and duration of flooding, as well as insuring against localized adverse effects attributable to prolonged flood flow discharge by detention reservoirs. However, subject to detailed hydrology and hydraulic routings, it was felt that these flood damage reduction benefits would be incidental and of minor significance as increments to the detention reservoirs. Hence these incidental benefits were not evaluated. Drainage benefits attributable to the channel improvements are estimated at $290,900 annually. A breakdown of these average annual benefits by watershed are shown in TABLE 13.

(3) Low-flow augmentation. Low-flow augmentation for water quality control, or for maintenance of base flow, is provided by the conversion of storage at selected times. All reservoirs except Reservoir No. 12

TABLE 13

BIG MUDDY RIVER BASIN
Flood Control - Drainage Benefits
(Dollars)

WATERSHED	Damage reduction	Changed land use	More intensive land use	Total flood control benefit	Drainage	Total
Casey Fork Creek	232,200	10,300	92,400	344,900	22,600	367,500
Cedar Creek	7,800	---	---	7,800	---	7,800
Crab Orchard Creek	92,300	41,200	55,700	189,200	33,300	222,500
Gun Creek	53,600	2,500	31,700	87,800	13,900	101,700
Hurricane Creek	21,800	4,400	13,200	39,400	6,900	46,300
Lake and Pond Creeks	76,200	11,400	48,400	136,000	27,700	163,700
Middle Fork Creek	319,700	45,200	149,000	513,900	50,700	564,600
Upper Big Muddy River	485,500	25,500	175,000	686,000	32,900	718,900
Galum Creek	136,400	48,700	54,400	239,500	16,200	255,700
Little Muddy River	269,000	28,300	138,700	436,000	52,800	488,800
Upper Beaucoup	315,700	52,800	127,800	496,300	33,900	530,200
TOTAL	2,010,200	270,300	886,300	3,166,800	290,900	3,457,700

in the upper Crab Orchard Creek watershed and No. 16A in the lower Crab Orchard Creek watershed have sufficient storage capability to meet the variable, time-phased target flows established by FWPCA for the selected water quality level. Reservoirs in the upper Crab Orchard Creek Watershed near Marion are limited by site topography and have storage potentials capable of meeting those supplemental water quality needs only to the year 2000. Since tertiary treatment is presently being provided to the discharge effluent from Marion, some form of advance treatment will be required after the year 2000 if adequate quality goals are to be maintained. In the case of the lower portion of Crab Orchard Creek, which flows through the environmental area of Carbondale, maintenance of a minimum base flow is the function provided by Reservoir No. 16A. A base flow equivalent to the target flow established by FWPCA for the maintenance of 3 mg/l DO for 100 percent of the time was selected as a minimum standard. Where low-flow augmentation in the interest of water quality control is provided, benefits are based on the cost of the most likely alternative that local residents would undertake in lieu of the type of service (dilution flows) under consideration for meeting this need. As was established in Section VII, advance waste treatment was selected as the equivalent measure of worth for all load point centers, except West Frankfort where the most likely alternative was to pump the waste effluent to the Big Muddy. The annual cost of meeting these needs was evaluated by FWPCA, using increments of development with the values based on a variable non-Federal interest rate, amortized over a period of 25 years, and converted to a uniform annual series for the period equivalent to the project's economic life, using the Federal rate of 3.25 percent. The use of 5.75 to 6 percent interest rate was selected

to reflect the ability of local interests to obtain Federal grants and loans, dependent upon the type of alternative considered. Average annual benefits attributable to the five reservoirs which provide dilution releases for water quality control are estimated at $701,000 annually. In the case of Reservoir No. 16A, benefits for maintaining a base flow were based on the cost of a single-purpose reservoir. The annual cost of meeting this need was evaluated, using increments of a development with value based on the Federal interest rate of 3.25 percent and an amortization period of 100 years. Benefits for the period of project analyses were converted to uniform annual series by the compound interest method, using the Federal interest rate of 3.25 percent. Average annual benefits attributable to Reservoir No. 16A for maintenance of a minimum base flow is estimated at $220,900 annually. Total low-flow augmentation benefits are estimated at $921,900 annually. A breakdown of these benefits, by watershed, is shown in TABLE 14.

(4) General recreation. Benefits creditable to the reservoirs are dependent upon the land and water surface acres available for related recreational pursuits and the facilities provided. Within the framework of optimum development the recreational benefits were limited by the capital investment that is anticipated to be expended in providing the initial facilities. The time-phasing of development was based on the size of the reservoir and its proximity to the main growth centers of the basin. The first costs for recreational development were based on analyses of existing reservoirs and are representative of an initial level of development reasonable of attainment and acceptable to the State of Illinois for this stage of coordinating planning effort. However,

TABLE 14

Low-flow augmentation benefits

	Watershed	Benefit	Purpose and basis of evaluation
6.	Upper Beaucoup Creek	$107,200	Water Quality Control; advance waste treatment
7.	a. Upper Crab Orchard Crk	149,600	Water Quality Control; advance waste treatment
	b. Lower Crab Orchard Crk	220,900	Social well-being; single-purpose reservoir
8.	Little Muddy River	172,000	Water Quality Control; advance waste treatment
12.	Middle Fork Creek	59,300	Water Quality Control; pipeline effluent transfer
15.	Casey Fork Creek	212,900	Water Quality Control; advance-waste treatment
	Total	$921,900	

no firm commitment has been received as to the extent and timing of future non-Federal investments. Thus until a definite program with amount and phasing of investment is established, no evaluation of the future recreational benefits could be included in the project's analyses. It is anticipated that the State and other non-Federal interests will assume responsibility for future incremental development in order to realize the full recreational potential of every reservoir. These future incremental stages of development will require statements indicating willingness to cost-share pursuant to PL 89-72 in advance of construction for this use. Thus, the future investments and accruing benefits would be incremental to the initial development as presently formulated. However, to insure selection of the optimum plan in the maximization process, a phasing of future user-day attendance reasonable of attainment was evaluated for each of the reservoirs considered for recreational development. The results are shown in TABLE 15 and range from 2,968,000 to some 5,044,000 for 1980 and 2020, respectively. The projects shown were selected after successive joint screening by the two construction agencies as alternative to meeting the needs within the basin. Based on a unit value of $1.00 per user-day attendance, total optimum recreational benefits are estimated at $6,124,100 annually, of which approximately 49 percent, or $2,968,000 annually, is creditable to initial developments.

TABLE 15

Time-phasing of net recreational needs
(user-day attendance)

Reservoir	Optimum	Initial (1980)	2000	2020
Cedar Crk. System	424,100	248,000	352,900	424,100
C-35	1,360,000	680,000	950,000	1,100,000
C-7	1,110,000	490,000	750,000	860,000
C-34	900,000	400,000	680,000	720,000
12-1	680,000	270,000	410,000	540,000
C-5	300,000	260,000	300,000	300,000
14-12	300,000	100,000	150,000	200,000
8-10	250,000	100,000	150,000	200,000
10-1	250,000	100,000	200,000	200,000
C-16A	200,000	150,000	200,000	200,000
6-18A	200,000	50,000	100,000	150,000
C-12 (7-7)	150,000	120,000	150,000	150,000
TOTAL	6,124,100	2,968,000	4,292,900	5,044,100
Projected net need		3,400,000	4,800,000	5,400,000
Percent attainment		87.3%	89.4%	93.4%
Percent: development to optimum		48.5%	70.1%	82.4%

c. Secondary benefits.

(1) Benefits attributable to relief of unemployment. Benefits attributable to relief of unemployment during the construction period and operation and maintenance of the project are based on use of labor in counties suffering from an unemployment rate in excess of 6 percent. This percentage has been defined by the Department of Labor as a classification limit for unemployment above which it becomes representative of an adverse economic situation, out of phase and below the nation's committed goals. Areas so designated by the Department of Labor as having a rate in excess of 6 percent are classified as suffering from substantial unemployment or underemployment, and as such become eligible for assistance under the Area Redevelopment Act of 1961, as amended. Hence, utilization of the area's labor resources that are unemployed or underemployed are valid benefits which are creditable to the project as provided by Senate Document No. 97. None of the basin's five counties are now (June 1968) classified as having substantial unemployment rates. This is a marked improvement in the economic situation, and is indicative of the reversal of past trends, and reflective of the success of governmental and local action programs. Because of this change in classification and economic situation, and is indicative of the reversal of past trends, and reflective of the success of governmental and local action programs. Because of this change in classification and economic situation, benefits in this particular category have not been evaluated since they would not be applicable to any of the projects under consideration.

(2) Benefits attributable to local economic development. The proposed reservoirs will provide benefits based on their permanent contribution to the reorientation of the area's economic structure. Construction of reservoirs has introduced a new and important factor, tourism and recreation, into the economy of many areas. This has been a basic concept in the State's planning efforts to upgrade southern Illinois. This long-

range benefit will accrue to all counties and be predicated on the provision of water surface acres with recreational potential sufficient to attract developments. Evaluations of these benefits was divided into two parts:

a. The wages that would accrue to the local economy from the money spent by the recreationists at the reservoirs.

b. The value of the recreation business as a stimulus to the total local economy in terms of new jobs and special services. Value of the wages that would accrue to the local economy from the money spent by the recreationists at the reservoirs were based on information and study data contained in the paper entitled, "Private and Public Provision of Outdoor Recreation Opportunity," printed in the ORRRC Study Report No. 24. This paper estimated expenditures by visitors to various types of public recreational areas, identifying the monetary outlay spent in or near the project area. A division of the money spent, according to the operational requirements of the recipient, was established and the wages paid for hired labor was determined. The impact that reservoirs have on an area's economic structure was evaluated, based on pilot studies made in areas where large bodies of water were relatively unavailable before the coming of man-made reservoirs. Previous studies for areas similar to this basin indicated that the reservoir projects acted as catalysts for the process of attracting outside dollars to the areas and putting them to work in an economically productive manner. The necessary capital, for the most part, comes from outside the local communities and thus starts the process of growth which local leaders of the basin have long sought. The economic impact of a new reservoir makes itself felt locally in six phases: land speculation, construction of new developments, recreational services, industries' effects

from the purchase of goods and services in the local areas, shift in economic structures of near-by towns (i.e., shifting from a single or restricted economic base to one that is diversified and provides the needs of visitors who expect services and goods equal to urban standards), and homesite development and construction, where newcomers, individuals, or real estate developers begin to build homes and subdivisions around the lake. Evaluation of this worth was based on past study data relating growth to bank deposits which were reflective of the inflow and the resultant effects of outside capital, both personal and public, on the local economic structure. Using an annual growth rate factor representative of past pilot studies, the net economic effect was identified. In determining the value of this growth, the development due to the six reservoirs was limited by a time factor of 10 years. This limitation was predicated on two factors: first, that Rend Lake, being the center of the recreational tourism impact on the basin, would be the prime factor in the total redevelopment; and second, that at some point in time, the economic development due to the recreational aspects would start a second round of spending and expenditures that would not be strictly applicable to the reservoirs and would be somewhat secondary in nature. Total benefits attributable to the reservoir's effect on the area's economic structure amounts to $5,273,400 annually. Because these benefits are directly related to the recreationist and his economic impact on the area, these benefits are creditable only to those reservoirs jointly selected for recreational development. The breakdown of the secondary benefits and the allocation to each applicable project are shown in TABLE 16 .

Table 16

Summation of area reorientation benefits
Local economic development

Reservoir	Accruing wages	Local economic impact	Total benefits
Cedar Creek	$ 141,400	$ 302,200	$ 443,600
C-35	387,600	828,500	1,216,100
C-7	279,300	597,200	876,500
C-34	216,600	463,500	680,100
12-1	153,900	328,800	482,700
C-5	148,200	316,500	464,700
14-12	57,000	122,200	179,200
8-10	57,000	122,200	179,200
10-1	57,000	122,200	179,200
C-16A	85,500	182,500	268,000
6-18A	28,500	61,000	89,500
C-12 (7-7)	63,400	146,200	214,600
TOTAL	$1,680,400	$3,593,000	$5,273,400

d. Total benefits. Total average annual benefits creditable to the potential projects in the various watersheds are estimated at $11,921,600 and are detailed in TABLE 17.

45. SELECTION OF BASE PLAN

a. Criteria. Selection of the best plan of development was based on a comparative analysis between those projects in each watershed that were formulated to meet all or portions of the same needs. Supplemental to these projects would be the recommended single-purpose flood control developments and dual flood control and recreation projects that complete the structural system required to satisfy the primary and secondary needs. The comparative analysis involved an evaluation of the level of investment relative to creditable beneficial returns and the degree of achievement in meeting the basin's needs. In all cases the engineering and economical feasibility of each project (s) had been established by the sponsoring agency. Hence, in accordance with Section V C 2, Senate Document No. 97, the scope of development was formulated to provide the maximum net benefits.

b. Rationale. The optimum scale of development is that economic point at which the net benefits (excess of benefits over costs) are at a maximum. Net benefits are maximized if the scale of development is extended to the point where the benefits added by the cost increment, be it project or separable segment of a project, are equal to the cost of adding that increment. Each competitive reservoir was analyzed on an individual basis to insure the "best use" of that development by obtaining the greatest excess of benefits over costs. The analysis was based on a functional assignment relative to the storage provided and the needs of the watershed and basin as a whole. The evaluation involved alternately rededicating and comparing the worth of each storage increment selected for single or dual

TABLE 17
Average Annual Benefits (Dollars)

Watershed	Flood damage reduction	Change land use	More intensified land use	Total flood control	Drainage benefits	L.F.augment-ation benefits	Recreation benefits	Total primary benefits	Accuring wages *	Local economic benefits*	Total secondary benefits*	Total primary and secondary benefits
No. 5 Galum Creek	136,400	48,700	54,400	239,500	16,200	---	---	255,700	---	---	---	255,700
No. 6 Upper Beaucoup Creek	315,700	52,800	127,800	496,300	33,900	107,200	450,000	1,087,400	245,100	524,500	769,600	1,857,000
No. 7 Crab Orchard Creek	92,300	41,200	55,700	189,200	33,300	370,500	270,000	863,000	153,900	328,700	482,600	1,345,600
No. 8 Little Muddy River	269,000	28,300	138,700	436,000	52,800	172,000	780,000	1,440,800	444,600	950,700	1,395,300	2,836,100
No.10 Hurricane Creek	21,800	4,400	13,200	39,400	6,900	---	100,000	146,300	57,000	122,200	179,200	325,500
No.11 Lake and Pond Creeks	76,200	11,400	48,400	136,000	27,700	---	---	163,700	---	---	---	163,700
No.12 Middle Fork Creek	319,700	45,200	149,000	513,900	50,700	59,300	760,000	1,383,900	433,200	926,000	1,359,200	2,743,100
No.13 Gun Creek	53,600	2,500	31,700	87,800	13,900	---	---	101,700	---	---	---	101,700
No.14 Upper Big Muddy River	485,500	25,500	175,000	686,000	32,900	---	100,000	818,900	57,000	122,200	179,200	998,100
No.15 Casey Fork Creek	232,200	10,300	92,400	334,900	22,600	212,900	260,000	830,400	148,200	316,500	464,700	1,295,100
Total	2,002,400	270,300	886,300	3,159,000	290,900	921,900	2,720,000	7,091,800	1,539,000	3,290,800	4,829,800	11,921,600

* These types of benefits creditable to projects developed specfically for general recreation

use. Benefits and costs were expressed on comparable quantitative economic terms to the fullest extent possible. Since each purpose varies in its competitiveness, when expressed in economic terms only, an analytical constraint was imposed on the comparative analysis. This constraint restricted selection of the best plan of improvement to a maximization of net benefits, based on primary benefits only. Inclusion of secondary benefits would tend to over-emphasize recreational development to the detriment of the other needs and possibly prevent total achievement of the study's objectives.

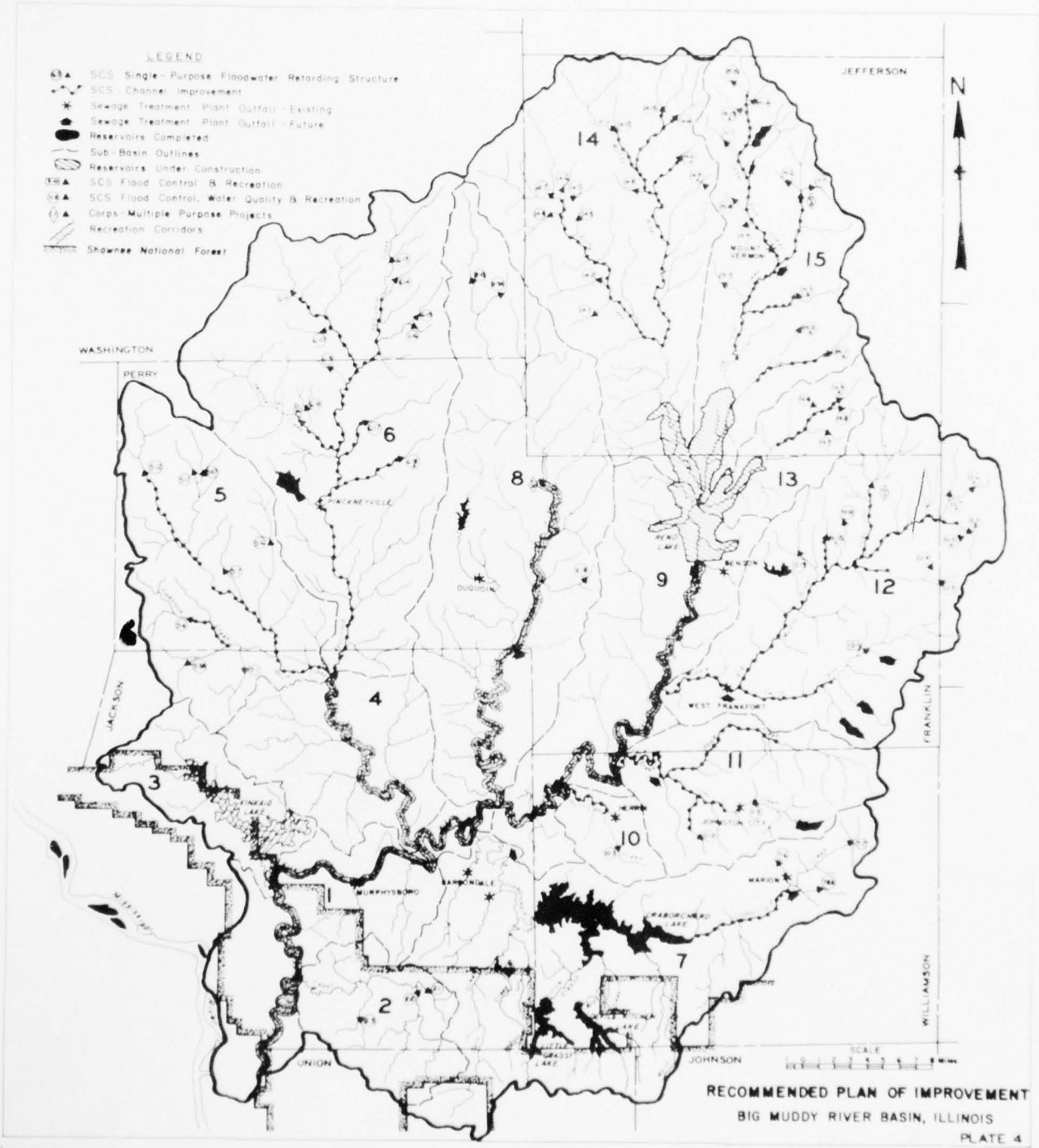
c. Economic maximization. The comparative analysis between the two alternative plans involved only 5 of the 10 watersheds in which developments were recommended: No. 6, Upper Beaucoup Creek; No. 7, Crab Orchard Creek (upper portion only); No. 8, Little Muddy River; No. 12, Middle Fork; and No. 15, Casey Fork. Involved were some 22 reservoirs with varying usage, costs, and benefits, and 207.9 miles of drainage improvements as a last-added increment. Maximization resulted in reducing the number of reservoirs to seven and, in some cases reformulated and reallocated the storage functions of these projects. Also, the 207.9 miles of channel were deferred for a higher use. Shown in Tables 18 through 22 are the results of the maximization analyses.

d. Summary. The base plan as formulated, consists of 71 reservoirs in the 10 watersheds, together with 1,017.6 miles of main, lateral and sublateral drainage channel improvements. The recommended base plan is shown on PLATE 4. Five of the six reservoirs recommended by the Corps of Engineers provided the maximum net benefits and were retained in the base plan. The remainder of the modified system's projects proved to be the most effective in obtaining the greatest excess of benefits over costs, and were retained in the base plan for construction by Soil Conservation Service under Public Law 566. A summary of the system's projects, costs, and benefits are shown in TABLE 23. Also shown are the applicable benefit-cost ratios for individual watersheds and the basin as a whole. Computation of the average annual costs included: interest and amortization on a sinking fund basis of the construction cost, annual operation and maintenance charges, and applicable replacement costs. All reservoirs were estimated to have a 100-year economic life. Interest and amortization were computed at the 3.25 percent Federal rate.

TABLE 18
Maximization for Watershed #6 - Upper Beaucoup Creek
Reservoirs only

	Alternatives						Reservoirs Combination		
	A-1	A-2	A-3	A-4	A-5	A-6	C-1	C-2	C-3
	Corps res 34 w/FC	Corps res 34 w/o FC	SCS res #6-3	SCS res #6-4	SCS res #6-5A	SCS res #6-7	A-3 + A-4 + A-5 + A-6	A-1	A-2
A. Benefits ($)									
1. Primary									
(a) Flood control	148,100	---	21,400	12,800	92,700	15,700	142,600	148,100	---
(b) Water quality	107,200	107,200	---	---	107,200	---	107,200	107,200	107,200
(c) Recreation	487,700	519,200	---	---	---	---	---	487,700	519,200
Subtotal	743,000	626,400	21,400	12,800	199,900	15,700	249,800	743,000	626,400
2. Secondary Local economic developments	680,100	680,100	---	---	---	---	---	680,100	680,100
3. Total accumulative benefits	1,423,100	1,306,500	21,400	12,800	199,900	15,700	249,800	1,423,100	1,306,500
B. Costs ($)									
1. Project costs	12,229,000	12,386,000	191,800	87,400	839,800	94,500	1,213,500	12,229,000	12,386,000
2. Annual charges									
(a) Interest & amortization	414,300	419,600	6,500	3,000	28,500	3,200	41,200	414,300	419,600
(b) Operation & maintenance	134,000	140,300	400	200	24,300	200	25,100	134,000	140,300
(c) Total	548,300	559,900	6,900	3,200	52,800	3,400	66,300	548,300	559,900
C. Excess of benefits over costs ($)									
1. Primary benefits	194,700	66,500	14,500	9,600	147,100	12,300	183,500	194,700 *	66,500
2. Primary & secondary	874,800	746,600	14,500	9,600	147,100	12,300	183,500	808,500	680,300

* Best combination of reservoirs to meet that portion of the local area and basin needs within the watershed. Would be supplemental to the remaining system.


LEGEND
SCS Single-Purpose Floodwater Retarding Structure
SCS Channel Improvement
Sewage Treatment Plant Outfall - Existing
Sewage Treatment Plant Outfall - Future
Reservoirs Completed
Sub-Basin Outlines
Reservoirs Under Construction
SCS Flood Control & Recreation
SCS Flood Control, Water Quality & Recreation
Corps-Multiple Purpose Projects
Recreation Corridors
Shawnee National Forest
N
JEFFERSON
WASHINGTON
PERRY
JACKSON
FRANKLIN
WILLIAMSON
UNION
JOHNSON
1
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14
15
SCALE
RECOMMENDED PLAN OF IMPROVEMENT
BIG MUDDY RIVER BASIN, ILLINOIS
PLATE 4

TABLE 19
Maximization for Watershed #7 - Upper Crab Orchard Creek
Reservoirs only

	Alternatives						Reservoirs Combination		
	A-1	A-2	A-3	A-4	A-5	A-6	C-1	C-2	C-3
	Corps res 12 w/FC	SCS res #7-6	SCS res #7-7	SCS res #7-7	SCS res #7-8A	SCS res #7-8A	A-2 + A-3 + A-5	A-1 + A-2 + A-6	A-2 + A-4 + A-6
A. Benefits ($)									
1. Primary									
(a) Flood control	62,400	36,100	62,400	62,400	65,700	65,700	164,200	164,200	164,200
(b) Water quality	141,000	---	---	141,000	141,000	---	141,000	141,000	141,000
(c) Recreation	130,500	---	130,500	130,500	---	---	130,500	130,500	130,500
Subtotal	333,900	36,100	192,900	333,900	206,700	65,700	435,700	435,700	435,700
2. Secondary Local economic development	214,600	---	214,600	214,600	---	---	214,600	214,600	214,600
3. Total accumulative benefits	548,500	36,100	407,500	548,500	206,700	65,700	650,300	650,300	650,300
B. Costs ($)									
1. Project costs	5,753,000	102,800	1,327,000	1,327,000	640,000	148,600	2,069,800	6,004,400	1,578,400
2. Annual charges									
(a) Interest & amortization	194,900	3,500	45,000	45,000	21,700	5,000	70,200	203,400	53,500
(b) Operation & maintenance	53,100	400	72,500	82,500	23,600	400	96,500	53,900	83,300
(c) Total	248,000	3,900	117,500	127,500	45,300	5,400	166,700	257,300	136,800
C. Excess of benefits over costs ($)									
1. Primary benefits	85,900	32,200	75,400	206,400	161,400	60,300	269,000	178,400	298,900 *
2. Primary & secondary	300,500	32,200	290,000	421,000	161,400	60,300	483,600	393,000	513,500

* Best combination of reservoirs to meet that portion of the local area and basin needs within the watershed. Would be supplemental to the remaining system.

TABLE 20
Maximization for Watershed #8 - Little Muddy River
Reservoirs only

	Alternatives				Reservoirs Combination		
	A-1	A-2	A-3	A-4	C-1	C-2	C-3
	Corps res 35 w/FC	Corps res 35 w/o FC	SCS res Group 1[a]	SCS res Group 2[b]	A-3 + A-4	A-1 + A-3	A-2 + A-3
A. Benefits ($)							
1. Primary							
(a) Flood control	318,000	---	31,200	356,800	388,000	349,200	31,200
(b) Water quality	172,000	172,000	---	---	---	172,000	172,000
(c) Recreation	801,500	876,900	126,200	---	126,200	927,700	1,003,100
Subtotal	1,291,500	1,048,900	157,400	356,800	514,200	1,448,900	1,206,300
2. Secondary Local economic developments	1,216,100	1,216,100	179,200	---	---	1,395,300	1,395,300
3. Total accumulative benefits	2,507,600	2,265,000	336,600	356,800	514,200	2,844,200	2,601,600
B. Costs ($)							
1. Project costs	17,215,000	17,538,000	1,626,400	1,037,200	2,663,600	18,841,400	19,164,400
2. Annual charges							
(a) Interest & amortization	583,200	594,200	55,200	35,100	90,300	638,400	649,400
(b) Operation & maintenance	198,800	213,900	72,300	2,000	74,300	271,100	286,200
(c) Total	782,000	808,100	127,500	37,100	164,600	909,500	935,600
C. Excess of benefits over costs ($)							
1. Primary benefits	509,500	240,800	29,900	319,700	349,600	539,400*	270,700
2. Primary & secondary	1,725,600	1,456,900	209,100	319,700	349,600	1,934,700	1,666,000

* Best combination of reservoirs to meet the total area and basin needs within the watershed. Represents the optimum plan of development for the total watershed.

a. Group 1 = 8-1B, 8-9A, 8-10
b. Group 2 = 8-2, 8-3, 8-4, 8-5, 8-6, 8-7, 8-8

TABLE 21
Maximization for Watershed #12 - Middle Fork
Reservoirs only

	Alternatives							Reservoirs Combination			
	A-1	A-2	A-3	A-4	A-5	A-6	A-7	C-1	C-2	C-3	C-4
	Corps res 7 w/o FC	Corps res 7 w/FC	SCS res #12-1	SCS res #12-9	SCS res #12-10	SCS res #12-1	SCS res #12-1	A-1 + A-4 + A-5	A-1 + A-7	A-2 + A-6	A-1 + A-6
A. Benefits ($)											
1. Primary											
(a) Flood Control	---	112,600	128,900	76,700	29,000	128,900	128,900	234,600	128,900	241,500	128,900
(b) Water Quality	59,300	59,300	46,800	12,500	---	---	---	59,300	59,300	59,300	59,300
(c) Recreation	624,800	601,300	126,200	---	---	341,700	---	126,200	624,800	943,000	966,500
Subtotal	684,100	773,200	301,900	89,200	29,000	470,600	128,900	420,100	813,000	1,243,800	1,154,700
2. Secondary Local economic developments	876,500	876,500	482,700	---	---	482,700	482,700	482,700	1,359,200	1,359,200	1,359,200
3. Total accumulative benefits	1,560,600	1,649,700	784,600	89,200	29,000	953,300	611,600	902,800	2,172,200	2,603,000	2,513,900
B. Costs ($)											
1. Project costs	11,945,000	11,854,000	2,154,000	654,000	175,000	2,977,000	477,300	2,983,000	12,422,300	14,831,000	14,922,000
2. Annual charges											
(a) Interest & amoritization	404,700	401,600	73,000	22,200	5,900	100,900	16,200	101,100	420,900	502,500	505,600
(b) Operation & maintenance	152,500	147,800	82,800	23,600	600	115,900	900	107,000	153,400	263,700	268,400
(c) Total	557,200	549,400	155,800	45,800	6,500	216,800	17,100	208,100	574,300	766,200	774,000
C. Excess of benefits over costs ($)											
1. Primary benefits	126,900	223,800	146,100	43,400	22,500	253,800	111,800	212,000	238,700	477,600*	380,700
2. Primary & secondary	1,003,400	1,100,300	628,800	43,400	22,500	736,500	594,500	694,700	1,597,900	1,836,800	1,739,900

* Best combination of reservoirs to meet that portion of the local area and basin needs within the watershed. Would be supplemental to the remaining system.

TABLE 22
Maximization for Watershed #15 - Casey Fork Creek
Reservoirs only

	Alternatives		
	A-1	A-2	A-3
	Corps res 5 w/o FC	Corps res 5 w/FC	SCS res #15-8
A. Benefits ($)			
1. Primary			
(a) Flood Control	---	72,200	72,200
(b) Water Quality	212,900	212,900	212,900
(c) Recreation	292,100	274,300	---
Subtotal	505,000	559,400	285,100
2. Secondary Local economic developments	464,700	464,700	---
3. Total accumulative benefits	969,700	1,024,100	285,100
B. Costs ($)			
1. Project costs	8,075,000	7,978,000	1,511,100
2. Annual charges			
(a) Interest & amortization	273,600	270,300	51,200
(b) Operation & maintenance	82,900	79,400	25,100
(c) Total	356,500	349,700	76,300
C. Excess of benefits over costs ($)			
1. Primary benefits	148,500	209,700 *	208,800
2. Primary & secondary	613,200	674,400	208,800

* Reservoir to meet that portion of the local area and basin needs within the watershed. Would be supplemental to the remaining system.

TABLE 23
Summary - recommended base plan

Watershed	Projects: No. of res.	Projects: No. of channels	Costs: Total first cost	Costs: Annual charges (financial)	Total benefits	B/C ratio	Reservoirs recommended for development
			$	$	$		
No. 5 Galum Creek							
Corps	---	---	---	---	---		---
SCS	8	69.4	2,157,700	84,200	255,700	3.0	Nos. 5-1,3A,4,6, 7,10,11,12
TOTALS	8	69.4	$ 2,157,700	$ 84,200	$ 255,700	3.0	
No. 6 Upper Beaucoup							
Corps	1	---	11,900,000	534,000	1,347,600	2.5	C-34
SCS	10	169.6	4,272,600	220,000	484,600	2.2	Nos. 6-8,9,10,11, 13,14,15,16,17,18A
TOTALS	11	169.6	$16,172,600	$ 754,000	$ 1,857,000	2.5	
No. 7 Crab Orchard							
Corps	1	---	7,420,000	317,000	618,900	2.0	C-16A
SCS	3	108.8	2,311,600	167,000	726,700	4.4	Nos. 7-6,7,8A
TOTALS	4	108.8	$ 9,731,600	$ 484,000	$ 1,345,600	2.8	
No. 8 Little Muddy							
Corps	1	---	16,700,000	766,000	2,429,100	3.2	C-35
SCS	3	---	1,498,400	117,800	310,600	2.6	Nos. 8-1B,9A,10
TOTALS	4	---	$18,198,400	$ 883,800	$ 2,783,300	2.8	
No. 10 Hurricane							
Corps	---	---	---	---	---		---
SCS	1	34.8	987,600	73,800	325,500	4.4	No. 10-1
TOTALS	1	34.8	$ 987,600	$ 73,800	$ 325,500	4.4	
No. 11 Lake & Pond							
Corps	---	---	---	---	---		---
SCS	2	112.2	1,569,200	66,500	163,700	2.5	Nos. 11-2,3
TOTALS	2	112.2	$ 1,569,200	$ 66,500	$ 163,700	2.5	

TABLE 23
Summary - recommended base plan
(continued)

Watershed	Projects: No. of res.	Projects: No. of channels	Costs: Total first costs	Costs: Annual charges (financial)	Total benefits	B/C ratio	Reservoirs recommended for development
			$	$	$		
No. 12 Middle Fork							
Corps	1	---	11,400,000	530,000	1,551,700	2.9	C-7
SCS	10	210.6	6,087,600	335,900	1,181,100	3.5	Nos. 12-1,2,3,4,5A,
TOTALS	11	210.6	$ 17,487,600	$ 865,900	$ 2,743,100	3.1	5B,6A,7A,11,12A,13
No. 13 Gun Creek							
Corps	---	---	---	---	---		---
SCS	4	51.7	887,000	35,000	101,700	2.9	Nos. 13-1,2,3A,4
	4	51.7	$ 887,000	$ 35,000	$ 101,700	2.9	
No. 14 Upper Big Muddy							
Corps	---	---	---	---	---		---
SCS	13	120.3	5,022,100	256,800	998,100	3.9	Nos. 14-1,2,3,4,5,6,
TOTALS	13	120.3	$ 5,022,100	$ 256,800	$ 998,100	3.9	7,8,9A,10A,12,14,15
No. 15 Casey Fork							
Corps	1	---	7,900,000	351,000	1,018,000	2.9	C-5
SCS	12	140.2	2,776,400	111,100	277,100	2.5	Nos. 15-1A,2A,3A,5,6,7,
TOTALS	13	140.2	$ 10,676,400	$ 462,100	$ 1,295,100	2.8	9,10,11,13A,14,15
TOTALS FOR BASIN							
Corps	5		55,320,000	2,498,000	6,965,300	2.8	
SCS	66	1,017.6	27,570,200	1,468,100	4,824,800	3.2	
TOTALS	71	1,017.6	$ 82,890,200	$ 3,966,100	$ 11,868,800	3.0	

SECTION X - MODIFICATION TO THE BASE PLAN

46. GENERAL

While the base plan would satisfy most of the water and land-related needs, it represented an economic evaluation involving only measurable primary and secondary benefits. Although comprehensive in scope, it did not include provisions for specific socio-environmental services. These intangibles are of sufficient import to warrant consideration for modifying, or extending, the base plan. In particular, planning agencies of the State and local counties had advocated the need to establish river recreational corridors and rehabilitate strip mine areas. Before any additional formulation was initiated, the base plan was analyzed to determine what particular products or services it provides that could contribute to an effective action program. Low-flow augmentation would enhance the recreational value of the waterway and the land contiguous to the stream. It would also provide opportunities for development of different types of water-related recreational pursuits not now readily available. Installation of drainage improvements would have a comparatively minor, but adverse, effect on flood characteristics on the main stem below Rend Lake. A joint hydraulic analysis undertaken by the construction agencies indicated a general increase in flood heights for the more frequent floods, with comparatively very little effect for the rarer floods. Shown in TABLE 24 are the results of the hydraulic routings.

TABLE 24

HYDRAULIC PROFILE MODIFICATIONS DUE TO CHANNEL IMPROVEMENTS (1)

Location	Elevations (m.s.l.) for selected flood frequencies					
	2-year	3-year	5-year	10-year	20-year	50-year
Middle Fork						
Existing - condition	375.3	377.9	380.8	384.8	388.3	392.5
SCS - - -	378.5	380.8	383.4	386.6	389.8	393.0
Diff.	+3.2	+2.9	+2.6	+1.8	+1.5	+0.5
Hurricane Creek						
Existing - condition	371.5	374.6	378.2	381.8	385.0	389.3
SCS - - -	371.0	374.3	377.5	381.1	384.1	387.6
Diff.	-0.5	-0.3	-0.7	-0.7	-0.9	-1.7
Crab Orchard Creek						
Existing - condition	367.5	370.7	373.8	376.9	379.7	382.7
SCS - - -	370.4	373.3	375.9	378.4	380.7	383.3
Diff.	+2.9	+2.6	+2.1	+1.5	+1.0	+0.6
Murphysboro						
Existing - condition	364.3	367.0	369.3	371.4	372.9	374.5
SCS - - -	367.9	369.6	371.0	372.5	373.8	375.0
Diff.	+3.6	+2.6	+1.7	+1.1	+0.9	+0.5

(1) Based on comparison of all-year flood frequency profiles for existing conditions with Rend Lake and the Crab Orchard reservoir complex in place and modified caused by SCS reservoir structures and channel improvements. Profiles reflect coincidental flooding from the Mississippi River.

47. RIVER RECREATIONAL CORRIDOR

a. Plan formulation. Establishment of recreational corridors has been identified as input considerations for the main stem of the Big Muddy River, Little Muddy River, and Beaucoup Creek. All three are suitable for development as recreational corridors, since the low-flow characteristics of the major portions of the streams will be augmented by Corps reservoirs: Rend Lake on the main stem; reservoir #35 located on the Little Muddy east of DuQuoin; and reservoir #34, located above Pinckneyville in the Upper Beaucoup watershed. Consequently, these reaches will provide an enhanced base for stream-related recreation, and special attention was given to the establishment of river recreational corridors in each of these areas. Formulation was based on a multiple-use concept providing: (1) a greenbelt to preserve the natural ecology that the residents need to insure their social well being; (2) the basis for preserving the environmental aspects of wildlife habitat required to offset future losses that will be incurred as the basin grows, and; (3) a base for stream-oriented recreation. To create such a managed environment, three particular facets had to be considered: the waterway itself, the geophysical aspects of the lands which border the stream, and the type of usage compatable with the stated objective. Essentially, the objectives of management would be the development of multi-use areas that are useful for specific recreational activities, aesthetic enjoyment, wildlife habitat, and the preservation and development of other natural resources, particularly the archaeological and historical artifacts. Waterway considerations would involve the quantity and quality of stream flow and the associated flora and fauna of the contiguous land.

Land management would seek a controlled intermix of agricultural development, pastures, timber, and specific cover and vegetation useful for the preservation and enhancement of the environment. The soils in the area lend themselves to this type of intermix, belonging to the Belknap-Bonnie-Karnak classification. The land has a low permeability rate with high seasonal water tables. It is slow to dry out, slippery when wet, and hard and rough when dry. While the vegetation is comparatively easily damaged when wet, the soil supports a variety of bottom land hardwood tree species native to the area.

b. Development requirements. To successfully achieve the stated objectives, it is necessary to control land on either side of the watercourse and have adequate length to assure a significant base for good management practices. Basic land management would be dedicated to the preservation of the natural environment and enhancement of wildlife habitat. Interspaced would be sites developed for specific stream-oriented general recreational opportunities. In general, the corridor would be a mix of public and private ownership, with restricted-use easements obtained on the acreage that is retained in private ownership. Dedication of a strip of land 1,000 feet in depth from the highbank on both sides of the stream is sufficient to provide a minimal working acreage for management and action programs. Three specific corridors would be established. The first corridor would extend some 103 miles along the main stem of the Big Muddy from the Rend Lake Dam downstream to the stream's confluence with the Mississippi River. A second corridor, some 47 miles in length, would be established below the Corp's reservoir #35 on the Little Muddy to its confluence with

the Big Muddy. A third corridor, 28 miles in length, would be created in the lower portion of the Beaucoup Creek extending from the confluence of Galum Creek to the Big Muddy River. Initial development of four specific sites for general recreational opportunities would be restricted to only the corridor on the main stem of the Big Muddy River. The other two corridors would initially be managed as a greenbelt, with emphasis on development of wildlife habitat. Specific landscaping with adequate buffer zones would be required to insure separation of recreational development from the remainder of the main stem corridor that would be retained in the natural but controlled environment. The recreational facilities provided should be developed in a primitive park setting and offer selected opportunities for both day and overnight usage. The first recreational area would be located near river mile 87 and be incorporated in the acreage controlled by the West Frankfort Park District, which includes the communities of West Frankfort and the village of Orient. The second site would be developed near the community of Hurst at river mile 64, where a good site with proper environment has been under consideration for park development. The third site would be located at approximately river mile 35 and should be planned in conjunction with the existing Murphysboro park adjoining the stream. The fourth area would be more than just a site development; rather, it would be an extensive park and recreational development strip extending from river mile 27 to the confluence of the Big Muddy and Mississippi Rivers. Contributing to the uniqueness of this particular area is the fact that these acreages generally lie within the holdings of the Shawnee National Forest and, in particular, in an area where the Oakwood Bottoms-Green Tree Reservoir

is located. In addition, the proposed Mississippi River linear recreational corridor, the Great River Road will traverse this same area. Because the forest contributes a much larger environmental support area, it is recommended that development of this area be integrated into the Shawnee National Forest recreational plan. Each of the recreational sites located on both sides of the waterway should have river frontage at least 5 miles in length, with the acreage purchased totally in fee. Development of these recreational areas would extend to both sides of the river, with the recreational facilities concentrated in the middle one-mile zone. It is in this area that such recreational pursuits as camping, bank fishing, picnicking, boat launching and possible swimming beaches would be provided. In addition, buffer zones two miles in length would be planned on either side of this center zone, separating those facilities from the rest of the recreational corridor and at the same time providing a basis for development of day-use activities. These day-use activities would include hiking trails, horseback riding trails, and other related nature-oriented pursuits. In addition to these four general areas, special attempts should be undertaken to purchase, in fee, acreages that contain unique ecological and environmental aspects or any archaeological findings worthy of preservation and which could serve as a tourist attraction. Location of the 3 corridors are shown on PLATE 4.

c. Implementation. In establishing these recreational corridors, the counties will face the possibility of a potential reduction in the land assessments which serve as their tax base. To partially offset this potential loss, it is felt that the ownership of these land portions should vary, depending upon the specific use of the reach of stream involved. As has been indicated, all lands that will be developed for recreational opportunities should be bought in fee. This applies to those acreages required for the

preservation of archaeological artifacts or special natural environment. The rest of the land can be controlled through the use of special easements that are restrictive in nature, but at the same time afford the owner a special inducement to insure participation. A decision will have to be made by the basin residents whether all of the recreational corridor acreage should be considered for total involvement in the recreational corridors. The option of zoning these lands for open-space usage is an attractive alternative to total purchase in fee, or use of restrictive easements. Zoning for open-space usage will permit certain acreage to remain or be developed for agricultural production. However, these can be complemented or supplemented by the use of scenic easements and special, but variable, reduced tax rates to control and develop a suitable environment that would include the type of agricultural production. Easements that specify the type, and amount, of the cultural work undertaken by the landowner would permit the owner to receive full value from any products harvested from the land. The harvesting be it field crop, pasture, or timber would be governed by a management plan and would have to be compatable and be subject to the primary-use requirements of that reach of stream.

Care should be taken to insure that the land-use planning is restrictive in nature and, at best, the agricultural lands should be interspersed throughout the various length of recreational corridor. To enhance the environmental aspects of these corridors, planting should be concentrated in selected types of timber and vegetative cover. Manipulation of the vegetation will affect the wildlife, recognizing that wildlife is not managed; it is the habitat which is managed. Trees species, particularly of the nut type, are to be encouraged and would include such species as black walnut,

pin oak, various ash species, with cottonwood as a possible supplement due to the flooding characteristics of the bottomlands. Planting of early spring flowering shrubs should also be encouraged, particularly dogwood and red bud. This, together with selected grasses, should provide adequate ground cover and protection against the soils' erodibility.

48. INCIDENTAL BENEFITS

Two important, but intangible, benefits will be obtained through the creation of these corridors. One would be the enhancement of the stream water quality, since control of the land use paralleling the stream and an action program that provides adequate cover would control the natural effluent interjected into the stream from surface runoff. In addition, commercial production of forest products, which is quite compatable with both the recreational usage and wildlife habitat development, will serve to encourage land owners in participating in the program. However, the success lies in the application of appropriate management techniques and use of selected timber. In planning the vegetative cover and the selection of tree species, assistance from the U. S. Forest Service and the Soil Conservation Service should be sought to insure proper management, grading, and land treatment measures.

49. REHABILITATION OF STRIP MINE AREAS

a. Basic conditions. Coal production in the upper portion of Beaucoup Creek, has been essentially confined to strip-mining operations. This form of production has stripped the over-burden above the coal seams and left a deep over-turn material exposed to the

elements of nature. This over-burden, commonly called "spoil" or "spoil banks," contains enough sulfide and sterile soil so as to create pollution problems in the stream and on the land. The sulfides in the soil combine with natural runoff to contaminate the basin by inducing sulfuric acid into the stream. At the same time, the runoff contributes a heavy sediment load to the stream from erosion of the spoil banks. The spoil also deters growth of plant life and renders the mined lands unattractive, creating an environmental and economic problem. After mining operations are completed, the land is no longer productive; its value decreases, and it becomes a source of minimal tax revenue to the county. As man becomes more concerned with his environment, increasing attention has been given to the restoration of these strip-mine areas. A land reclamation program depends upon the short and long-range objectives that are adopted and the type of soil native to the area. The accruing benefits from an action program can be oriented to the public or private sector, with the programs being dependent upon the ability of the spoil to support the planned activities as well as the capability of the land owners and the counties to finance the selective programs. Very little can be done to increase the low-quantity soil that is left exposed, unless there is sufficient soil nearby to economically mix with the spoil in an effort to achieve a minimum of 40 percent soil content. This soil-underburden mix is the minimum needed to sustain some suitable form of vegetation. While the acid content of the spoil can be overcome by application of lime, spoil bank stability is another factor that can adversely affect rehabilitation. Steep spoil banks are conducive to sliding, which is detrimental to plant life survival. However, site-grading the steep slopes will stop the sliding conditions. Time

itself can, through a process of aging, improve the soil texture and reduce the acid content. The plant growth that does take hold eventually improves the soil quality by decomposing and aerating the spoil.

b. Potential land use. Any program for rehabilitating the strip mine areas must be considered within the framework of long-range planning, with corrective programs time-phased as short-range and intermediate steps. Dependent upon the type of soil involved, there are four specific uses that can be planned in a rehabilitation program. Specifically, they include agricultural production, commercial reforestation, wildlife refuge, and recreational use. However, dependent upon the size, soil type and content, and site-grading requirements of the strip mine areas, a combination of at least three of the four uses are compatable and could conceivable be intergrated into a comprehensive land-use plan, on a time-phased basis. In considering agricultural development, usage would be dependent upon the investments planned for rehabilitation. If crop production is envisioned, an extensive fertilizer and lime program generally would be required to improve soil quality and to overcome the inherent acid conditions of the soil. In addition, grading operations are usually required to level or cover the infertile spoil, sufficiently to permit effective agricultural practices. A lesser investment would be required if beef grazing or orchards were to be established, since far less site-grading or clearing, or fertilization, is required. Commercial reforestation is by far one of the best rehabilitation programs available to the conservationist. Trees will grow on a wider range of spoil conditions than any other plant and it is the simplest and usually the least expensive method of revegetating the spoils. But, most important, once started it establishes

an environment conducive to other multiple uses. Spoil areas are well adapted for development of wildlife habitat. Since it can be easily integrated with other types of planting, it lends itself to a multiple-use program. Wildlife planting can be induced to grow on land that is too acidic for agricultural uses and on terrain with minimal (erosion prevention) site grading. Chokberry, arrow-wood, silky dogwood and hazelnut shrubs are usually good cover that do well in most types of acidic soil. General recreation usage is possible only after extensive investments have been made. In addition to good plant growth, the land must be able to hold and impound water, support fish life and have suitable level sites for development of facilities. Thus, it is a long-range objective that can be integrated with other usage.

c. Recommendations. Any action program adopted must involve a cooperative effort on the part of the counties, State and Federal Governments. However, before any detailed plans are prepared, samples of the type and acidic content of spoil should be secured and tested. The results and percent of soil content will determine the type(s) of usage possible. Based on past studies and information applicable to Southern Illinois soils, it is recommended that a comprehensive program be initiated by the land owners in cooperation with the counties and State. Immediate emphasis should be given the establishment of commercial reforestation for two reasons: first, under existing forest-support programs with special tax provisions, certain economic incentives can be offered the landowners to obtain maximum participation; and second, reforestation will enhance the natural environment of the upper Beaucoup Creek area and attract

residential development that heretofore has avoided the area because of its natural environment and ecology. In the long run, this type of program will add to the tax base and will help to maintain a balance of growth throughout the basin. Furthermore, establishment of timber stands lends itself to development of wildlife refuge and land-based recreation, which are both additional income programs to the landowner. A comprehensive cooperative program planned and supported by Federal and State Forestry agencies should be sought by the Greater Egypt Regional Planning Commission and then offered the landowners in the area. Selection of tree species to speed revegetation and provide optimum growth and income should be established, and the necessary support programs immediately be made available. Dependent upon the initial success of the reforestation program, a second land-use should then be established. A ground cover compatable with the selected timber species and soil acidity should be planted to enhance the wildlife habitat. This supplemental program will help preserve the basin's wildlife resources and offset the losses caused by the more intensified agricultural production that is expected to develop in the area.

SECTION XI - IMPLEMENTATION OF BASIN PLAN

50. EFFECTS OF BASIN PLAN

a. General. The 71 reservoirs, 1,017.6 miles of channel improvements, 178 miles of recreational corridor and the rehabilitation of the strip mine areas will afford a proper scale of development in each of the watersheds and meet the immediate and long-range needs of the basin. The basin plan will provide: (1) flood control based on retention of some 2.6 inches of runoff or a flood having a frequency of occurrence of once in 5 years; (2) drainage improvement to enhance agricultural productivity; (3) all of the low-flow supplementation required to maintain adequate stream DO levels except in the Crab Orchard Creek and the Lake and Pond Creek Watersheds; (4) General recreational developments to meet the immediate and future needs to the fullest practical extent; (5) preservation of wildlife environment as protection against future growth intrusion in the habitat and ecology; (6) improvement of economic conditions throughout the basin, particularly the agricultural and the tourism and recreational industries; (7) enhancement of the residents' social well-being.

b. Satisfaction of basin needs. Subsequent to the selection of the base plan, an analysis was made to determine the effectiveness of the reservoirs in meeting the basin needs. The success in meeting the two primary water consumptive needs is discussed below:

(1) Low-flow augmentation. Of approximately 370 miles of main stem and major tributaries considered for quality improvement by low-flow augmentation, about 277 miles would be maintained at an adequate DO level. TABLE 25 shows pertinent data relative to the protection provided by the recommended

TABLE 25

Effectiveness of low-flow augmentation

Stream	Total stream miles	Protected DO standard	Protected stream miles	Percent miles protected
Beaucoup Creek	83.5	5mg/1	55.8	67
Little Muddy	73.7	5mg/1	46.2	63
Casey Fork (1)	32.7	4mg/1	14.5	44
Middle Fork	29.6	5mg/1	25.7	65
Crab Orchard Creek (2)	37.2	(2)	32.0	86
Big Muddy (below Rend Lake)	103.1	5mg/1	103.1	100
Total	369.8		277.3	75

(1) Modified by Rend Lake.

(2) Modified by Crab Orchard Reservoir. DO level of 3 mg/1 in Carbondale area and 4 mg/1 above Crab Orchard Reservoir could be maintained.

reservoirs. Maintenance of stream flow at the indicated water quality standard will provide basic protection to the public. Regulated flow will enhance the stream's ecology and use, and provide tributary input with quality that is adequate to meet the current inter-state standards for the Mississippi River.

(2) General recreation. The need for recreational opportunities was identified on a time-phase basis and expressed in terms of user-day attendance and water surface acreage. Incremental development was based mainly on the project's location relative to the areas growth centers. Information regarding the capability and potential of the selected reservoirs in meeting the projected needs are shown in TABLE 26.

51. PHASING OF BASE PLAN

The selection of the time sequence and order of development for the various elements of the basin plan have been predicated on the projected time patterns of water and land resource demands. While projected demands are based on the best information currently available, it is recognized that their dependability and accuracy lessen within the length of the period of projection. After completing each phase and segment of construction, definition of needs should be reexamined before continuing with the next phase and segment of development. Such reexamination could result in some modification in the use of projects previously constructed as well as improvements planned for subsequent construction. To meet the immediate and long-range water needs of the basin, the following order of construction is proposed: (a) initial construction within the next 10 to 15 years of those improvements which are economically justified and for which there is an immediate need; (b) later construction of those improvements which are economically justified and for which there is a foreseeable future need. Present proposals for initial Federal participation are limited to those

TABLE 26

Effectiveness of meeting recreational needs
(user-day attendance)

Reservoir	Optimum	Initial (1980)	2000	2020
Cedar Crk. System	424,100	248,000	352,900	424,100
C-35	1,360,000	680,000	950,000	1,100,000
C-7	1,110,000	490,000	750,000	860,000
C-34	900,000	400,000	680,000	720,000
12-1	680,000	270,000	410,000	540,000
C-5	300,000	260,000	300,000	300,000
14-12	300,000	100,000	150,000	200,000
8-10	250,000	100,000	150,000	200,000
10-1	250,000	100,000	200,000	200,000
C-16A	200,000	150,000	200,000	200,000
6-18A	200,000	0	50,000	100,000
C-12(7-7)	150,000	120,000	150,000	150,000
Total furnished	6,124,100	2,918,000	4,242,900	4,994,100
Projected net needs				
5 county		1,000,000	1,960,000	2,320,000
8 county		2,400,000	2,840,000	3,080,000
Total (13 county)		3,400,000	4,800,000	5,400,000
Difference**		-482,000	-557,100	-405,900
Percent of needs met**		86%	88%	92%

* Figures include effects of selected SMSA

** Based on a comparison of the anticipated time-phased development to the estimated net needs for the 13 counties

Note: C designates Corps reservoirs all other are SCS reservoirs

elements of the basin plan that current and projected needs indicate should be constructed prior to 1980. The schedule for the individual watershed development is shown in TABLE 27. The project elements proposed for initial construction are shown in Phase I. Included are 10 multiple-purpose reservoirs, 43 single-purpose flood-water retarding structures, and 778.6 miles of channel improvements. The second phase of construction consists of 1 multi-purpose reservoir, 17 flood water retarding structures and 239.0 miles of channel improvements. It is essential that proper land use and treatment be recognized and carried out as part of the initial phase. Concerted efforts are required to assure that the land is used within its capability and treated in accordance with its needs. Treatment of crop and pasture land will consist of such conservation practices as contouring, terracing, grass waterways, conservation cropping system, minimum tillage, farm ponds, drainage field ditches, pasture planning, pasture renovation, and others. Conservation treatment of forest lands includes timber stand improvement, livestock exclusion, tree planting, planned harvesting, and insect and disease control.

52. PROBLEMS

a. Sediment and erosion. During the study effort, it was recognized that man's use of the land has greatly increased the rate of erosion and thus the amount of sediment carried in the stream. Unfortunately, there are no sediment discharge records available to formulate an effective action program to overcome this problem. As a partial solution, emphasis has been given the need for land treatment and flood control measures. These will minimize sheet and channel erosion and thereby diminish the stream's sediment load. What is still required is collection of basic data to identify

TABLE 27

Time-phasing of construction program*

A. Phase I - recommended for installation prior to 1980

Watershed No.	Name	1st Increment	2nd Increment	3rd Increment	4th Increment
4	Lower Beaucoup	RC @ 28.0	---	---	---
6	Upper Beaucoup	C-34	---	---	---
7a	Upper Crab Orchard	7-7	7-8A	7-6, Ch@108.8	
7b	Lower Crab Orchard	C-16A	---	---	---
8	Little Muddy	C-35, 8-10	8-9A, 8-1B	RC @ 47	---
10	Hurricane Creek	10-1, Ch@34.8	---	---	---
11	Lake & Pond	11-2, 11-3, Ch@112.2	---	---	---
12	Middle Fork	C-7, 12-1	12-7A, 12-3, 12-4, 12-5A, 12-5B, 12-6A	12-11, 12-12A 12-13	Ch@210.6
13	Gun Creek	13-1, 13-2 13-3A, 13-4	Ch @ 51.7	---	---
14	Upper Big Muddy	14-3, 14-4 14-5, 14-6, 14-7	14-12	14-8, 14-9A, 14-15, 14-10A, 14-14	14-1, 14-2, Ch@120.3
15	Casey Fork	C-5, 15-15, 15-11, 15-13A, 15-14	15-6, 15-7, 15-9, 15-10	15-5, 15-1A 15-2A, 15-3A	Ch@140.2
9&1	Main Stem, Big Muddy	RC@103	---	---	---

B. Phase II - recommended for installation after 1980

5	Galum Creek	5-10, 5-11, 5-12	5-1, 5-3A, 5-4	5-6, 5-7,	Ch@ 69.4
6	Upper Beaucoup	6-13, 6-14, 6-15, 6-16	6-17, 6-18A	6-8, 6-9, 6-10, 6-11	Ch@169.6

*Reservoirs with "C" prefix denotes Corps reservoir. All others are SCS (PL 566) projects. "Ch" designates channel improvements. "RC" designates river recreational corridor. Figures cited with the "Ch" & "RC" designation are mileage involved.

known problem areas and their causes. This study should give initial emphasis to those watersheds where water resource developments are contemplated. Furthermore, a concentrated effort is required to establish a basin-wide remedial program. Otherwise, these losses will continue, although at a lesser rate.

b. Recreational planning. With emphasis placed on preservation of the natural environment; development of land and water-related recreational facilities, and expansion of the tourism and recreational industry, proper in-depth planning must be undertaken to insure successful implementation. A recreational master plan is needed to avoid unwarranted duplication of facilities and services and to insure the compatability and adequacy of the development. The master plan should be prepared on a basin-wide basis, establishing the types of recreational opportunities and number and size of sites that should be developed over time.

Included should be the existing Rend Lake, Kinkaid Lake and Crab Orchard complex. When completed, this master plan will serve as a framework for the detailed planning required by the sponsoring Federal agency prior to construction of the project. In particular, a detailed plan of the development is required for the recreational corridors. The master plan for the recreational corridor should be sufficient in scope and analysis to assure successful implementation. Required are design controls relative to usage, cost, operation and maintenance for the various stream reaches and the zoning and adjusted tax structure needed to insure local participation. This work plan would then serve as a basis for possible Federal and non-Federal cost sharing under the Federal Water Recreation Act, Public Law 89-72.

c. Stream water quality. Even with the recommended water resource developments there would still remain specific areas with water quality

problems. Supplemental action is needed involving the State and counties working in close cooperation with the local communities and industries involved. Specifically, this need relates to the communities of Carbondale and Marion, as well as the Lake and Pond Creek watershed. The municipalities of Carbondale and Marion will face a problem regarding contamination of their environmental area. There is a need for Carbondale to expedite its plans for treatment and handling of its sewage discharge. Either an advanced form of treatment will be required or a pipeline transfer of its effluent to the main stem, Big Muddy will have to be undertaken to prevent further degrading of its streams' quality. Special Federal grant-in-aid programs exist that the community, in cooperation with the State, should utilize in formulating its action program. The community of Marion also faces a similar problem. Provision of storage for low-flow augmentation in the interest of water quality control will delay the problem that the community will eventually have to face. The drainage area available for impoundment of supplemental storage for dilution flows is very limited and its yield capability will essentially be reached by the year 2000. At that time, the community of Marion, which already has a form of tertiary treatment, will need to provide advanced waste treatment to its effluent or suffer a deterioration in the DO level of the upper Crab Orchard Creek. The problem in the Lake and Pond Creek watershed is essentially mining oriented. Cooperative planning and control by the State and the coal industry is required. This one watershed is a prime source of the induced acidic waters in the basin streams. Use of settling ponds and control of wash waters in the coal treatment plants, together with proper ditching and diversion of runoff, are part of an action program that must be undertaken.

53. INSTITUTIONAL CONSTRAINTS

a. Governmental units. To effectively institute the needed land and water uses and promote a proper growth framework, special consideration must be given the reorganization of cooperative workings of the existing governmental structure. What is required are two types of responsive governmental units. One a planning unit, the second an action unit. Presently, there is a grand total of 262 units of local government performing various functions. Out of this total, 139 can be considered special functional units. There are five counties, 59 municipalities, 44 townships, 15 road districts in non-township counties, 5 county housing authorities, 5 soil and water conservation districts, 91 school districts, 3 mosquito abatement districts, 3 river conservancy districts, 2 hospital districts, 3 airport authorities, 7 park districts, 11 special water districts, 2 health districts, 5 drainage districts, and 2 fire prevention districts. If the basin plan of improvement is to be successfully implemented, the two types of governmental entities must be effectively organized on a functional basis.

b. Planning. Of all the political entities in the basin, the five core counties have set an example of local leadership. To avoid waste and duplication in planning and to foster proper development, they have jointly created the Greater Egypt Regional Planning Commission. This legal entity has the authority to prepare plans which, in the judgment of the county board, will be in accordance with the present and future regional needs. The Commission will prepare plans to best promote the health, safety, order and convenience, prosperity, efficiency, and economy in the process of development and general welfare of the region. The Commission with a board membership of 4 representatives from each county has a permanent

planning staff in addition to various resource-related advisory committees. Four of the five counties have adopted a land-use plan, but to date none has been implemented by zoning ordinances to insure obtaining the desired development. Until such action is undertaken, the successful achievement of the ultimate potential offered by basin development cannot be assured. The Commission is currently preparing a land-use plan for Jefferson County which should be completed within the next two years. To supplement the recommended water and land development, the Commission must increase its effort to enhance the area's environment and public services. This should specifically include: the rehabilitation of strip-mines; control of urban growth; consolidation and improvement of such county and municipal functions as education, health, road net, sewage and refuse treatment; and most important- examination of the area's tax structure and local governmental services.

c. Implementation. In order to implement the objectives of the basin plan certain levels of non-Federal governmental entities should be regarded as logical co-sponsors. Because of its responsibility for control of intra-state stream quality and its declared committment for development of tourism and recreation, the State of Illinois has a vested interest requiring its participation. The other legal entity is a conservancy district which, by the nature of its charter, has vested interest in the preservation and conservation of the land and water-related resources. This usually involves flood control, drainage and preservation of wildlife environment. There are 3 districts legally established in the basin. They are: Rend Lake Conservancy District, the Kinkaid-Reid Creek Conservancy District, and the Saline Valley Conservancy District. Unfortunately, the legal boundaries

of the three do not encompass the basin's total drainage area. To date, there has been no concerted effort to undertake cooperative planning and action programming. If the potential agricultural enhancement is to be achieved there must be coordinated programs, particularly in terms of sponsorship and operations and maintenance. Ideally, the plan of improvement for land treatment, flood control and drainage, lends itself to a basin-wide conservancy district program. Undertaking an expanded and coordinated effort or merging into the legal entity, would offer a valuable supplement to the county structure in providing total service and development.

54. LEGAL CONSTRAINTS

Subsequent to installation of the basin plan, legal efforts will be required to insure the optimum attainment and control of the basin's resources. The plan of improvement will affect the hydrologic and hydraulic regimen of the basin and in supplement to the counties' use plan, affect the environment for the residents and the industries in the area. Efforts will be required to insure that once the flood-retarding structures are installed, unwise occupation and use of the flood plain is prevented. What is needed is the enactment and enforcement of regulatory zoning measures to prevent future indiscriminate encroachment of the flood plains. Such a program can only be achieved through the cooperative and coordinated efforts of the local citizens and the counties. The development of a flood control program requires comprehensive planning, with zoning based on adequate flood plain maps. The Corps of Engineers has been designated in response to Congressional legislation as the Federal agency responsible for assisting the local governments. Based on a cooperative State program, the Corps, surveys and maps the flood plain and undertakes the hydrology and frequency studies

necessary to establish the flood damage, potential flood heights and the extent of inundation involved. Such information is provided to aid local interests in establishing rights-of-way lines, stream clearance lines, and land-use regulations. The Greater Egypt Planning Commission and counties should utilize this program in implementing their zoning ordinances. The Illinois State legislature has given the Department of Public Health the responsibility of establishing reasonable standards of purity of the intra-state streams. These standards are consistent with the use of those waters, including the use in carrying away the water-borne waste products. The State agency is currently involved in establishing these standards and has issued regulations through the Illinois Water Sanitary Board. In addition, there will be required changes in the State's laws dealing with riparian rights. The right of the landowner to unregulated use of water passing through his lands will have to be reevaluated to recognize society's rights and concern.

55. PARTICIPATION

Active participation during the planning effort prior to construction of the recommended plan will involve all levels of government. Certain planning functions, normally assumed by the Federal agencies, are required of the local governmental agencies as well as the State. There follows a listing of the planning actions and programs required from various entities involved in the basin study.

a. State of Illinois. Correspondence to date with the State of Illinois has indicated its satisfaction with the scope of planning undertaken for the basin. Prior to construction of reservoirs selected for recreational development, the degree of State participation, both in cost sharing (first cost) and operation of specific areas, should be deter-

mined before any commitments are obtained from other (local) entities. It is anticipated that the Department of Conservation will participate in the development and the operation of selected reservoirs. Under a comprehensive program, operation of these projects reservoirs would be satellite to their existing base in Kinkaid and Rend Lake and Giant City State Park. The Department of Public Health should establish monitoring and gaging stations to coordinate the low-flow releases in the interest of low-flow augmentation for water quality control and base flow maintenance. A monitoring system is required to insure against future quality degradation of the stream.

b. Greater Egypt Regional Planning Commission. It is anticipated that counties, through the Commission, should play a predominant planning role in the basin. It should be responsible for preparation of a basin-wide master plan for recreational development with special emphasis on lands surrounding the proposed projects. The master plan for recreation will then be supplemented by the construction agencies under normal agency requirements. In addition, it should head a special committee to establish a detailed work plan for the recreational corridors. This committee should be composed of members from the Bureau of Outdoor Recreation, Corps of Engineers, Soil Conservation Service, U. S. Forest Service, U. S. Fish and Wildlife Service, and the State Conservation Department. Subsequent to completion of the master plan it would be forwarded by the Corps of Engineers to Congress for possible cost-sharing under Public Law 89-72 and be integrated into the development of the 3 reservoirs that supplement the stream's low-flow. The Commission should prepare zoning ordinances for adoption by the counties and the residents. These zoning ordinances should include the flood plain to prevent any future encroachment in the bottomlands which would negate the recommended improvement. Federal and

State cooperative gaging programs should be used to formulate an action program to control erosion and sediment transfer and be integrated into its land-use plans. Furthermore, assistance from the State and U. S. Forest Service should be obtained in planning and rehabilitating the strip-mine areas.

c. Conservancy districts. Consideration should be given to: either expanding the boundaries of the existing three conservancy districts to include all lands within the basin and jointly evolving a concerted action program; or combining into one district to act as co-sponsor with the State of Illinois for the recommended projects. This might best be done with State guidance, since revisions in charters and/or State laws would be required. there should be
Either way, a definite commitment to the programs of the Soil Conservation Service and the Corps of Engineers. This commitment would encompass project('s) sponsorship and operation and maintenance and tend to supplement the counties' planning function.

d. National Park Service. The National Park Service should, in cooperation with the Greater Egypt Regional Planning Commission, expand its study to detail all the remaining archaeological and historical artifacts within the basin. The study should be more than an inventory, and contain recommendations as to specific development, land parcels, and costs required for integration into the recreational master plan.

e. Forest Service. The Forest Service should assist the Planning Commission in formulating a planting program for both the recreational corridors and the rehabilitation of the strip-mines. In addition, its program for acquiring private in-holding within the boundaries of the Shawnee National Forest should be expanded to supplement the recommended recreational

developments. The lands contiguous to the project requirements of reservoir 16A and that part of the recreational corridor in the lower 27 miles of the Big Muddy should be purchased to enhance the aesthetic and ecological environment.

f. Bureau of Outdoor Recreation. The Bureau of Outdoor Recreation should work very closely with the Regional Planning Commission and the State. Such cooperative work will insure that the recreational developments contained in the master plan will supplement the State approved recreational plan of development. In particular, it should give special guidance in the final selection and determination of the acreage and design criteria required for development of the recreational corridor. The agency also should work very closely with the construction agencies in establishing the master plan for reservoir recreational developments.

g. U. S. Fish and Wildlife Service.

The U. S. Fish and Wildlife Service has expressed concern for the preservation of the wildlife habitat and the need to improve the stream ecology. The U. S. Fish and Wildlife should work very closely with the local Planning Commission and State in the establishment of the recreational corridors. Then any land required for mitigation could properly be incorporated in the Commission's plan of development. In addition, the agency should work with the construction agencies in establishing the master plans for development of the recreational reservoirs.

h. Construction agencies. Due to the special (system) hydraulic considerations, it is imperative that the two construction agencies properly phase and coordinate their preconstruction planning activities. Both

agencies should work very closely with local agencies to insure that the required terms and action programs are instituted before construction is undertaken. If at all possible, the State should be regarded as the prime sponsor for the multiple-purpose projects. While these reservoirs essentially satisfy local needs, they are nonetheless responsive to the State-indicated desires for: establishment of tourism and recreational industry in Southern Illinois; and maintenance of intrastate stream quality. Before flood water retention storage is provided, commitments from the same local sponsorship should be obtained by both agencies. If this fails, then the multi-purpose reservoirs shold be reanalyzed, with storage dedicated to flood control deferred and reallocated to recreation until such time as local interests can meet the terms of local sponsorship.

SECTION XII - DISCUSSION AND CONCLUSIONS

56. GENERAL

In evaluating the basin needs, three factors affected the analysis: time, area, and economic reorientation. Time was the factor in identifying the short-term and long-term needs; area, or the geographic dispersal of the various needs, was a factor that led to the decision that an analytical division for each of the main watersheds was the only practical approach; and economic reorientation was a concept recognizing the need to assist the state and the five counties in planning the reorientation of the area's economic base. In defining the resource planning and ultimate development required, a three-fold objective was established: to help in providing the necessary land and water development needed to sustain the projected economic growth; to encourage the preservation and enhancement of the area's natural environment; and to assist in developing a framework for social development, stressing the well-being of the people so that the growth and living conditions will be beneficial to all. Planning for these objectives involved balancing the distribution of resource development to assure that all parts of the basin will share in the projected socio-economic growth. Towards this end, the land-use plan prepared by the Greater Egypt Planning Commission was used as a basic guideline. As part of the planning effort to reorient the economic structure, particular emphasis was placed on the enhancement of the agricultural industry and the establishment of an adequate base for development of a tourism and recreational industry. However, to insure the success of this basin plan requires the participation at all political levels. Participation of State, counties, and local residents in

are needed to implement the recommended land treatment measures and the multi-resource developments. Obtainment of the agricultural enhancement cannot be a piecemeal affair, and to insure proper results requires total resource management. To encourage establishment of the tourism industry, selection of reservoirs and complete development of the recreational facilities will be required if the basin is to secure a new and vibrant input to the economic structure.

57. ECONOMIC CONSIDERATIONS

While this report has concentrated on the development of the area's water and land resources, the planning entities in the basin should be cautioned as regards the need to control certain economic factors. The projected growth indicated for the demographic and economic development of the basin and the service area must be tempered with a realization of the need to control this phase of input. There are factors which could easily alter the evolution of the basin's economy, causing substantial, long-run deviations from the depicted norm. These factors specifically involve the basin's available labor supply and its present industrial mix. The entire Southern Illinois labor market is dominated by low and semi-skilled labor, and the Big Muddy Basin is no exception. Excluding agriculture, manufacturing and services are the key industrial employers, which have certain employment characteristics that should be recognized. The manufacturing firms now entering the basin are generally small, assembly-type operations, while the service industries are often seasonal and offer only part-time employment. This situation is one of the predominant causes of a below-average per capita income which, in turn, acts as a constraint on the economic acceleration. Within this framework, a lower middle-income society evolves

with a resultant lower tax base, both individual and corporate. These factors then limit the municipal services that can be offered to the residents and serve to attract future industry. In addition, the quality of services provided the public by schools, hospitals, roads, and utilities become commensurate with the standard of living in the basin. The economic study assumed that this extreme condition will not continue; but that a realistic approach to land use and urban planning will be provided by the appropriate State and local agencies. What will be needed will be a coordinated effort to control all aspects of economic growth, i.e., land, labor, and capital. There is an abundance of unskilled labor in Southern Illinois which must be trained. Skilled labor must be created, not only for personal benefit but as a base to attract new types of industry. Labor must be prepared to supply the skills necessary to satisfy the demands of various industries. If the economic base structure is to be enhanced, the planning entities must identify the type of industry that will improve the economic base; and then provide adequate training of labor to serve these types of industries. The industrial employers must be selected on the basis of two criteria: first, as a user of the basin's labor skills; and second, on their potential contribution to the balance of payment of the area. This last criteria is the most critical. Typical of most undeveloped areas, the limited amount of manufacturing industries found in the area seldom complement each other's demands. Usually the industries are forced to obtain their raw material or semi-finished products from outside the basin, causing a net loss of revenue to the area. Basin assembly plants purchase components from St. Louis, replace machine parts in Chicago, and ship their finished products out of the basin by rail to be distributed by a metropolitan wholesaler.

While all raw materials cannot logically be expected to be produced locally, a definite attempt should be made to provide a total range of services in the basin. Where the finished products are produced regionally, the various firms that manufacture the components of a particular type of product should be encouraged to operate within the region. This means that local entities should try to incorporate as much of the vertical integration of a specific industry and its functions as is possible;and concentrate on developing industrial services for manufacturing industrial needs. This will contribute to a self-sustaining economy and produce a net flow of income and a positive balance of payment for the region.

58. LOCAL COOPERATION

The specific definition of the institutional arrangements required for implementation of the various projects and programs included in the recommended basin plan is to be accomplished in separate actions by the sponsoring agencies, in this case the Corps of Engineers and the Soil Conservation Service. However, since the Federal interests is heavily involved in the first phase of the plan, presentation of current policy relating to local cooperation requirements for Federally authorized projects is cited below. These general requirements for the types of projects considered and recommended are outlined. It should be borne in mind that the specification of the precise terms of local cooperation in any Federally authorized project or program is a prerogative of Congress which authorizes the program. Hence, the requirements for local cooperation for any project or program which may ultimately be authorized by the Congress, may differ from the information presented herein.

a. Corps of Engineers reservoirs

(1) Recreation and fish and wildlife. In accordance with the Federal Water Project Recreation Act agree to: (a) administer project land and water areas for recreation and fish and wildlife preservation; (b) pay, contribute in kind, or repay (which may be through user fees) with interest one-half of the separable first cost of the reservoir project allocated to recreation and fish and wildlife preservation; (c) pay all costs of maintenance, operation, and replacement of recreation and fish and wildlife lands and facilities; (d) acquire necessary water rights.

(2) Water quality control. (a) exercise to the full extent of their legal capability control against removal of stream flow made available for water quality control purposes until it accomplishes its purposes and becomes a resource to the stream; (b) through adequate treatment or other methods of controlling wastes at its source, contribute to pollution control in the streams for which low-flow augmentation is provided; (c) acquire all necessary water rights.

(3) Flood control. (a) protect channels downstream of the reservoirs from encroachment which would adversely affect operations of the reservoir; (b) adequately inform all affected persons at least annually that the projects will not provide complete flood protection; (c) provide guidance with leadership in preventing unwise and uneconomical future development of the flood plain areas by encouraging prudent use of flood proofing, land regulation planning, or other flood plain management techniques to reduce future flood losses; (d) cooperate with the Corps of Engineers in public dissemination during the release, at least once a year, of the design capacity

flows from the damsites. This flow release serves the purpose(s) of stream flushing in the interest of public health and visual pollution and for channel sizing in the interest of discouraging unwise or unknown encroachments.

b. Public Law 566 flood prevention programs

Local organizations will be required to assume the following costs of installing structural works of improvement for which Federal financial assistance is provided for both reservoirs and channel improvements.

(1) The cost of acquiring land, easements, or rights-of-way for all works of improvement for purposes other than public fish and wildlife or recreational development.

(2) At least 50 percent of the cost of the land, easements, and rights-of-way to be acquired for works of improvement for fish and wildlife or recreational development.

(3) The cost of acquiring water rights.

(4) The cost of administering contracts on non-Federal land.

(5) The construction cost allocated to purposes other than (a) flood prevention, (b) the agricultural water management, and (c) public fish and wildlife or recreational development.

(6) At least 50 percent of the construction cost allocated to (a) the agricultural phases of the conservation, development, utilization, and disposal of water, and (b) public fish and wildlife or recreational development.

(7) The cost of engineering and other installation services allocated to purposes other than (a) flood prevention, (b) the agricultural water development, and (c) public fish and wildlife or recreational development.

(8) At least 50 percent of the engineering and other installation services required in connection with minimum basic facilities for public fish and wildlife or recreational development.

(9) The cost of operating and maintaining works of improvement on non-Federal land.

(10) An equitable part of the cost of operating and maintaining works of improvement on Federal land in consideration of the benefits that accrue to non-Federal land.

59. CONCLUSIONS

The basin plan consists of 11 multiple-purpose reservoirs, 60 flood-water retention projects, and 1,017.6 miles of channel improvement, together with 178 miles of river recreational corridors. These developments together with the rehabilitation of strip mine areas would provide the best use or combination of uses of water and related land resources to meet all foreseeable short and long-term needs. Each project is economically and engineeringly feasible, both individually and as elements in the basin plan; and each purpose served by the projects is fully justified. The projects recommended for construction under Phase I to meet the immediate needs are consistent with the comprehensive plan for basin development, both from the State and local planning commission. The State recreational plan and the Planning Commission's land-use and development plan have served as guidelines for final development. Installation of the base plan will provide the necessary inputs for the water and land related needs required to meet the primary demands for products and services. Addition of the recommended recreational corridor will complete the necessary

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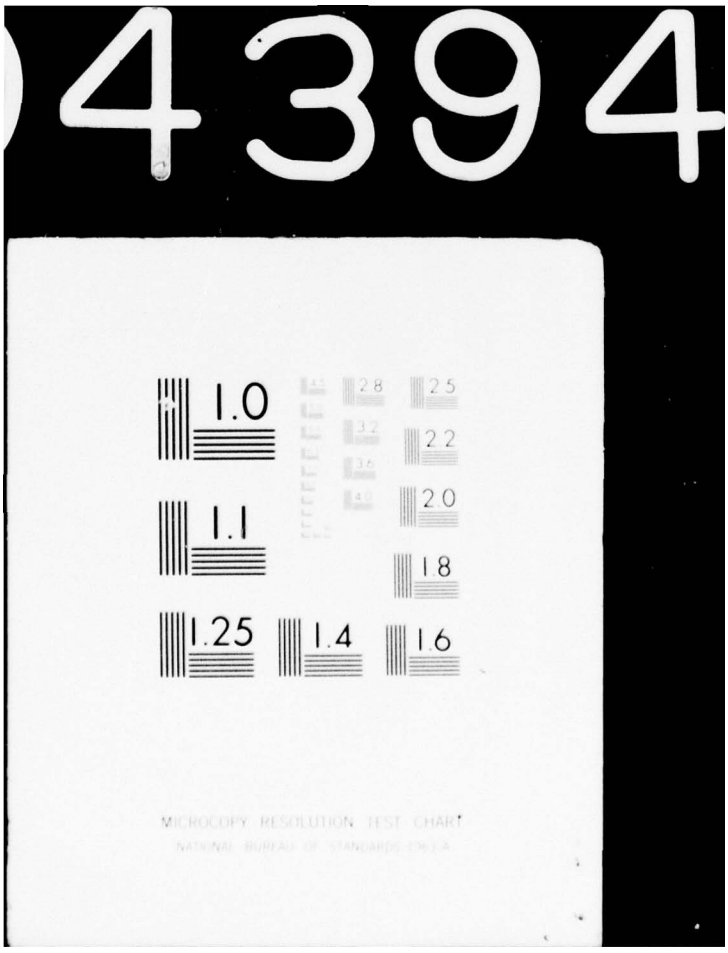
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input for the social well-being of the area and the preservation of wildlife habitat. While the recreational corridors are included in the basin plan, the detailed costs and final scope have not been established. A recommended concept and scope has been indicated as the basis for inclusion in the basin plan. However, evaluation of the final scope and costs required for the authorization and installation by the Corps of Engineers has been deferred, subject to preparation of a basin master plan for recreation.

SECTION XIII - RECOMMENDATIONS

60. RECOMMENDATIONS

The comprehensive basin plan is intended to serve as a flexible guide for future actions in planning and implementing the development of the water-and land-related resources of the Big Muddy River Basin. It is recommended that the following action be taken at the Federal, State or local level as appropriate to implement this plan.

a. Federal.

(1) That the following projects and programs be implemented as soon as practicable and in any event within the next 10 to 15 years.

TABLE 28

Recommended project

Watershed	Reservoirs Corps	Reservoirs SCS	Drainage Channels Impro (SCS) (Miles)	Recreational Corridors (Miles)
4-Lower Beaucoup Creek	- -	- -	- - -	28.0
6-Upper Beaucoup Creek	1	- -	- - -	- - -
7-Crab Orchard Creek	1	3	108.8	- - -
8-Little Muddy River	1	3	- - -	47.0
10-Hurricane Creek	- -	1	34.8	- - -
11-Lake & Pond Creek	- -	2	112.2	- - -
12-Middle Fork Creek	1	10	210.6	- - -
13-Gun Creek	- -	4	51.7	- - -
14-Upper Big Muddy River	- -	13	120.3	- - -
15-Casey Fork Creek	1	12	140.2	- - -
Main Stem Big Muddy	- -	- -	- - -	103.0
Total	5	48	778.6	178.0

(2) That upon completion of a basin-wide master plan for recreational development, the river recreational corridors be incorporated into the plan of development for the Corps reservoirs -- Rend Lake, No. 35 near DuQuoin and No. 34 on the Upper Beaucoup above Pinckneyville.

(3) That planning for the U. S. Department of Agriculture watershed projects provide for accelerated treatment of agricultural and forest lands for improvements needed for watershed management.

(4) That all lands and water area designated for recreational usage be administered in accordance with the Federal Water Project Recreation Act.

(5) That appropriate coordinating activities be undertaken with the State to insure protection of public health by establishing vector control programs and providing adequate sanitary facilities at recreation sites.

(6) That more extensive basin-wide archeological surveys be undertaken by the National Park Service for the preservation of areas unique in aesthetic, archeological, historical and scientific value; and that the preservation of these areas be incorporated into the basin's master plan for recreational development and the individual project's plans where appropriate.

(7) That existing Federal-State cooperative forestry programs be expanded particularly with purchase of inholdings contiguous to the recommended recreational developments and reservoirs where appropriate.

(8) That existing recreation areas be expanded in accordance with experienced visitation patterns.

(9) That lands obtained for mitigation of wildlife losses be licensed to respective State game and fish agencies.

(10) That current land management and conservation programs be continued and expanded.

(11) That full consideration be given during the preconstruction planning by the construction agencies to the provision of facilities for collecting hydrologic data.

(12) That this report of the coordinating committee be used as a supporting document for authorization requests initiated by the construction agencies.

b. State.

(1) That a cooperative quality control program be instituted with the sponsoring constructing agencies for those reservoirs providing low-flow augmentation. The program would establish a monitering system to prevent further degrading of stream quality.

(2) That in cooperation with the Greater Egypt Regional Planning Commission institute a program to trace and identify the main erosion and sediment problems. This is particularly needed in those watersheds where development is recommended.

(3) That action be taken to review the existing laws, policies, and programs relating to the possible implementation of the plan of improvement and modify where appropriate.

(4) That all practical measures be undertaken to control pollution of the streams by adequate treatment or other methods to control wastes at their sources.

c. Local.

(1) That a preparation of a master plan be undertaken by special committee headed by the Greater Egypt Regional Planning Commission. Particular emphasis should be to establish the requirements relative to creation of the recreational river corridors.

(2) That local interests in cooperation with the State of Illinois institute measures to rehabilitate the strip mines in accordance with the action plan outlined in this report.

(3) That programs for the development of more precise data relating to the definition of flood hazards be instituted in cooperation with the State and Corps of Engineers.

(4) That the Greater Egypt Planning Commission and local agencies provide guidance in leadership in preventing unwise and uneconomical future development of the flood plain areas. They should encourage prudent use of flood proofing land regulation planning, or other flood plain management techniques to reduce future flood losses.

(5) That local interests particularly the Planning Commission and local supporting agencies adequately inform all effected persons at least annually that the projects will not provide complete flood protection.

(6) Protect channel downstream of the reservoirs from encroachment which would adversely effect operations of the reservoirs.

(7) That local interests re-examine its laws, policies, programs, and too base structure relating to, implementation of the water and land resource development.

d. All.

(1) That approval of the comprehensive plan not be a bar to development of projects not included therein.

(2) That each of the affected and concerned Federal, State and local agencies keep current the segments of the comprehensive plan for which it is assigned responsibility.

(3) That cooperative action be taken to expand and improve river and flood forecasting services.

(4) That consideration be given the inclusion of recreation and conservation programs as a purpose in the formulation of all future water and related land resource development projects.

(5) That proper recognition be given the official State comprehensive plan and the proposed basin-wide master plan for outdoor recreation in all recreation planning and development activities.