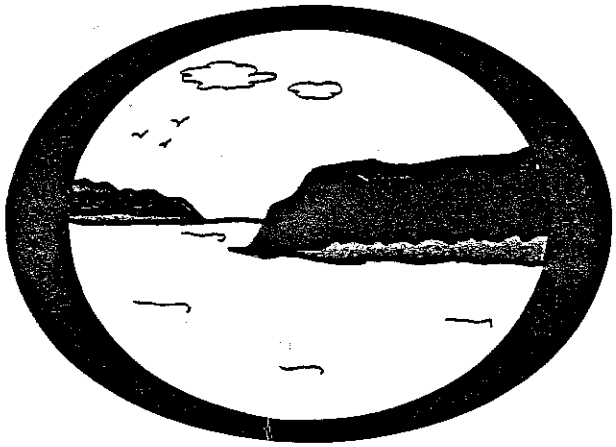
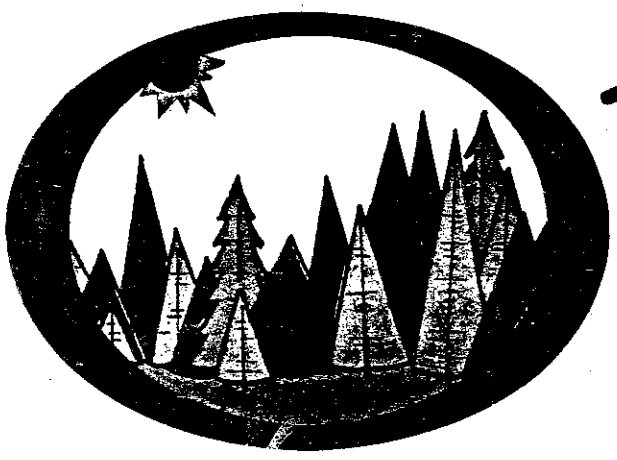
J. R. YOUNG

ARKANSAS
STATE WATER PLAN

WATER AND RELATED LAND RESOURCES



MAIN REPORT



Department of Commerce
Division of Soil & Water Resources

STATE OF ARKANSAS
DEPARTMENT OF COMMERCE
DIVISION OF SOIL AND WATER RESOURCES

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1200 Westpark Drive, Third Floor Little Rock 72204

October, 1975

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JOHN P. SAXTON
DIRECTOR
(501) 371-1611

DEPARTMENT OF COMMERCE
DIVISION OF SOIL AND WATER RESOURCES
1200 WESTPARK DRIVE, ROOM 308
LITTLE ROCK, ARKANSAS 72204

December 15, 1975

The Honorable David Pryor, Governor
State of Arkansas, and

Members of the Legislature, and

People of the State:

We take great pleasure in transmitting the first edition of the Arkansas State Water Plan. This plan has been developed in response to Acts 217 of 1969 and 555 of 1975 of the General Assembly of Arkansas. We believe that the publication of this plan is a significant land mark in planning for the management of one of Arkansas' most vital natural resources.

This plan presents a broad assessment of the means by which Arkansas' water and related land resources can eventually be developed for fullest use. It contains few details since flexibility is one of its key elements. In preparation of this plan we have looked to the challenge of a changing future environment and anticipated progress.

The final decisions on specific objectives to be attained through resource development must ultimately be value judgements reached through the political process. Therefore, we commend the Plan to your consideration. Our Commission trusts that its recommendations will be translated into action through development of more detailed plans for specific projects.

Very truly yours,

John Luce, Chairman

Wayne Gairhan

Jack A. Gibson

Earl G. Landers

Gerald C. Hendrix

Graham P. Mullen

Robert P. Lewis

PREFACE

The major objective of the State Water Plan is to determine the most economical and most desirable methods by which water can be provided to all users in the state. Specific parameters governing the mandate are that water must be provided in definite and exact quantities, and locations, and with a predetermined quality. These limiting factors serve to guide water and related land resource planning and implementation.

Actions taken by either individuals or governments which impact upon the water resource affects a more diverse group of interests than perhaps any other natural resource activity. Because of the apparent abundance of water in our state, land use planners (urban, industrial and farmers) in past years have assumed water would be available for whatever use was desired. As our population increases and land use patterns change, water uses change; and, in many instances, requirements cannot continue to be satisfied unless extensive planning and construction of water development projects is accomplished.

Another paradox generated by changing land use patterns is the absolute necessity to control the excess of water during certain periods of the year. Development in areas subject to water excesses has resulted in sporadic efforts to solve local problems with no attention being given to developing coordinated programs for the entire state. One of the basic contributions that the state water plan purports to make is a state policy in the area of water resource management.

The water plan as published here does not attempt to give explicit answers to all water related problems known to exist at the current time. It will serve, however, to consolidate a summary of all the data we have available. We are hopeful that the information contained herein can and will be used to make management decisions concerning future efforts to further delineate specific problems and to enable the establishment of priorities for implementation of solutions to these problems.

We also realize that the State Water Plan is not a static instrument. Continual revisions must be made as new data becomes available and additional management decisions are made. Therefore, we are hopeful that all agencies, persons, and other entities will provide comments and proposals concerning needed revisions to our state water planning and implementation activities as the need arises.

ACKNOWLEDGMENTS

Most of the basic data used in the preparation of this report was furnished by state and federal government data-collecting agencies and compiled by the staff of the Division.

Particular appreciation is expressed to Mr. Robert P. Cantrell of the Soil Conservation Service, through whose efforts the report was guided to its completion. Mr. Cantrell worked for the Division through the Intergovernmental Personnel Act of 1970.

Appreciation is expressed to the U. S. Water Resources Council for financial assistance through Title III funds of P.L. 89-80.

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CHAPTER I

INTRODUCTION

THE STATE WATER PLAN

Arkansas, like most of the Lower Mississippi Valley states, is rich with water in an abundance and variety of forms. For so many years, the demands on these ground and surface supplies have seemed negligible in comparison with the vast quantities available. Recent and dramatic increases in population and economic activity, however, have resulted in sharply increased requirements for water use in all areas of the United States--requirements which are projected to increase even more sharply during the next 50 years. In Arkansas, for example, total water use requirements are projected to triple between 1970 and 2020.

In many areas of the United States, these increased requirements and the problems of pollution, poor drainage, flooding, droughts, erosion, and poor land use management have resulted in a situation where resources are barely able to meet current burdens and demands, much less those of the future.

It is now recognized, therefore, that water resources--like natural gas resources--are not inexhaustible nor exempt from misuse or mismanagement. The regional and national shortage of natural gas--once available in abundant supplies--is a prime example of the results of improper, inadequate, or nonexistent planning. Comprehensive water and related land resources planning is essential; therefore, in order to conserve and develop adequate amounts of these resources for the use of present and future generations.

Generally speaking we have four basic problems in our use of land and water resources:

First, as pointed out earlier, Arkansas' water and land resources are limited in an amount compared to potential need. There is not enough land and water for each person to have all he wants or use as each might see fit, therefore, we must use our resources wisely. Some states which are not as fortunate as Arkansas are already experiencing severe water shortages and are spending millions of dollars to investigate the possibility of importing water from great distances or using desalted sea water.

Second, as a rule our natural resources do not occur where man wills them but where nature places them. Fertile soils without adequate water do not produce, rather it is their productive union that provides the value to man. Arkansas is fortunate to have fertile farmland which has sufficient water to make us a great agricultural state. Generally, the water problem in Arkansas is not insufficient quantity but distribution and quality.

Third, our land is always with us but water supply is variable--dependent on rains. During drought periods our supply is limited and can become critical; however, during flood we suffer tremendous property

damage, erosion, and loss of life. If we are to make maximum beneficial use of our water it must be under control and available in time of need.

Fourth, recreation is an important part of our well being, and the need for recreation will continue to increase. Fish and wildlife are important resources to the state and are an integral part of recreation. We must plan for sufficient water and land resources to continue to provide recreation sites and fish and wildlife resources for the people of the state.

Fifth and finally, the goal of a water and related resource plan is to provide water to the people of the state where, when, and in amounts required and quality suitable for its intended use.

The welfare of the people of the State of Arkansas depends materially upon the peoper utilization and control of the water and related land resources. The people of the state can best achieve the proper utilization and control of the water and related land resources through the development of a well-balanced, coordinated and comprehensive state water resources policy and plan. Act 217 of 1969 requires the Soil and Water Conservation Commission to develop such a plan for the State of Arkansas. The adequacy of a plan is dependent on the accuracy and completeness of the materials that have been used in its formulation.

The plan will address water and related land resource activities; however, there are many other activities and functions that are dependent upon water for a complete achievement of their anticipated goals; for example, water-based recreation and wildlife habitat. In these instances we will want to depend upon the expertise of all related state agencies.

This leads to another point: that the process of planning must be an integral part of the management of water and related land resources. Management of the water and related land resources will require constant communication among planning, executing and evaluating programs on the part of those state agencies responsible for Arkansas' water resources. With this in mind, the limitations of a State Water Plan can be readily seen. The plan can only serve as a strategy or outline, of an approach to managing the water resource. Because a State Water Plan is published does not mean the work is finished; on the contrary, it has just begun. The plan will constantly need up-dating and revising to meet changing needs, and recommendations set forth in the plan must be implemented.

The long-range goals and objectives are:

A. Provide adequate quantities of acceptable quality water for:

   (1) Public water supply (municipal and industrial)

   (2) Rural water supply (domestic and livestock)

   (3) Self-supplied industries

(4) Irrigation

(5) Fish farms

(6) Electric power generation

(7) Wildlife (fish and game)

(8) Recreation

(9) Navigation

B. Alleviate flood damages to urban, rural, and farm lands.

(1) Non-structural methods
flood plain regulations

(2) Structural methods

a. Flood water regarding structures

b. Channel improvement

C. Reduce soil erosion and sediment deposition

(1) Land treatment measures

(2) Encouraging proper land use

(3) Sediment retention structures

(4) Water retarding structures

D. Provide adequate water for the increasing needs of outdoor recreation.

E. When in the best interest of the state, preserve scenic rivers and natural or unique areas.

Policies to be considered in developing the State Water Plan:

1. Maximum economic development of the water resources of the state, for the state as a whole.

2. Benefits to be derived from development of reservoir sites for the combined purposes of flood control, water conservation, recreation or municipal water supply.

3. Protect and help preserve unique resources such as wild and scenic rivers.

4. Safeguards to public health, aquatic and animal life.

5. Water development policies, whenever possible consistent with the beneficial development of other natural resources.

6. Inter-relationship of groundwater and surface water supplies.

7. Alternative programs, projects and developments in the interest of effecting maximum water resource development.

8. Use of stored waters in augmenting streamflow for aquatic and other wildlife.

9. New water laws to protect the state water and related land resources.

10. Investigation of inter-basin transfers as a solution to Arkansas water problems.

STATUS OF WATER PLAN

As was stated earlier, the adequacy of the water plan is dependent on the accuracy and completeness of the materials used in its formulation. Much of the information needed for the development of a state water plan is either incomplete or nonexistent. The Arkansas Division of Soil and Water Resources has, for the past several years, been working to obtain more accurate and complete data. For example, the Division has initiated research contracts to study: the suitability of the Arkansas and Red Rivers for irrigation; the groundwater resources in Northwest Arkansas; and to develop an Arkansas Water Resource Management Information System. Several other needed studies have been initiated by the Division which include a state water use inventory, an inventory of the remaining critical dam sites, and a statewide Type IV River Basin Study.

At the time this plan was published, much of the data needed for a state water and related land resource plan was lacking. Therefore, much of the information in this plan is general in nature and will require revision and updating. It should be recognized that a water plan will never be a completed document, but rather will continually require revisions and updating due to changing conditions, unforeseen developments and changing technology.

CHAPTER II

Arkansas Water Resource Management Information System (AWRMIS)

AWRMIS COMPUTER PROGRAM

AWRMIS is a computerized tool for water resource planning. The system has been under development for several years. The first such system, known as HISARS (Hydrologic Information Storage and Retrieval System) was developed by E. H. Wiser, Department of Biological and Agricultural Engineering, North Carolina State University, and became operative in July, 1969.

The system is running on the IMB system/370 model 155 computer at the University of Arkansas. By making use of an operating system feature known as the indexed sequential access method, together with the direct access capabilities of the PL/1 language, AWRMIS can retrieve any one of the hydrologic or climatological records directly.

The following data are now stored by the system:

a) Streamflow
b) Rainfall
c) Temperature
d) Evaporation
e) Snowfall
f) Events (days with occurrences of various types of weather phenomena)

Operations in AWRMIS are divided into two divisions: Accessing and Processing. The Assessing function serves to obtain required records for listing or processing. The Processing function performs a number of routine analyses (low flow, statistical, etc.) on the data.

Although additional features of the system are planned, we believe that the current version will be useful for a large number of potential users. In its final form, the system will include the basic data and the means for:

a) Making estimates of projected water availability
b) Making economic projections and translating these into projected demands for water resources
c) Identifying problem areas and considering alternate solutions

NEED FOR AWRMIS

The considerable scope of state water resources planning responsibilities in Arkansas ranges from intra-state planning at county, municipal and conservation district level, to inter-state planning at a regional level in the formulation of interstate river basin plans. Thus, this extensive range of planning responsibility requires access to planning data at all levels. Equally essential is the ability to utilize such data in the recurring development and review of water and related land resource plans. It is toward the resolution of these two requirements that the Arkansas Water Resources Management Information System (AWRMIS) is directed.

OBJECTIVES AND FEATURES OF AWRMIS

The AWRMIS is a computerized tool for water and land related resource planning. There is an extremely large amount of water and land related resource data available for the State of Arkansas. This information is available through several different federal and state agencies, which make it difficult for a planner to sort out and compile the desired data. Through the aid of AWRMIS the available information can be stored, retrieved and manipulated to present data in any form desired by the water resource planner.

The first chore in developing the AWRMIS was to obtain all water resource data, store it in the computer and develop necessary processing programs. Once the basic data and processing programs were developed, such programs as demographic projection, streamflow simulation, water budget, water use projection etc. were developed. Much of the data necessary to water resource planning was not available and separate studies had to be initiated. For example, water use data for Arkansas was inaccurate and incomplete and there is very little data available on the groundwater of Northwest Arkansas.

AWRMIS is the single most important aspect of the State Water Plan, because it will provide answers to our water and related resource problems or provide the necessary information for planning decisions. The state water plan essentially summarizes the state's water and related land resources, points out problem areas and makes certain recommendations; however, AWRMIS will provide the answers to the problems and the basis for the recommendations.

The ultimate objectives of AWRMIS is the assembly of a large data base, consisting of a variety of water and land resources, economic and demographic information and manipulating these data by computer in order to: predict future water demands for cities, counties, watershed or river basins for all major water uses; such as, municipal and industrial, self-serviced industries, irrigation, fish and minnow farms, rural, wildlife, navigation, hydroelectric power; analyze possible source of supply to determine their adequacy; and provide other information necessary to insure the wise use and protection of Arkansas' water and related land resources.

AWRMIS is available to anyone desiring to use the system. The system is user orientated in that the command language consists of a set of English language words. Appendix D is a users manual for that portion of AWRMIS which is complete at this time. It is anticipated that state and federal agenices plus private concerns will benefit from this system.

When completed, Appendix D will provide a more detailed descripition of AWRMIS and its capabilities and complete user's manual.

CHAPTER III

PLAN FORMULATION

PLAN FORMULATION

INTRODUCTION

Act 217 of 1969, known as "An Act for a Comprehensive Water and Related Land Resources Management Program for the State of Arkansas," charged the Arkansas Soil and Water Conservation Commission with the duty of developing a State Water Plan. The act instructed the Commission to protect the waters of the state from encroachment by other states or the United States and give due consideration to existing state or individual water rights and make equitable adjustments of individual water rights affected by implementation of the plan. Act 217 states that the Water Plan will be state policy for development of water and related land resources in the State of Arkansas.

Act 217 of 1969 did not indicate a time limit for completion of the proposed water plan nor did it define the scope of such a plan.

HISTORY OF PLAN

Shortly after 1969 an attempt was made to gather the necessary data to produce a water plan. At first the idea for the state water plan was to publish river basin reports for all the major basins in the state. The Commission published two basin reports, the Ouachita River Basin Report in 1970 and the Bartholomew-Beouf-Macon River Basin Report in 1972. This concept was abandoned in 1972 because several federal agencies were preparing river basin reports, and this was a duplication of effort.

In 1973 the Commission employed the Gulf South Research Institute to prepare Phase I and II of the state water plan. Phase I was a preliminary water use inventory, using existing water use data and projecting it to indicate the water needs in the year 2020. Phase II was an outline of study procedures, which pointed out the procedure for developing a state water plan. The information in these two publications was general in nature and confirmed the need for more accurate and complete information.

The Commission re-evaluated the State Water Plan and took positive action to develop a plan that would fill the need for the present and future. A contract was initiated with the University of Arkansas to develop the Arkansas Water Resources Management Information System. This is a computerized program to store the multitude of water and related land resource data. The Arkansas Water Resource Management Information System, known as AWRMIS, is the most important single aspect of the State Water Plan. AWRMIS enables the water resource planner to manipulate raw data and produce valuable information on the state's water resources. When completed, AWRMIS will be able to print out present water use for any county, city or watershed and predict future water needs. It will indicate future problem areas and alternate sources of water supply. These are only a few of the tasks that can be performed with the AWRMIS

program. The Commission has been able to make good progress on the AWRMIS through a yearly contract with the University of Arkansas for only $50,000 per year. It is very important that the AWRMIS receive legislative and executive support because of its importance to the State Water Plan. In 1975 money was not appropriated for the AWRMIS program, which will cause a delay in its completion.

NEEDS AND RECOMMENDATIONS

General

Much of the data needed for compiling a state water plan is either incomplete or does not exist. This became quite evident as a result of the Division's involvement in the 1975 Assessment of Water and Related Land Resources as described on page 12 of Appendix "A". The data and information needed for a water plan, and especially AWRMIS, should be as complete and accurate as possible in order to produce sound plans and decisions. As a result, the Division found it necessary to contract for additional research and studies in these deficient areas.

For example, little is known about the groundwater resources in the Ozark and Ouachita Mountain Highlands; therefore, the Division contracted with the Water Resources Research Center at the University of Arkansas to study this area. The research has been completed and the final report was submitted to the Division in July of 1975. The Summary, Conclusions and Recommendations of the report indicate that the present data may prove insufficient in many respects as the utilization of groundwater resources increases as is indicated by the projected future economic growth in northern Arkansas.

In 1975 Congress enacted Public Law 93-251 which enabled the Army Corps of Engineers to cooperate with states in developing water plans. The Commission has asked the Little Rock District of the Corps of Engineers to make a comprehensive water use inventory for the state. An accurate, complete and precise water use inventory is a must in order to develop and maintain a well planned water resources management program.

The Commission has requested that the U. S. Department of Agriculture, Soil Conservation Service prepare a Type IV River Basin Study for the State of Arkansas. The major objective of this study will be to develop a Land Resources Management Information System by combining the soils data which is available through the Soil Conservation Service with the land use data available through the U. S. Geological Survey's Land Use Data and Analysis (LUDA) Program. The final product will hopefully provide for a comprehensive and systematic analysis of land use. Soils data is perhaps the single most important attribute of a land resources management system. From properly defined soils data, inferences can be made on such things as potential use, erosion hazards, and sediment yields. This report would also be beneficial in that it would update all existing basin reports. The proposed Type IV statewide basin report is scheduled to begin in fiscal year 1976.

The Division of Soil and Water Resources, by authority of Arkansas Act 14 of 1963, cooperates with the Water Resources Council and receives grants as provided for by Title III of the Water Resources Planning Act and administered by the Water Resources Council. The objective of the program is to increase the capabilities of states for water resources planning. The planning grant funds have been used to build staff capability, initiate and/or expand Arkansas' water planning activities, obtain consultants services, and participate in state and/or regional planning efforts.

The Division has been receiving planning grant funds from the Water Resources Council since fiscal year 1967 to assist with water and related land resource planning. We are of the opinion that the Title III assistance given to Arkansas has vastly improved our water resource planning efforts.

There are several areas, relating to the State Water Plan, that need the support of the legislative and executive branches of state government. A detailed discussion can be found on page 12.

Research and Data Collection

A need exists for more funding for the purpose of research and data collection. Some areas in which additional study is needed are as follows:

(1) Accurate and complete water use inventory for the state. This study should be detailed enough so that water use figures can be compiled by county boundaries, hydrologic boundaries and for individual towns and cities. Water use data should be collected for all categories of use such as, public supplies, self-supplied industry, rural, irrigation, fish and minnow farms, wildlife impoundments and fuel electric power for incorporation into AWRMIS. At the present time the U. S. Army Corps of Engineers has been requested by the Division to contract for such a study under authority of P. L. 93-251.

(2) Additional information is needed on groundwater resources in the Ouachita and Ozark Mountain Highland. The following recommendations for further studies should be considered as increased utilization of groundwater from the Roubidoux and Gasconade Formation occurs.[1]

a) Data are needed to outline more accurately the depths, thicknesses, facies changes, and continuity of the aquifers. As new wells are drilled they should be evaluated and the new data incorporated to increase the accuracy of existing maps.

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[1]MacDonald, H., Doy L. Zachary, Hugh Jeffus, Northern Arkansas Groundwater Inventory, Little Rock, Arkansas, Arkansas Soil and Water Conservation Commission, 1975.

b) Analysis of existing geophysical well logs may offer valuable information on porosity, permeability, safe yield, occurrence of subsurface movement of water within the aquifer units.

c) A more comprehensive study is necessary to establish the magnitude of influence that linear and fracture systems exert on water availability from the aquifers.

d) The existing water level monitoring program in northern Arkansas should be expanded to include several well sites equipped with continuous monitoring devices. This would provide more accurate information on discharge, recharge and water declines.

e) A program of co-operation between drillers, engineering companies, and state and federal agencies should be initiated in Arkansas to insure the optimum development and utilization of data from newly drilled wells.

(3) Development of socio-economic projections including city, county and state data is needed for incorporation into AWRMIS for the purpose of predicting future water use. The University of Arkansas is presently under contract to the Commission to develop these projections.

(4) An inventory of existing dams has been completed and one should be made to identify the remaining dam sites which are significant to the state as a natural resource.

(5) More information is needed on the quality of the state's waters for certain purposes such as irrigation and public supplies. A report entitled "Irrigation-Using Arkansas River Water," prepared under contract by the Water Resources Research Center, University of Arkansas, was published by the Division in FY 75. The University of Arkansas is currently under contract to the Division to investigate the suitability of the Red River for irrigation.

(6) At the present time AWRMIS is approximately one-fourth complete. Additional funds are needed to complete this project (see Appendix "D").

State Approval and Support

The State Water Plan, as set forth in Act 217, "shall be the state policy for the development of water and related land resources." Therefore, the State Water Plan must be approved and supported by the Legislative and Executive branches of State Government. Some of the areas which we believe to be of particular significance in this regard are as follows:

(1) Legislation is needed to require that all persons, municipalities and industries report annual water use, including surface and groundwater supplies. Some industries are reluctant to report water use for various reasons; provisions can be made to keep these figures confidential or incorporate them in totals that will not disclose one company's water use.

(2) Legislative and Executive support to promote the multi-purpose aspect for flood control projects. For example, encourage the inclusion of public water supply or recreation in the Corps of Engineers and Soil Conservation Service projects.

(3) Continued support for flood control projects in those areas of the state that need structural measures to protect lives and property.

(4) More control is needed on the development of rural water supply systems. The Commission supports the organization of regional water distribution systems which can serve entire counties or multi-county areas. This type or organization is particularly adaptable to counties surrounding the large Corps of Engineers lakes. Numerous smaller water users associations are springing up around the state which are difficult to keep up with and sometimes do not fit in with the overall State Water Plan. Legislation is needed which would provide a means to monitor the formation of these smaller associations to ensure compatibility with the State Water Plan.

(5) In areas where public water supply is inadequate, support is needed to encourage the United States Congress to reallocate water in the conservation pools, of the large Corps of Engineers lakes, for the purpose of public water supply.

(6) Groundwater legislation is needed so that pumping can be controlled in areas where there is a danger of depleting the groundwater supply.

(7) Legislation is needed to control erosion and sediment during construction of subdivisions, shopping centers, highways and drainage and flood control projects. A plan for controlling erosion and sediment should be submitted and approved before construction begins. This will help preserve our streams, lakes, wildlife and aesthetic values.

(8) Continued support for eliminating pollution sources through the Arkansas Department of Pollution Control and Ecology. The natural salt pollution sources on the Red and Arkansas Rivers are located in Texas and Oklahoma and we need to encourage the Corps of Engineers and others to proceed with their projects designed to reduce the salt concentration in these rivers.

(9) A land use policy is needed to insure an orderly development of the states resources.

FORMAT

This plan is presented in several volumes, a Main Report and several appendices. The Main Report contains general information about the Water Plan and the State. At the present time there are four appendices. These appendices contain information on water use, existing and proposed water development projects, existing water laws and proposed legislation, and water and related land resource problems and needs including recommendations.

FUTURE PLANS

As work on the State Water and Related Land Resource Plan continues it is recommended that a special committee be organized to: establish state water policy; recommend research and study needed for further refinement of the water plan; outline water plan format; review and comment on applicable sections of the plan; and serve as technical advisors. The committee should be composed of state and federal agencies and organizations that have expertise in the applicable water and related land resource field.

Recommended Committee members:

- ✓ a. Soil and Water Conservation Commission (Chairman)
- ✓ b. Arkansas Health Department
- c. Arkansas Forestry Commission
- ✓ d. Arkansas Geological Commission
- ✓ e. Department of Local Services
- ✓ f. Department of Pollution Control and Ecology
- ✓ g. Arkansas Waterways Commission
- h. Committee on Waterwell Construction
- ✓ i. Stream Preservation Committee
- j. University of Arkansas - Water Resources Research Center
- ✓ k. Governor's Office of Planning
- ✓ l. Arkansas Industrial Development Commission
- ✓ m. Arkansas Game and Fish Commission
- n. Municipal League
- o. Agricultural Extension Service
- p. Department of Parks and Tourism
- q. USDA - Soil Conservation Service
- r. U. S. Army Corps of Engineers
- s. USDA - Farmers Home Administration

t. USDI - Geological Survey

u. USDI - Bureau of Sport Fisheries and Wildlife

v. USDA - Economic Research Service

w. USDA - Forest Service

CHAPTER IV

IMPLEMENTATION OF THE STATE WATER PLAN

IMPLEMENTATION OF THE STATE WATER PLAN

The ability to achieve the benefits of developments proposed in this water and related land resource plan lies largely with the legislative and the executive branches of the state government. Unless specific steps are taken to cause development to occur in accord with this document, the water plan will be only an optimistic prediction of what could have been attained.

BASIC PREMISE

A cursory review of the data concerning the existence of these vast quantities of water would seem to indicate that there is adequate water for all needs. However, in order for a true appraisal of the situation to be made, certain limiting factors have to be considered. These limitations include for surface water, such items as time of year water is generated as rainfall, quantities generated in relation to time of year and day, capability to store water, locatation of water collection centers (reservoirs, streams, etc.) in relation to point of use requirement, quality, etc.; and for subsurface water, such items as quality, quantities produced by water-bearing aquifers in relation to requirements, and location of point of use. Therefore, since there is sufficient water available within the state to satisfy all needs, the fundamental value of the Water Plan is to facilitate a water management system. Only through the installation of logical and consumer orientated management can the requirements of all citizens be satisfied.

REQUIREMENTS FOR IMPLEMENTATION

Plans

Implementation of projects and programs for development, regulation, protection, and use of Arkansas' water and related land resources can be successful only if based on well-conceived and adequate plans. The opportunities for implementing certain types of plans are often sporadic depending on public sentiment, availability of funds, and changing priorities of need. Generally a wide array of plans must be available to permit a selection of those to be implemented from among several plans serving similar objectives.

The availability of completed plans containing proposals of specific needs and evaluations of the costs and benefits of such actions is essential to the decision-making process of rational implementation.

Funds

Implementation of needed programs and projects requires that a portion of our present productivity be reinvested to gain increased future productivity, and that we yield a part of our economic opportunity to preserve and enhance non-economic values.

Projects and programs needed in Arkansas and contained in this plan must compete with numerous other highly desirable and beneficial uses for public funds. When suitable plans are available, non-federal obligations are assured, and adequate institutional arrangements are made, there still remains the problem of securing the funding and other forms of federal assistance which may be required. Concerted and intensive action at the local and state levels will be required to otbain the type and amount of assistance desired at the time needed.

Water resource development programs and projects require large financial outputs. Consideration must be given to both initial construction costs and continued maintenance. Since programs are normally undertaken only if the benefits in dollar terms and otherwise, exceed the costs, such outlays of funds are more properly viewed as investments than expenditures.

INSTITUTIONAL CONSIDERATIONS

Presently, in Arkansas, a wide variety of state and local agencies carry out planning activities with emphasis on certain asepcts of development. The institutional arrangements under which many planning activities are carried out warrant the highest level of attention. The ever-present possibility for vital planning to become biased must be recognized and procedures instituted to insure that limited agency interests never take precedence over broad public needs.

With fracturing of responsibilities, agencies are cast into the role of alternately advancing their programs and defending their assigned interests against the programs and projects desired by others. To this extent, agencies can themselves become special interests rather than guardians of the public trust.

The majority of projects and programs included in this plan have local, state and federal impact. Relationships throughout these governmental levels must be based upon mutual understanding and guided by stated and accepted procedures to encourage joint and harmonious action. Conflicts between vested interests will arise. Provision must be made to insure that adequate means are available for discussing all views and yet insure resolution of conflicts so that progress is not impeded. Public bodies especially must see that potentially controversial issues are raised, adequately examined and fairly settled as early as possible in the planning process in order that decisions, once made, can be supported.

ITEMS REQUIRING LEGISLATIVE ACTION

Beyond the establishment of goals and their quantification into specific amounts of desired outputs of resource development, the rules under which these products of development can be attained must be established. These rules are generally established through a series of legislative or administrative policy decisions. The most basic of public policies already exist in law, generally stated in response to some past need. However, planning for the future must deal with problems not yet encountered and questions which have not yet been answered.

Implementation of projects included in this plan would be accelerated by clear statements of legislative policy concerning several basic issues:

1. Interbasin transfer. Under the riparian doctrine of water rights existing in the State of Arkansas, the surface waters originating in a particular river basin are owned by the riparian landowners of that basin. Therefore, transfer of any portion of that water would be illegal. There are situations in which portions of the quantities of water generated within a basin are surplus to the requirements of that basin. Concurrently, population centers in adjacent river basins need more water than riparian watersheds will produce. Legalization of interbasin transfer will alleviate the situation.

2. Subsurface water use. The State of Arkansas has no law in regard to rights to use of subsurface water. The few court decisions that have been rendered awarded the riparian owners of land the right to "reasonable use" of underground water. These decisions do not take into account the capability of the subsurface water aquifers to continue to produce at the current rate of withdrawals. In many areas of the state, groundwater is being withdrawn at a rate greater than recharge is accomplished. This fact creates either existing or future water shortages. Yet, despite the impact of this situation on all forms of water use, no state policy has been established in regard to either the mining of underground water or priorities of use. Immediate consideration by the legislature of a solution to this problem is of utmost importance.

3. Water use reporting system. Various state and federal agencies have fragmented reporting systems for water use. When the total available information is compiled, there are remaining many elements of water use for which no data is reported. Without this information, planning for current and future water needs is seriously limited. No valid projections are possible; therefore, no valid management decisions can be made.

CHAPTER V

HISTORY

HISTORY

PEOPLE OF THE STATE

The earliest inhabitants of Arkansas were probably the Bluff Dwellers, about 500 B.C. to 1300 A.D. Their presence is indicated by artifacts that have been found in caves and dry shelter areas, under rock ledges in the northern sections of the state, particularly the bluffs of the White River and other streams of that area.

From 1300 A.A. to 1700 A.D., a people referred to as the Top Layer People occupied shelters above those of the Bluff Dwellers.

Then came Indians from the north who were hunters in search of buffalo and established themselves around the northern Arkansas waters. These were the Osage Indians that were here when the first white settlers came to Arkansas.

The Mound People were also early inhabitants. They built mounds, which have archeological importance, made pottery, worked stone and mined novaculite. Their mounds can still be found in many areas of the state along rivers.

The Mound People disappeared and were followed by the Cole Creek Indians who occupied the same general area. The Cole Creek Indians were in Arkansas from 1100 A.D. to 1400 A.D., and developed a more organized tribal life form than the Mound People.

From 1400 into the 1800's, the Caddo Indians could be found on most streams in southwestern Arkansas. They probably migrated from Mexico or the Western Plains and took over the mounds and villages of the Cole Creek Indians. The Caddo Indians are known to have cultivated crops such as beans, squash and corn, but were also hunters. Their buffalo hunts into the area above the Red River often encountered problems with the Osage Indians, who came down from the northwestern area for the same reason.

The Quapaw Indians migrated into the east central part of the state and along the Mississippi River and lower parts of the Arkansas River. The Quapaws were also known as the Downstream People and the Arkansas Indians.

When DeSoto came to Arkansas in 1541, the Osages, Caddoes and Quapaws were the inhabitants of Arkansas. DeSoto did not find the riches he was searching for during his expedition, but did observe the abundant wildlife, fertile soil, geography, and the people.

In 1673, the Frenchmen, Marquette and Joliet, explored Arkansas along the Mississippi River down to the mouth of the Arkansas River, then returned to Canada.

LaSalle claimed the Mississippi Valley for France in 1682. He came down from Canada, built a fort near where Memphis is now, and stopped again at the mouth of the Arkansas River where he named the country, "Louisiana."

Henri DeTonty was given a tract of land on the lower Arkansas River by LaSalle. DeTonty set out from Fort St. Louis down the Mississippi River to meet LaSalle. Since LaSalle had been murdered, DeTonty never made contact and returned to the land that he had been given. Here he established a trading post, in 1686, called Arkansas Post. This was the first white settlement of Arkansas.

In 1717, a few German immigrants settled in the area near Arkansas Post. The organization of this settlement was the intention of the Mississippi Company formed by John Law, a wealthy Scott living in France. When he became bankrupt the colony was deserted, but Arkansas Post remained to become an important trading post.

In 1763, the French gave Spain the area known as Louisiana. Some American and French settlements began to appear along the Arkansas, Black, White and Little Red Rivers. Most of the American settlers were from Kentucky and Tennessee.

EARLY RIVER TRANSPORTATION

As has happened in most pioneer-developed areas, the easiest and fastest access to the lands was by waterways which was the case in the early days of settling Arkansas. The waterways were used to transport new immigrants and supplies to the settlements along the river. With the advent of the steamboat, travel became even faster and easier. In 1834, the rivers of Arkansas had 9 steamboats carrying materials and people.

The snagboat, invented by Henry Shreve in 1833, was used to clear the Arkansas River up as far as Little Rock, and the Red River for a few miles. The Red River was not navigable to steamboats for many years due to the large amount of logs and trees blocking the river.

Little Rock, Arkansas Post, Batesville, Fort Smith, Helena, Pine Bluff and Camden all became important shipping points and trade centers as a result of steamboat travel.

USE OF LAND RESOURCES

The Indians of Arkansas were primarily hunters of buffalo, deer, and other game, which was abundant at the time and supported the Indian population.

The Caddo Indians used large bones of animals, stones and sticks as instruments of cultivation for the crops they produced. Corn, beans and squash were some of the crops of the Caddoes. These Indians were very likely the first farmers in Arkansas. Their nature was considered as peaceful. The Quapaw Indians were also farmers in that their women were responsible for the corn and other crops.

It seemed natural that the Indians who lived in the plains, lowlands and river valleys would establish some form of agriculture, whereas the Indians to the northwest hill and mountain regions of Arkansas would depend primarily on hunting and existing vegetation.

During the French and Spanish periods of ownership of Arkansas, trading, trapping and hunting were the only activities of white men in the region. Shortly after 1800, a few people from Kentucky moved into the area around Helena. They raised cattle and did a little farming of cotton and grain.

In the early 1800's, farming began in the uplands of Arkansas; also, cotton plantations developed in the delta and river valleys. This influx of people was due to the availability of cheap land and resulted in large forest areas being cleared for cultivation. By 1850, the number of plantations increased in size and number. More cotton production meant more cleared forest lands in the delta. An attempt was made to protect more delta land along the Mississippi River by building a levee, most of which was destroyed in the floods of 1858 and 1859.

The farmers of the hill regions were growing corn, wheat, tobacco, potatoes, fruits and vegetables, as well as raising cattle. A little further northwest, wheat and flax were being grown.

Railroads expanded in Arkansas after the Civil War. This started the decline of river navigation along with the fact that silt had begun to accumulate in the rivers, making it difficult for boat passage. Silt accumulations were the direct result of deforestation of land for lumber and crop production. The water runoff was carrying the soil with it.

Large plantations of southeast Arkansas were maintained by slave labor previous to the Civil War. After the war, the system of share cropping allowed continuation of these plantations.

In areas where farming was the main interest, the farms increased in number and decreased in size. This led to soil depletion, poor productivity and obviously poor economic conditions.

The only cash crop of importance in Arkansas during the 1800's was cotton. It was subject to war demands and over-production, which made its value unstable at times, but new lands were plowed into production anyway. In 1893, a levee was begun that allowed the reclamation of a million acres of productive land in the St. Francis River Basin.

From 1900 to 1930, cotton occupied about 75 percent of the southern and eastern lowlands. Over-production of cotton occurred during the First World War, causing the land to be overworked. Competition from foreign cotton created economic problems that carried into the great depression of 1929. Also, during this time, large forest areas were being cleared in the northeast, exposing new lands for farming with new mechanical equipment that was beginning to appear.

Apple production began in Baxter County in 1887. It became a successful crop and stimulated an increase in apple orchards of the northwestern highlands. 1919 was a peak year for apples, but by 1921 drought, parasites and falling prices reduced and destroyed most of the large orchards.

Other specialty crops appeared, such as peaches, in 1928, especially in Johnson County. Strawberries, as a substitute for cotton, were popular in White County after 1920. Watermelon brought fame to Hope, Arkansas. The growing of grapes increased to a large scale around Altus and Tontitown, given stimulus by prohibition. All areas of Arkansas were growing sorghum cane for making syrup.

The production of lumber has had a great influence on the land and the economy during these times. Timber was being cut four times faster than it was being replaced prior to 1925. This destroyed much of the virgin timber and created increasing erosion problems. The damage to the forest led to forest conservation practices after 1925.

LEGISLATION AFFECTING ARKANSAS' WATER AND LAND RESOURCES

As a consequence of the problems that grew out of the 1930's, such as stream pollution, soil depletion and erosion, the government accepted the responsibility for helping the people help themselves. Since man was the primary creator of these problems, it was obvious that man had to find the ultimate solution to the problems.

In the area involving water resources, the Corps of Engineers began work on the Arkansas River for the purpose of river navigation, authorized by the River and Harbor Act of 1832 passed by Congress. Later, more river and harbor bills were passed which provided funds for work on the tributaries of the Arkansas River. All the work on the state rivers from 1832 to 1912 was for river navigation, but the coming of the railroad was causing a decline in river traffic.

Floods of 1912 gave stimulus to the idea of river control and hydroelectric dam construction. In 1920, the Federal Water and Power Act allowed construction of dams such as the Remmel Dam in Arkansas, completed in 1924.

In the 1940's, the St. Francis River Basin was partially navigable, but the need for improvement of the basin has not been for navigation purposes. The need for watershed development, flood control, recreation and agricultural uses has taken foremost consideration.

The first important work has been done by private interests from 1904 to 1933 for flood control and drainage, by building levee systems and headwater diversions. By 1933, $69 million had been spent by the private sector. Their work greatly increased the agricultural area. Public Law 566 opened the way for watershed projects in the area.

The Flood Control Act of 1928, authorized the Corps of Engineers to begin flood control in the basin. Levee construction from Crowley's Ridge to Marianna, channel improvement from Wappapello to Crowley's Ridge, levee construction on the Little River down to St. Francis Lake, and other work on the tributaries and headwaters in the St. Francis Basin are either completed, under construction, or planned.

In the White River Basin, the White, Black and Current Rivers were important navigation routes in the early years of settling in Arkansas, and some early projects for the purpose of maintaining navigation.

Since about 1926, when traffic on these rivers declined, the work in this basin has been directed toward flood control, power generation, and recreational facilities for public use. Levee and drainage construction along the Black and White began in the 1930's, and much of the work has since been completed. Table Rock Lake and Bull Shoals Lake on the White River; Greers Ferry Lake on the Little Red River; and Norfork Lake on the North Fork River have all been constructed for flood protection, power and recreation within the White River Basin.

In the Red River Basin in Arkansas, levee construction in Hempstead County has protected some 5,000 acres in and around Fulton, Arkansas, from flood damage. On the Little River, Millwood Lake construction began in 1961 and is now complete. Another flood control project, now complete, is the channel work on Walnut Bayou, a tributary of the Red River.

The Arkansas River Basin development also received authorization from the Flood Control Act of 1938. Many flood control projects have been completed, such as the construction of the Blue Mountain Lake and 20 miles of levee on and along the Petit Jean River; levee and floodwall construction on Spadra Creek; the Nimrod Lake on Fourche LaFave River; and levee, pumping stations and drainage structures on Fourche Bayou. All of these are on tributaries of the Arkansas River.

On the Arkansas River itself, drainage structures, levee construction and improvements have been completed around Morrilton, Cadron Creek, Conway, Fort Smith and Dardanelle. Also, from Van Buren to Frog Bayou and from North Little Rock to Plum Bayou, as well as in many other areas, work has been completed.

Since river navigation is considered to have present and future importance on the Arkansas River, 17 lock and dams have been constructed to allow river traffic as far as Catoosa, Oklahoma.

As population increased, and the demand for water along with it, the need for planning water uses and supply became apparent. Through a long series of federal consideration and studies, beginning with President Truman in 1950 to President Johnson in 1965, the Water Resources Planning Act became law. This law allowed creation of River Basin Commissions and a Water Resources Council, to help solve the problems now and in the future.

In the area of land resources, governmental policy and law also developed out of need. The Department of Agriculture began in 1862. That same year the Land-Grant College Act was passed which provided Arkansas with a university. Directly out of these colleges grew the Agricultural Extension Service which served the farmers with advice and information.

The Agricultural Adjustment Administration was established in 1933, to help stabilize farm prices by paying farmers to reduce crop acreage. This helped take the production load from much of the soil as well as helping the farmer to survive. More than these actions were necessary, though. There was a real need for educating and technically assisting the farmer in the proper methods of handling the land. These needs became very apparent during the 1930's. To resolve the need, the Soil Conservation Service was begun in 1935, by the New Deal Congress. This agency alone could not solve the nation-wide conservation need problem. This led to the formation of Conservation Districts. The Conservation Districts became legal subdivisions of state government and the board of each district was made up of elected farmers of the district. They were given authority to develop and carry out their own conservation programs and prescribe regulations to prevent and control erosion.

The Soil Conservation Service then became the federal agency that provided technical assistance, equipment, and planting stock to the districts to help carry out their programs. This assistance also included what is now entitled the P. L. 566 program of construction of flood control measures on watersheds of less than 250,000 acres. Flood control measures may be water retarding and drainage structures, water supply for M & I, irrigation, fish and wildlife, and recreation, as well as land treatment to prevent erosion.

Since Arkansas has abundant resources of both water and land, these actions by the government have had in the past, and will have in the future, a tremendous impact on the preservation of these resources, the well-being of Arkansas people and the economy of our state.

CHAPTER VI

DESCRIPTION OF ARKANSAS

PHYSIOGRAPHIC REGIONS

The landforms of Arkansas belong to two major physiographic divisions of the nation, the Atlantic Plain and the Southern Interior Highlands. Physiographic regions may contain a diversity of terrain features but the type and structure of the bedrock and the processes involved in landform development are relatively the same within each region. Physiographic divisions are divided into provinces and those, in turn, into sections. The outline below shows the relationship of these in Arkansas.

Southern Interior Highlands Division
- Ozark Plateaus Province
  - Salem Plateau
  - Springfield Plateau
  - Boston Mountains
- Ouachita Mountains Province
  - Arkansas Valley
  - Fourche Mountains
  - Central Ouachita Mountains
  - Athens Plateau

Atlantic Plain Division
- Coastal Plain Province
  - West Gulf Coastal Plain
  - Mississippi Alluvial Plain

The Ozark Plateaus cover northern Arkansas and extend into eastern Oklahoma and to the Missouri River to the north. (See map, page 31). They consist of sedimentary rock which has undergone massive uplift and which remains relatively horizontal with only minor deformations. Stream erosion has removed much of the original surface rock and has dissected the area into hills and low mountains although some plains occur.

The Salem Plateau is mainly north and east of the White River in Arkansas. Elevations are generally 500 to 1,000 feet above sea level. Streams are gradually dissecting the broad uplands and the area is undulating to hilly, relief seldom exceeding 200 feet. The Springfield Plateau is found in northwestern Arkansas and in a narrow belt eastward. Elevations generally are from 1,000 to 1,500 feet. Extensive relatively level areas exist in Washington and Benton counties but relief of 200 to 300 feet occurs along major streams. Outliers of the Boston Mountains appear as isolated low mountains on the Plateau, the most notable being the Boat Mountain group near Harrison.

The Boston Mountains are the higher southern edge of the Ozarks. They are capped by Pennsylvanian sandstone, which has been removed from the areas to the north. The mountains are primarily flat-topped, summit ridges representing the original erosion surface of the plateaus. Great stream dissection has occurred, creating steep sided mountains and deep narrow valleys. Elevations generally range between 1,500 and 2,200 feet but exceed 2,500 feet. Relief is mainly within the 500 to 1,000 feet range but exceeds 1,600 feet. The northern boundary is well marked by a retreating escarpment in most areas, being especially prominent in its central extent from Jasper to Mountain View. On the south, the mountains descent rather sharply to the Arkansas Valley.

The Ouachita Mountains are also of sedimentary rock but here it has been folded to create generally parallel ridges and valleys which have an east-west orientation. Most of the mountain ridges are narrow, with steep slopes; crests tend to be sharp; valleys are generally rather broad. Within the Ouachitas, the sections are distinguished largely by the spacing of the folds.

The Arkansas Valley is from thirty to forty miles wide and the Arkansas River traverses it from northwest to southeast. The ridges are widely spaced, valleys dominating. The Arkansas alluvial plain is a distinct feature. Elevations of valleys generally are 500 feet, declining eastward. Mt. Magazine, elevation 2,823 feet and the highest point in the state, is in the Valley, as is Mt. Petit Jean.

The Fourche Mountains contain several major ridges. The crest of Rich Mountain is 2,500 feet and Fourches and Poteau mountains are little lower. The folding is closer than in the Arkansas Valley, but valley floors are broad and often of considerable elevation, around Mena reaching 1,100 feet at the center.

The Central Ouachitas are very closely folded. Some principal mountains are Caddo, Cossatot, Trap, Crystal, and Zigzag; the Caddo, Mazarn, Saline, and Ouachita basins are outstanding. Elevations of 2,000 feet are common toward the center and the west and local relief is between 300 and 900 feet.

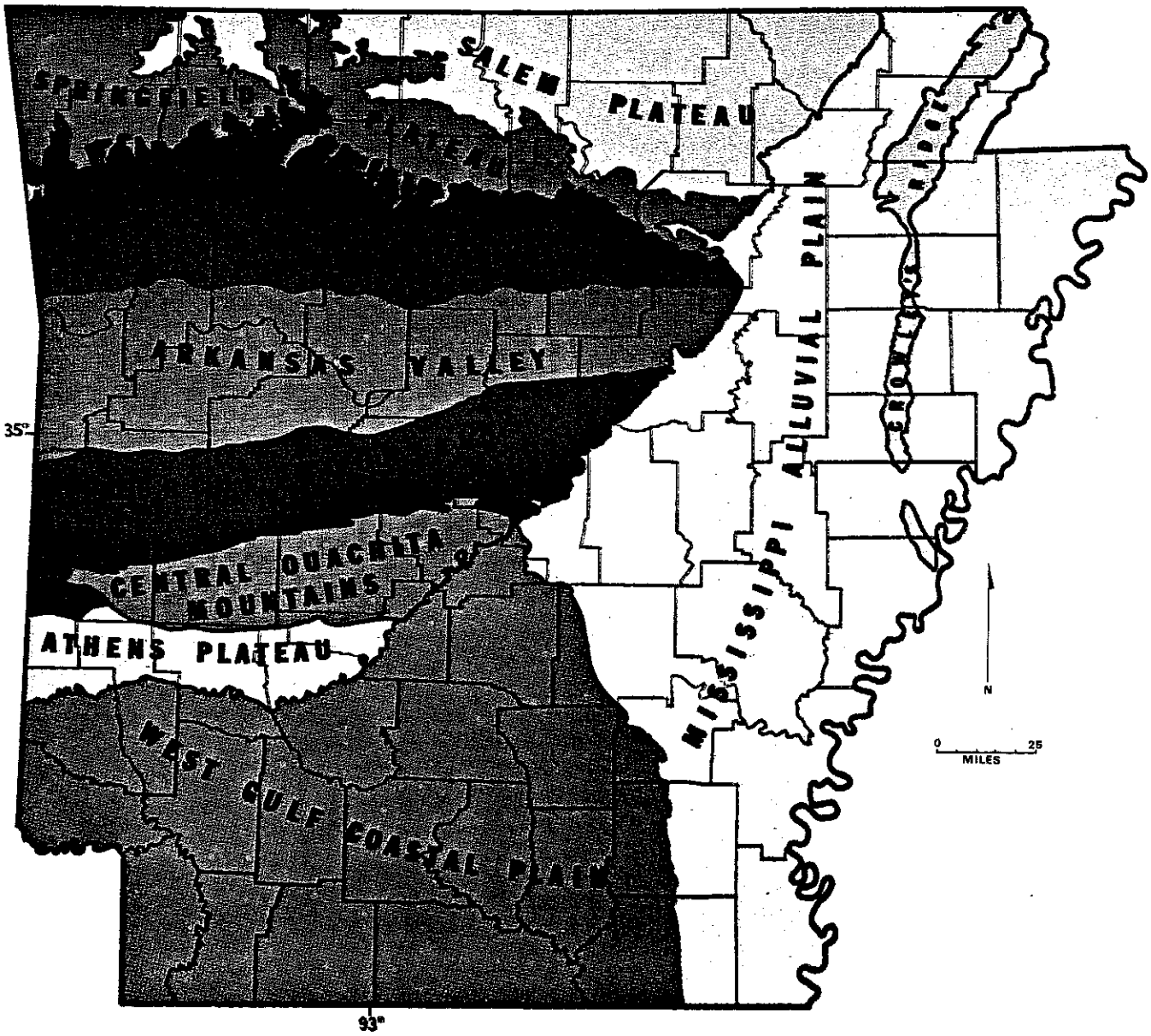
The Athens Plateau is a very narrow belt extending along the southern edge of the Ouachitas. Elevation is little above 500 feet and it has an undulating appearance. Occasional hills are remnants of an older surface.

The West Gulf Coastal Plain stands between 100 and 500 feet above sea level. It has a gently rolling surface, only moderately dissected by streams. Much of the surface material is unconsolidated sands deposited in the sea which once covered the area.

The Mississippi Alluvial Plain is a trough filled by stream sediments of great depth. The surface is generally flat, with local relief of less than 100 feet. Elevations range from 500 to 100 feet, decreasing southward. Crowleys Ridge is a striking irregularity upon the Plain. It is 3 to 12 miles wide, rising 200 feet above the Plain in the north and 100 feet in the south. It has a deep cover of loess, fine wind-deposited material, and is dissected into a rolling hill region.

GEOLOGY

The surface geology of the state is described by the eleven areas shown on the map on page 35 and described in the following narrative. The following table of geological history gives approximate ages of the geological periods mentioned in area descriptions.



PHYSIOGRAPHIC REGIONS

Source: Atlas of Arkansas, Arkansas Department of Planning

Figure 6-1

TABLE OF GEOLOGICAL HISTORY

ERA	PERIOD	EPOCH	APPROXIMATE AGE (in years) BEFORE PRESENT
CENOZOIC	Quaternary	Recent (Holocene)	10,000
		Pleistocene	1,000,000
	Tertiary	Pliocene	13,000,000
		Miocene	25,000,000
		Oligocene	36,000,000
		Eocene	58,000,000
		Paleocene	63,000,000
MESOZOIC	Cretaceous		135,000,000
	Jurassic		180,000,000
	Triassic		230,000,000
PALEOZOIC	Permian		280,000,000
	Carboniferous: Pennsylvanian		310,000,000
	Carboniferous: Mississippian		345,000,000
	Devonian		405,000,000
	Silurian		425,000,000
	Ordovician		500,000,000
	Cambrian		600,000,000

Area 1

The surface rocks of the Salem Plateau are the oldest of the Ozark Highlands, younger ones having been removed by erosion. They are largely Ordovician in age, and predominantly dolomite and limestone with some sandstone and shale. The Cotter dolomite of Lower Ordovician age, a massive formation 500 feet thick, covers most of the east and north of this region. The Everton Limestone is the prominent rock in the western and southern areas. The Calico Rock sandstone, a white sand, is at the base of Everton. Dolomite and glass sand are quarried. The former zinc-producing area of Arkansas is centered in the Ordovician rocks of Marion County but zinc was mined in numerous other areas where the same strata were exposed by stream cutting. Some lead is associated with the zinc deposits.

Area 2

This area is primarily the Springfield Plateau. The Boone formation, consisting of limestone and chert of Lower Mississipian age, is the surface rock. Weathering more easily reduces the Limestone, leaving large pieces of chert which are especially prominent on hillsides where the finer materials have been eroded away. The limestone is quarried in many localities. The St. Joe marble member is at the base of the Boone and is locally quarried for commercial purposes. Outliers of the Boston Mountains are especially common in the western part of the region.

They consist largely of sandstone and shale found in the Boston Mountains but lack the Atoka formation which caps the mountains. Manganese was formerly mined in Independence County and deposits still exist.

Area 3

The Boston Mountains and the eastern part of the Arkansas Valley are surfaced in sandstone and shale of Pennsylvanian age. The massive Atoka formation, over 1,500 feet thick, is the most prominent. The Atoka sandstone forms the bluffs at the top of the Boston Mountains.

Area 4

The western part of the Arkansas Valley is surfaced in Upper Pennsylvanian rock. The Savanna sandstone, Paris shale, Spadra shale, and Harthshorne sandstone are all significant. Coal is important in the Paris and Spadra shales, much of it accessible by stripmining. There are numerous natural gas fields in this region, producing a dry gas.

Area 5

Mississippian rocks surface most of the Fourche Mountains and the Athens Plateau of the Ouachitas. The Jackfork sandstone is particularly important in the major mountain ridges. The Stanley shale is the most widespread formation.

Area 6

The Central Ouachitas are closely folded ridges and valleys of Ordovician and Silurian sandstone and shale. Two prominent formations are the Crystal Mountain sandstone which is overlain by the Mazarn shale.

Area 7

Arkansas novaculite is exposed along the outer edge of the Central Ouachitas, sometimes referred to as the Novaculite Uplift. The novaculite is Devonian in age and is situated below the Hot Springs sandstone. It is a very hard, fine-grained rock of silica, used as an abrasive stone and as a silica source in manufacturing.

Area 8

Recent alluvium and terrace deposits cover much of the lowlands in the southeastern half of the state. Particularly, they provide the

surface materials in the Mississippi Alluvial Valley and along the rivers of the Gulf Coastal Plain. The recent alluvium has been deposited by flood waters of the streams and consists of a variety of water-washed material, especially silt. The terrace deposits are frequently older, often Pleistocene, representing former levels of bottomland below which streams have now cut.

Area 9

The edge of Crowley's Ridge and a large area of the Gulf Coastal Plain are surfaced with the Claiborne, Wilcox, and Mickey formations of Eocene age. The area in the Coastal Plain is interrupted by the more recent alluvial deposits of the major rivers, the Saline, Ouachita, and Red. Generally, the surface materials are poorly consolidated sand and clay. There are scattered deposits of lignite. Some quartzite occurs in the Claiborne and Wilcox formations and the Midway contains white limestone. The bauxite deposits of Pulaski and Saline counties occur in this surface area and the oil and gas deposits of South Arkansas are in older and much deeper formations below the Coastal Plain. The Wilcox formation is the source of several industrial clays.

Area 10

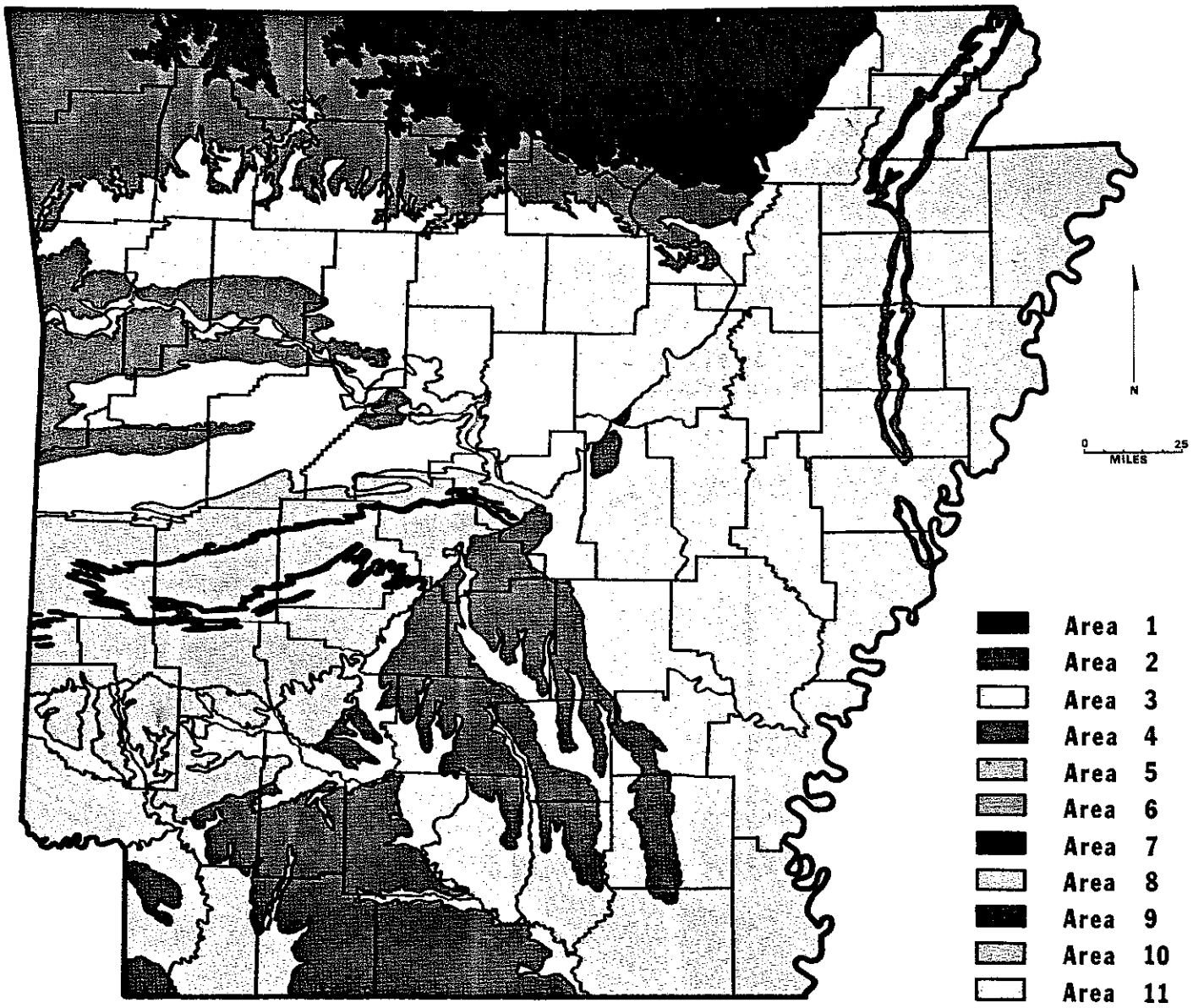
Scattered Cretaceous formations occupy the inner edge of the Gulf Coastal Plain from the Oklahoma line to Clark County. Most of the beds are coarse sand, clay, or gravel. The lowermost formation is the Trinity which also contains gypsum. The Tokio formation represents the Middle Cretaceous and contains some lignite; the Upper Cretaceous is represented by the Brownston marl which is a fossiliferous calcareous clay.

Area 11

Loess caps the higher portions of Crowley's Ridge. This is a fine, wind-blown silt derived from the alluvial deposits to the west of the Ridge. The prevailing westerly winds picked up the dried alluvium which was deposited mainly during the Pleistocene and carried it eastward, dropping it when forced to rise. The bluffs on the east side of the Mississippi Valley, from Cairo, Illinois, southward, are also capped with loess.

PRECIPITATION

The mean annual precipitation ranges from about 40 inches in the western Arkansas River Valley to about 56 inches in the western Ouachitas. (See map of Arkansas showing average annual precipitation, Page 37 .)



SURFACE GEOLOGY

Source: Atlas of Arkansas

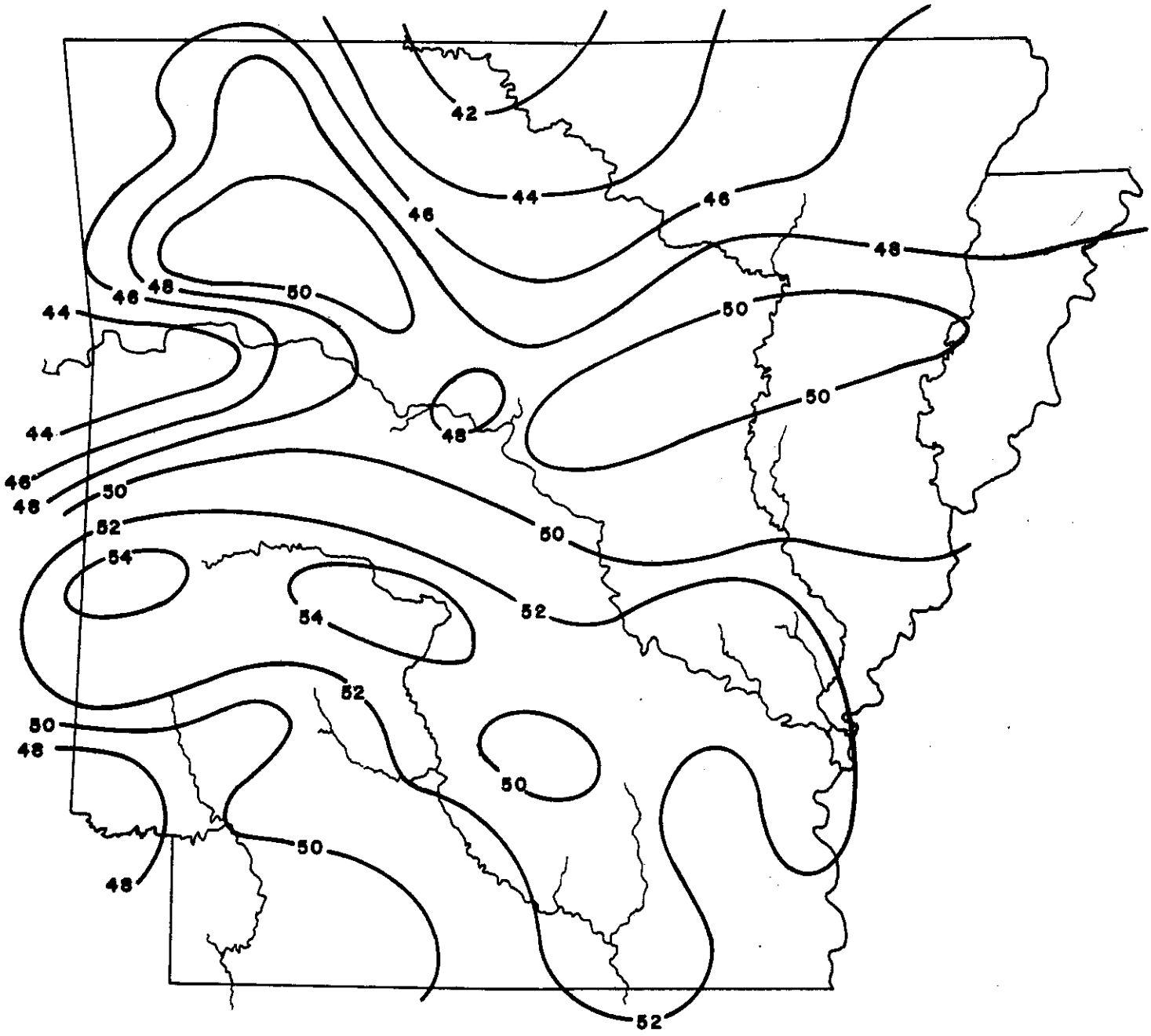
Figure 6-2

Most precipitation in Arkansas is frontal in origin, occurring along the zone or "front" where two unlike air masses meet. Locally in highland areas precipitation amounts are increased by orographic action which occurs when moist air is forced to rise over a land form barrier. This happens especially in the area of the Ouachitas that has the highest mean annual precipitation in the state. Most precipitation is in the form of rain. Snowfall occurs throughout the state, but nowhere is it great enough to add significantly to the precipitation total. Snowfall in the south is usually very light; in some years only a trace is recorded.

Since most of the state's precipitation is of the frontal or cyclonic type, the locations of the major storm tracks in the area are important factors in Arkansas' precipitation. Three major storm tracks affect the state. The most important is the South Pacific track which crosses the state diagonally from the southwest to the northeast. The effects of this track can be seen on the map as the area having the greatest annual precipitation through the center of the state. As a low, or cyclone, moving along this track reaches the central part of the nation, it draws warm, moist air toward it from the Gulf of Mexico; thus creating precipitation in Arkansas.

The Texas storm track passes to the south and east of the state. Lows following this track are able to draw considerable moisture up from the Gulf. The track comes closest to the southeast corner of Arkansas, evidenced by the area with above 50 inches of precipitation in that region of the state.

The third track, and the one of least importance to the state, is the Colorado storm track which passes to the north of Arkansas through southern and central Missouri. This track is farther from the moisture source of the Gulf so it has less effect on the precipitation in the state. However, the Colorado track is responsible for some of the precipitation received in northwest Arkansas.



MEAN ANNUAL PRECIPITATION (INCHES)

Figure 6-3

Source: State of Arkansas
Arkansas Geological Commission
Water Resources Circular No. II
by James L. Patterson
U.S. Geology Survey

ARKANSAS

PRECIPITATION NORMALS

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ABBOTT	2.64	3.07	3.89	4.65	5.51	3.52	3.26	3.45	3.58	3.06	3.00	2.82	42.45
ALUM FORK	4.49	4.20	5.50	5.67	5.83	4.47	4.16	3.76	3.00	3.30	3.89	4.19	53.26
ARKADELPHIA 2 N	4.46	4.36	5.40	5.97	5.76	3.80	3.66	3.07	4.13	3.50	4.09	4.32	52.54
ARKANSAS CITY	5.15	5.24	5.99	5.13	4.60	3.05	4.85	2.84	3.42	2.84	4.11	4.85	52.15
BATESVILLE LIVESTOCK	3.43	3.53	4.45	4.72	4.99	3.77	3.81	3.32	3.67	3.00	3.87	3.54	46.14
BATESVILLE L AND D 1	3.81	3.83	4.30	4.68	5.01	3.80	3.99	3.42	3.91	3.13	4.28	3.64	47.89
BEECH GROVE	3.85	3.75	4.65	4.35	4.70	3.48	3.30	2.97	3.32	2.55	4.16	3.72	44.86
BEEDEVILLE	4.42	4.27	5.02	4.69	4.81	3.38	3.15	3.54	3.23	2.81	4.12	4.19	48.23
BENTON	4.39	4.45	5.08	5.71	5.71	3.59	3.93	3.83	3.72	3.58	4.15	4.31	52.45
BLACK ROCK	3.61	3.68	4.07	4.40	4.91	3.85	3.44	3.18	3.61	2.96	4.35	3.74	45.90
BLYTHEVILLE	4.50	4.40	5.24	4.41	4.50	3.58	3.50	3.12	3.45	2.66	4.01	4.38	47.83
BOONEVILLE	3.07	3.31	3.88	4.53	5.73	3.68	3.93	3.44	3.67	3.24	3.33	3.06	44.98
BOUGHTON	4.07	4.10	5.08	5.60	5.84	3.49	3.54	3.04	4.00	3.46	4.00	4.15	50.51
BRINKLEY	4.44	4.60	5.09	5.44	5.01	3.33	3.73	3.36	3.48	2.86	3.95	4.70	50.08
CALICO ROCK	3.24	3.33	3.89	4.38	5.20	4.52	3.28	3.32	3.66	3.51	3.67	3.11	45.11
CAMDEN 1	4.21	4.40	5.23	5.46	5.05	3.27	3.87	3.17	3.86	3.12	4.38	4.64	50.65
CARLISLE 1 SW	4.13	4.25	4.82	4.86	5.21	3.40	3.29	3.55	2.86	2.74	3.56	4.07	46.76
CLARENDON	4.43	4.67	5.10	5.34	4.42	3.46	3.64	3.19	3.23	3.04	4.00	4.49	49.03
CONWAY	4.04	4.22	5.14	5.15	5.70	3.69	3.41	3.00	3.89	3.10	4.14	4.12	49.60
CORNING	4.20	3.80	4.43	4.40	5.76	3.81	3.75	3.03	3.32	3.03	3.93	3.61	47.07
CROSSETT 7 S	5.00	5.05	5.57	5.36	4.66	3.74	4.71	4.08	3.51	2.89	4.21	5.12	53.70
DANVILLE	3.40	3.79	4.93	4.80	6.07	3.67	3.84	3.70	3.52	3.50	3.66	3.61	49.49
DARDANELLE	3.59	3.81	4.75	4.71	5.38	4.14	3.71	3.52	3.21	3.41	3.98	3.60	47.89
DE QUEEN	3.53	3.73	4.67	5.72	6.57	3.43	3.65	3.50	3.67	3.55	3.39	3.86	49.27
DERMOTT 3 NE	4.94	5.26	6.12	5.14	4.25	3.12	4.22	3.17	3.23	2.74	4.19	4.83	51.23
DES ARC	4.45	4.69	5.22	5.21	5.61	3.41	3.92	3.54	2.96	2.88	3.96	4.56	50.41
DUMAS	4.46	4.72	5.07	5.31	5.18	3.13	4.32	3.02	3.26	2.73	3.90	4.54	50.44
EL DORADO FAA AIRPORT	4.60	4.48	5.21	5.80	4.64	2.93	3.47	3.42	3.15	3.26	3.87	4.48	49.41
EUREKA SPRINGS	2.20	2.98	3.40	4.40	6.24	5.43	3.92	3.44	4.12	3.70	3.33	2.72	45.92
EVENING SHADE 1 NE	3.58	3.59	4.39	4.50	5.28	3.87	3.50	2.90	3.78	2.91	3.85	3.45	45.62
FAYETTEVILLE EXP STA	2.13	2.89	3.16	4.78	6.22	4.90	3.65	3.05	3.72	3.66	2.87	2.60	44.43
FORDYCE	4.71	4.47	5.72	5.78	5.12	2.90	3.06	3.10	3.66	3.36	4.52	4.92	52.27
FORT SMITH WSO //R	2.38	3.20	3.64	4.74	5.40	3.93	3.24	2.91	3.31	3.47	3.08	2.89	42.27
FORT SMITH WATER PLANT	2.53	3.34	3.90	5.46	6.36	4.56	4.09	3.38	4.40	4.12	3.44	3.35	48.93
GEORGETOWN	4.21	4.21	5.29	5.07	5.25	3.69	3.39	3.48	3.27	2.87	3.97	4.15	48.83
GILBERT	2.82	3.24	3.50	4.58	5.32	3.93	3.22	3.27	3.41	3.13	3.43	2.85	42.70
GLENWOOD 3 ENE	3.99	4.17	5.45	6.20	7.03	4.27	3.97	3.01	4.40	3.65	4.10	4.20	55.44
GRAVELLY 4 E	3.45	3.76	4.71	5.22	5.70	3.93	4.07	3.13	3.34	3.35	3.53	3.55	47.74
GRAVETTE	1.94	2.65	3.46	4.90	6.06	5.37	3.16	3.22	4.21	3.56	2.69	2.52	43.74
GREEN FOREST	2.25	2.80	3.27	4.37	5.76	4.87	3.69	2.88	3.90	3.43	3.18	2.52	43.00
GREENWOOD	2.57	3.40	3.81	5.12	5.69	3.60	4.05	3.16	3.86	3.68	3.47	3.17	45.58
HARRISON	2.47	3.09	3.50	4.51	5.76	4.73	3.88	3.33	3.30	3.42	3.33	2.61	43.77
HELENA 5 NW	4.72	4.84	5.43	5.30	4.18	3.23	3.73	3.07	3.27	2.91	4.09	4.82	49.59
HOPE 3 NE	4.16	4.35	5.18	5.96	5.84	3.83	3.87	3.09	3.50	3.36	3.99	4.17	51.90
HOT SPRINGS 1 NNE	4.28	4.64	5.48	6.03	6.39	4.03	4.97	3.43	4.06	3.46	4.04	4.29	55.10
JONESBORO	4.30	4.15	5.07	4.78	4.60	3.64	3.43	3.15	3.38	3.18	4.18	4.20	48.03
LAKE CITY	4.17	3.94	4.88	4.84	4.16	3.55	2.97	3.25	3.60	2.77	3.81	4.34	46.28
LEAD HILL	2.33	2.93	3.32	4.07	5.17	4.52	3.60	3.16	3.49	3.38	3.20	2.60	41.76
LITTLE ROCK WSO //R	4.24	4.42	4.93	5.25	5.30	3.50	3.38	3.01	3.55	2.93	3.86	4.09	48.52
MADISON	4.75	4.81	5.15	5.24	4.84	3.04	3.24	3.76	3.33	3.15	4.01	4.66	50.04
MAGNOLIA 3 N	4.20	4.39	4.58	5.91	5.09	3.00	3.54	3.02	3.24	3.10	4.22	4.77	49.36
MAMMOTH SPRING	3.47	3.57	4.20	4.48	5.52	3.90	3.49	2.87	3.60	3.03	3.65	3.19	45.00
MARIANNA 2 S	4.65	4.64	5.16	5.50	4.77	3.03	3.69	3.15	3.22	3.22	3.95	4.73	49.69
MARKED TREE	4.55	4.36	5.27	5.16	4.54	3.61	3.47	3.36	3.37	2.09	4.19	4.53	49.32
MARSHALL	3.07	3.32	3.95	4.56	5.41	3.96	3.63	3.00	3.67	3.23	3.44	3.01	45.05
MELBOURNE 5 WNW	3.34	3.37	4.31	4.43	5.16	4.10	3.62	3.06	3.69	2.81	3.80	3.26	45.03
MENA	3.80	4.16	5.11	5.97	6.34	4.52	4.51	3.63	4.43	4.15	3.81	3.78	54.32
MONTICELLO 3 SW	4.71	4.91	6.09	5.49	4.74	3.26	4.38	2.86	3.56	2.74	4.10	4.84	51.80
MORGAY LOCK NO 8	4.55	4.51	5.32	5.60	4.73	3.05	4.30	3.20	3.24	2.94	3.79	4.40	49.67
MORRILTON	3.75	3.80	4.95	4.80	5.61	3.70	3.19	3.13	3.62	2.94	3.58	3.84	47.04
MOUNT IDA 3 SE	3.95	4.28	5.52	5.36	6.77	4.04	4.69	3.55	4.26	3.76	4.11	4.30	54.59
MOUNTAIN HOME 1 NNW	2.73	3.30	3.65	4.30	5.14	4.45	3.29	2.96	3.17	3.10	3.34	2.97	42.40
MOUNTAIN VIEW	3.65	3.65	4.46	4.76	5.19	4.37	3.96	3.80	4.45	3.22	3.90	3.46	48.92
MULBERRY 6 NNE	2.90	3.68	4.10	5.28	6.22	4.45	3.84	3.25	3.67	4.03	3.65	3.33	48.50
NASHVILLE EXP STATION //	3.91	4.26	5.07	6.11	6.66	4.37	3.73	3.41	4.13	3.77	3.83	4.04	53.31
NEWPORT	4.21	4.07	4.97	5.00	5.15	4.20	3.88	3.94	3.20	3.21	4.11	3.90	50.00
NIMROD DAM	3.61	3.60	4.92	5.03	5.79	3.80	3.78	3.52	3.43	3.22	3.53	3.70	48.17
ODELL 3 N	2.88	3.21	3.77	5.27	6.43	5.35	4.31	3.82	4.34	4.10	3.49	3.04	49.99
OKAY	4.04	3.97	4.79	5.61	6.07	3.67	3.49	3.56	3.74	3.51	3.95	3.84	50.34
OSCEOLA	4.30	4.22	4.96	4.57	4.47	3.45	3.70	3.02	3.54	2.58	4.01	4.46	47.28
OZARK	3.03	3.74	4.02	4.76	5.62	3.90	3.64	3.06	3.77	3.38	3.36	3.05	45.24
PARAGOULD RADIO KDRS	4.26	4.07	4.94	4.56	4.45	3.62	3.32	3.59	3.65	2.72	4.04	4.24	48.06
PARKS	3.39	3.48	4.69	5.46	6.07	3.24	3.90	3.04	3.03	3.48	3.28	3.37	47.30
PERRY	3.66	3.61	5.12	5.07	5.64	4.07	3.64	3.30	3.70	2.94	3.64	3.50	47.89
PINE BLUFF	4.47	4.79	5.41	5.65	5.51	3.85	3.97	3.14	3.60	3.23	4.00	4.50	50.72

Table 6-1

PRECIPITATION NORMALS

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
PINE RIDGE	3.01	4.23	5.45	5.57	6.57	4.02	4.69	3.71	4.22	3.64	3.64	3.94	53.56
POCAHONTAS 1	4.17	3.77	4.60	4.72	5.14	3.62	3.54	2.98	3.32	3.03	4.20	3.58	46.73
PRESCOTT	4.44	4.42	5.39	5.32	5.74	3.78	3.96	3.17	3.78	3.67	4.09	4.13	52.49
ROGERS	2.21	2.87	3.46	4.88	6.31	5.20	3.78	3.80	4.41	3.93	2.99	2.62	46.46
RUSSELLVILLE 4 N	3.74	3.94	4.85	5.13	5.60	4.30	3.80	3.92	3.40	3.67	3.72	3.86	49.91
SAINT CHARLES	4.66	4.59	5.36	5.42	4.25	3.19	3.76	3.24	3.35	3.15	4.12	4.65	49.74
SAINT FRANCIS	4.17	3.75	4.82	4.52	4.98	3.81	2.99	2.81	3.64	2.80	4.00	3.85	46.16
SEARCY	4.35	4.30	5.42	5.13	5.58	3.60	3.60	4.00	3.65	3.21	4.15	4.38	51.53
SHERIDAN TOWER	4.57	4.67	5.54	5.00	5.59	3.76	3.84	3.65	4.02	3.57	4.25	4.69	54.05
SHIRLEY	3.85	3.84	4.91	4.80	5.61	4.61	4.03	3.81	3.82	3.28	4.24	4.05	50.85
SILOAM SPRINGS	1.94	2.68	3.34	5.00	6.37	5.07	3.08	3.79	3.93	3.75	2.86	2.41	44.22
STUTTGART	4.63	4.87	5.75	5.76	4.80	3.78	3.81	3.08	3.60	2.98	3.98	4.54	51.58
STUTTGART 9 ESE	4.36	4.52	5.21	5.35	4.26	3.19	3.55	3.10	3.67	3.15	3.98	4.36	48.70
SUBIACO	3.00	3.57	4.12	4.87	5.83	4.31	3.92	3.31	3.60	3.56	3.25	3.30	46.72
VALDRON	2.88	3.40	4.00	4.46	5.65	3.72	3.90	3.12	3.50	3.42	3.34	3.29	44.68
WARREN	4.71	4.88	5.98	5.73	4.97	2.99	3.76	3.56	3.43	2.91	4.11	4.68	51.71

Table 6-1

RUNOFF

Runoff is water that drains from the land by means of surface streams. These streams are supplied by surface flow and by drainage from groundwater sources. Basically, runoff is the water remaining from precipitation after losses to evaporation, transpiration, soil moisture, and groundwater.

Many variables regulate the amount of runoff. Precipitation is the most basic regulator. Amount, duration, intensity, and frequency of precipitation all affect it. If precipitation amounts are small, or infrequent, or come as light showers, runoff will be small. It will be greater if precipitation comes in large quantities in a short period of time. Vegetative cover is another factor that determines the amount of runoff. A thick ground cover will retain more of the precipitation and slow surface runoff. Soil conditions are yet another factor to be considered. If the soil is loose and porous, more water can percolate into the ground to become part of the soil moisture or the groundwater, thus slowing the rate and decreasing the amount of runoff. A hard-packed soil increases the amount, and the porosity of the subsoil and bedrock can also influence runoff. Slope also has a significant effect; a steep slope decreases the time in which water can soak into the ground, thus increasing runoff. All these factors must be considered together in order to understand properly the pattern of the runoff in Arkansas. (See map page 41 for average annual runoff for the State.)

A few examples of these effects on runoff will aid in interpreting the mean annual data. Heavy precipitation, considerable slope, and shallow soil with rather impervious bedrock are probable reasons for the large annual runoff in southwestern Arkansas. Similar effects are possibly responsible for the area with the greatest amount of runoff in the state; however, methods of data collecting may have exaggerated the size of this area to some extent. Dense forest vegetation, little slope, plus a combination of various other factors create the low amount of runoff in extreme southern Arkansas. Not reflected by the map data are urban areas where large paved expanses increase runoff markedly.

TEMPERATURE

The Humid Subtropical climate occurs throughout Arkansas. However, the state extends from 33 degrees to 36 degrees 30 minutes North Latitude with the northern boundary in the transition zone between the Humid Subtropical and the Humid Continental climates. Also, elevations range from over 2,500 feet in the Ouachita and Ozark highlands in the west and northwest to less than 200 feet in the Mississippi River lowlands in the east. Both highlands trend in an east-west direction. These facts help explain the twelve degree range in mean January temperatures and the arrangement of isotherms in a basically east-west direction.

Mean Annual Runoff (in inches)

The northern boundary is three and a half degrees or about 250 miles north of the southern boundary. A distance this great can influence climatic conditions considerably. In addition, the close proximity of a more severe climate to the north causes the northern areas of the state to experience much colder winters than do the southern areas. The substantial range in elevation further adds to the contrast in mean January temperatures. It is estimated that, climatically, each 300 foot rise in elevation is equivalent to travelling 100 miles farther north. The means conceal temperatures that often drop below freezing and occasionally below zero in the north. The southern areas of the state experience below-freezing temperatures each winter, and have been known to have below-zero weather. However, the cold periods are much shorter than those in the north.

The location and trend of the Ozark and Ouachita highlands are influencing factors in determining the east-west orientation of the isotherms. The Ozarks act as a partial barrier to cold air advancing from the north; thuse sheltering the southern areas of the state to some degree and forcing the cold air to spread in an east-west direction rather than southward.

The Ouachita Mountains function as a second barrier to cold air from the north. They, along with the Ozarks, also serve as barriers to the warm air coming northward from the Gulf Coast. Neither highland area is elevated enough to block warm or cold air masses completely, but they do serve as limiting factors.

With the temperatures for July varying only from 76 degrees to 82 degrees, the entire state can be termed hot. Daytime highs even in the highlands to the north will reach into the 90's and sometimes beyond. Relatively cool nights ranging from the upper 60's in the north through the 70's in the south are responsible for lowering the mean temperatures to the rather moderate levels shown on the map. Monthly means are derived by averaging daily means, and daily means are found by averaging the high and the low temperatures of each 24-hour period.

Cooler air from farther north occasionally ameliorates the hot July weather in the northern part of the state. This, combined with the sightly cooler conditions caused by increased elevation, creates the lower means in the north. The increase in elevation afforded by the Fourche Mountains and the Central Ouachitas is responsible for the mean of below 80 degrees in the west-central portion of the state.

Except in the Ozarks and the higher Ouachitas, the July heat is relatively constant over the state. Daytime highs may be very little, if any, above those in the northern areas, but there is less likelihood of nighttime cooling or of the inflow of cooler air from other regions. This keeps the temperature nearer the mean at all times.

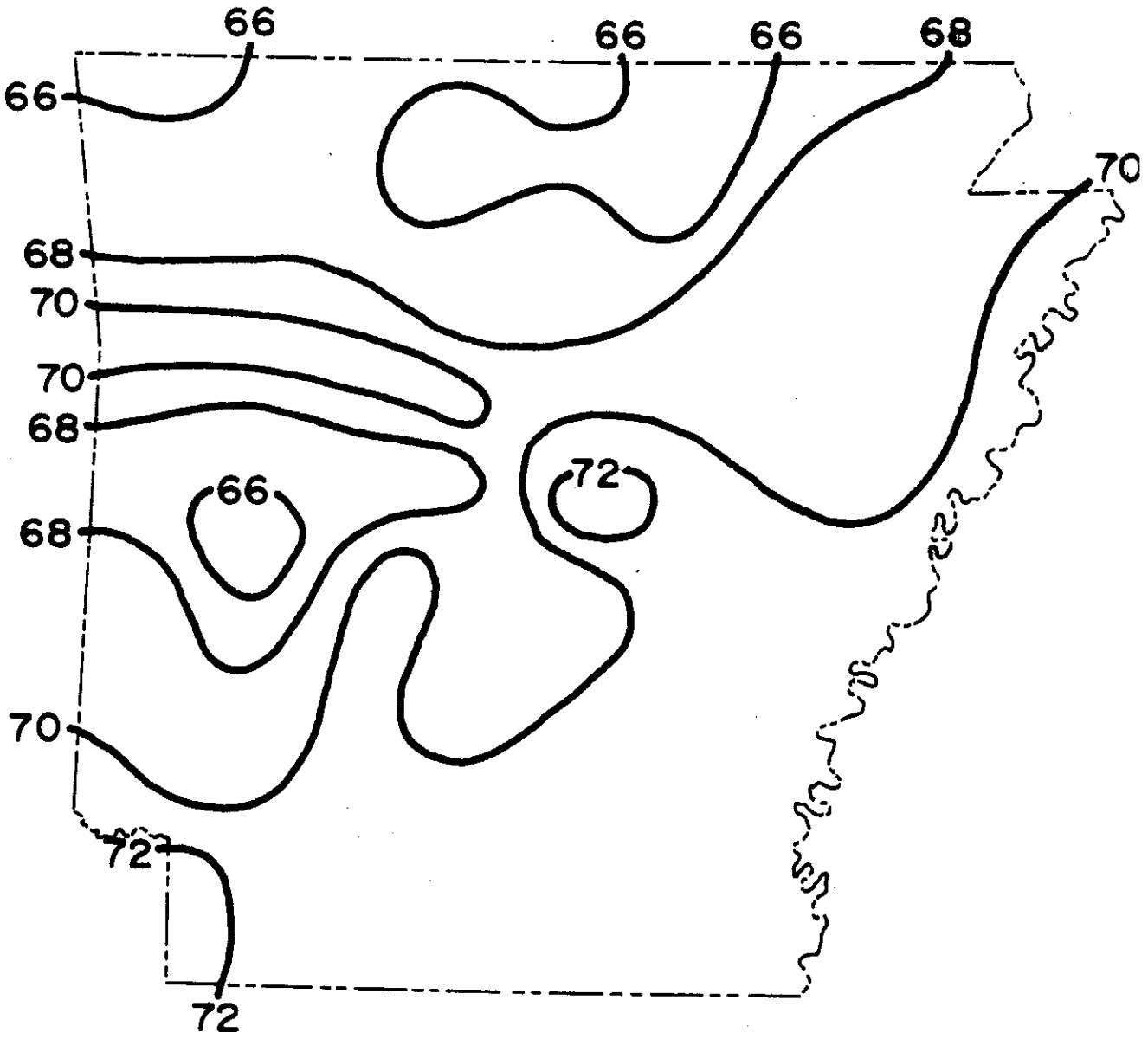
The elongated area with a mean temperature above 82 degrees through the center of the state rather closely follows the Arkansas River Valley and contrasts with the lower means in the highlands to the north and south. The lower elevations and the restricting effect of the valley on warm air are factors in maintaining these high means. The area with the highest mean is in extreme southern Arkansas in the lowlands along the southern Ouachita River and Bayou Bartholomew.

ARKANSAS

MEAN TEMPERATURE

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
ALUM FORK	41.4	44.7	51.2	62.5	69.7	77.0	80.5	79.9	73.5	63.7	51.7	43.6	61.6
ARKADELPHIA 2 N	42.9	46.5	53.3	63.7	70.9	78.1	81.6	81.1	74.6	64.1	52.3	44.5	62.8
BATESVILLE LIVESTOCK	37.9	40.9	48.3	60.0	67.3	75.2	79.2	78.1	71.3	60.9	48.6	39.6	58.9
BENTON	40.5	44.0	50.9	61.7	68.8	76.4	79.9	79.2	72.3	61.8	50.5	42.4	60.7
BLYTHEVILLE	38.9	42.6	50.2	62.1	70.9	78.0	81.3	79.9	73.0	63.0	50.5	41.5	61.1
BRINKLEY	40.8	44.1	51.3	62.5	70.5	78.1	81.0	79.9	72.8	62.4	50.8	42.7	61.4
CADDEN 1	43.7	47.4	54.2	64.7	71.8	79.0	82.1	81.3	74.7	64.3	53.1	45.6	63.5
CONWAY	41.4	45.0	52.0	63.2	70.2	77.7	81.5	80.7	73.8	63.6	51.6	43.2	62.0
CORNING	37.7	41.0	49.0	61.0	69.2	77.4	80.4	79.1	71.7	61.2	48.8	39.7	59.7
CROSSETT 7 S	46.4	48.6	55.2	64.7	71.4	78.3	81.2	80.7	75.1	65.2	54.1	47.0	63.9
DARDANELLE	40.6	44.6	51.7	63.2	70.7	78.1	81.0	80.8	74.1	63.5	51.2	42.6	61.9
DE QUEEN	42.9	46.6	53.1	63.4	70.5	77.6	81.0	80.7	74.1	63.9	52.2	44.5	62.5
DES ARC	41.1	44.3	51.6	63.2	70.9	78.4	81.4	80.2	73.3	63.3	51.6	43.0	61.9
DUMAS	43.7	47.0	53.8	64.3	72.1	79.6	82.3	81.3	74.8	64.5	53.2	45.5	63.5
EL DORADO FAA AIRPORT	44.5	47.8	54.2	64.4	71.7	79.0	82.1	81.3	75.2	64.6	53.5	46.2	63.7
EUREKA SPRINGS	37.6	41.3	47.7	59.9	66.6	74.2	78.5	77.9	70.7	61.2	48.8	40.2	58.7
FAYETTEVILLE EXP STA	37.1	41.1	47.4	59.4	66.5	74.4	78.6	77.8	70.5	60.6	48.2	39.9	58.4
FORDYCE	44.3	47.7	54.4	64.7	71.5	78.9	81.8	81.3	75.2	65.2	53.7	46.1	63.7
FORT SMITH WSO	39.0	43.3	50.3	62.2	70.1	78.0	82.2	81.4	74.0	63.2	50.4	41.5	61.3
GILBERT	37.3	40.6	47.3	59.5	66.5	74.5	78.5	77.3	70.1	59.7	47.8	39.4	58.2
GRAVETTE	39.9	43.0	48.6	60.9	66.1	74.0	78.5	77.9	70.6	60.2	47.2	38.7	57.9
HARRISON	37.8	40.7	47.3	59.4	66.7	74.4	78.5	77.2	69.9	59.9	47.8	39.6	58.2
HELENA 5 NW	41.6	44.9	52.0	63.1	71.1	78.5	81.2	80.1	73.8	63.8	52.1	43.8	62.2
HOPE 3 NE	42.2	45.6	52.2	62.9	70.5	77.9	81.4	80.9	74.4	64.1	52.4	44.3	62.4
HOT SPRINGS 1 NNE	43.1	46.8	53.5	64.6	71.4	78.7	82.3	81.9	75.3	65.7	53.3	45.2	63.5
JONESBORO	39.5	42.8	50.3	62.0	70.2	78.2	81.2	80.0	73.1	63.0	50.5	41.6	61.0
LEAD HILL	36.8	40.6	47.3	59.4	66.9	75.1	79.6	78.3	70.7	60.4	48.0	39.3	58.5
LITTLE ROCK WSO	39.9	42.9	50.3	61.7	69.8	78.1	81.4	80.6	73.3	62.4	50.3	41.6	61.0
MAGNOLIA 3 N	45.7	48.9	55.3	64.9	71.6	78.5	81.6	81.1	75.1	65.3	54.3	47.3	64.1
MAMMOTH SPRING	36.6	40.0	47.8	59.7	66.9	74.9	78.5	77.7	70.1	59.9	47.5	38.7	58.2
MARIANNA 2 S	40.0	44.1	51.3	62.3	70.6	78.1	80.4	79.2	72.8	62.9	51.4	43.0	61.4
MARKED TREE	38.6	42.0	49.5	61.3	70.0	78.0	80.7	79.3	72.2	62.0	49.6	40.9	60.3
MENA	41.2	44.9	51.2	62.3	69.2	76.4	79.9	79.5	72.0	63.2	51.5	43.2	61.3
MONTICELLO 3 SW	43.9	47.1	54.0	64.1	71.3	78.4	80.9	80.4	74.4	64.7	53.3	46.0	63.2
MORRILTON	40.7	44.4	51.3	62.8	70.4	78.2	81.7	80.7	73.8	63.5	51.4	42.8	61.8
MOUNT IDA 3 SE	40.5	43.6	50.0	61.2	68.5	76.1	79.0	79.0	72.1	61.8	50.1	42.3	60.4
MOUNTAIN HOME 1 NNW	36.8	40.6	47.5	59.8	67.2	75.0	79.0	77.9	70.7	60.0	48.3	39.5	58.6
NASHVILLE EXP STATION	41.5	45.1	51.5	62.2	69.8	77.2	80.8	80.5	74.3	64.1	51.9	43.9	61.9
NEWPORT	40.2	43.6	51.0	62.6	70.8	78.3	81.2	79.9	72.9	62.7	50.9	42.2	61.4
OKAY	46.2	48.6	55.1	65.2	72.1	79.1	82.4	81.3	75.5	65.7	54.4	46.7	64.3
OZARK	40.2	44.3	50.8	62.5	69.8	77.4	81.5	80.9	74.1	63.5	51.0	42.4	61.5
PARAGOULD RADIO KORS	38.5	41.9	49.5	61.2	69.5	77.5	80.0	78.7	71.4	61.5	49.5	40.7	60.0
PERRY	41.0	44.3	51.3	62.5	69.8	77.3	80.8	80.1	72.9	63.2	50.9	43.0	61.4
PINE BLUFF	44.3	47.8	54.3	65.2	72.4	79.7	83.0	82.3	75.7	65.9	54.1	46.1	64.2
POCAHONTAS 1	37.9	41.4	48.7	60.6	68.9	76.7	80.1	79.0	71.8	61.5	48.9	39.7	59.6
PRESCOTT	43.3	46.9	53.8	64.3	71.8	79.1	82.5	82.1	75.3	65.2	53.2	45.1	63.6
ROGERS	37.3	41.2	47.4	59.6	66.3	73.8	78.0	77.4	70.6	61.1	48.5	39.9	58.4
RUSSELLVILLE 4 N	40.6	44.4	51.3	62.8	70.1	77.7	81.5	80.5	73.7	63.3	51.0	42.6	61.6
SAINT CHARLES	41.1	44.6	52.0	63.2	71.0	78.4	81.4	80.4	73.5	63.6	51.7	43.5	62.1
SEARCY	40.7	44.1	51.3	62.6	70.2	77.8	81.4	80.4	73.5	63.1	51.1	42.7	61.6
SHERIDAN TOWER	42.5	45.7	52.9	63.4	70.2	77.4	80.6	79.5	73.0	63.7	52.1	44.1	62.1
SILOAM SPRINGS	37.2	41.1	47.6	59.5	66.7	74.6	78.9	78.4	70.0	60.9	48.4	40.0	58.7
STUTTGART	42.8	46.1	52.9	64.0	71.6	79.1	82.3	81.3	74.3	64.7	52.8	44.8	63.1
STUTTGART 9 ESE	40.3	43.6	50.7	61.9	70.4	78.2	80.9	79.7	73.0	62.5	50.9	42.6	61.2
SUBIACO	40.5	44.7	51.5	63.0	70.2	77.8	81.7	80.7	74.0	63.9	51.6	42.7	61.9
WALDRON	40.8	44.5	51.1	62.6	69.9	77.4	81.0	80.1	73.1	62.6	50.7	42.8	61.4
WARREN	44.5	48.1	54.7	64.7	71.9	79.0	82.2	81.5	75.2	65.2	54.1	46.4	64.0

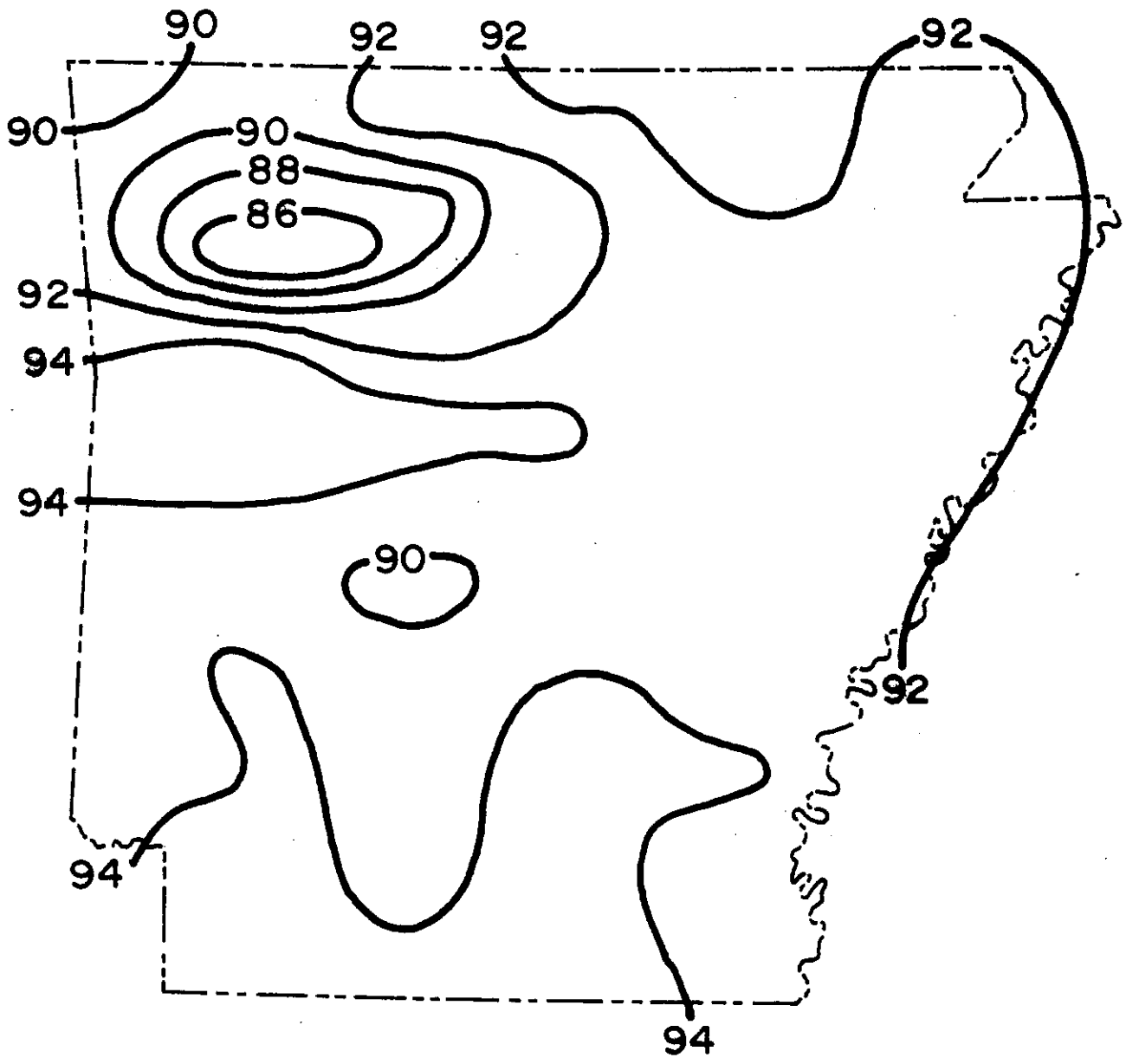
Table 6-2



Mean Minimum Temperature (°F) July

Figure 6-5

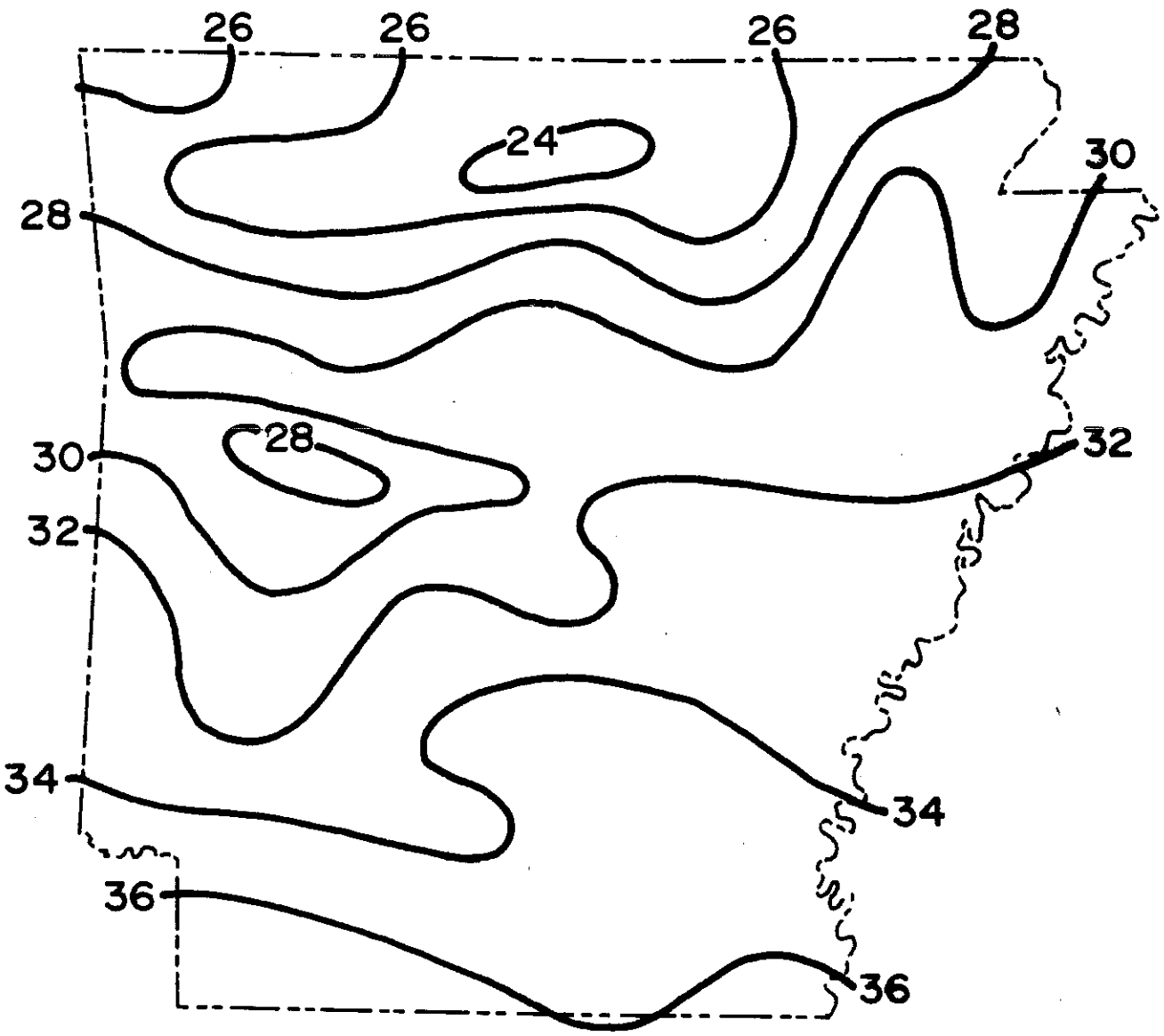
Source: U. S. Weather Bureau



Mean Maximum Temperature (°F) July

Figure 6-6

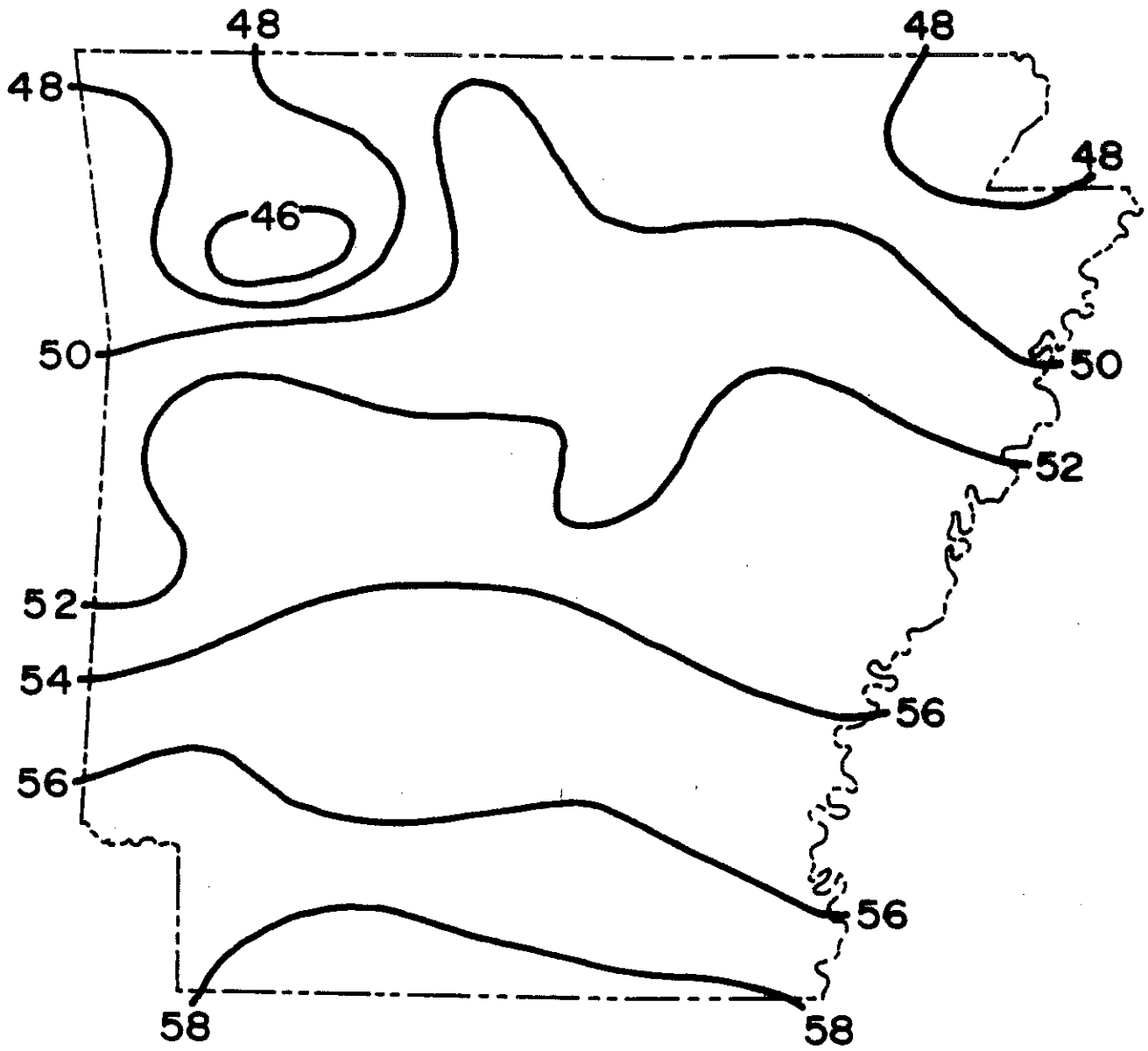
Source: U. S. Weather Bureau



Mean Minimum Temperature (°F.) January

Figure 6-7

Source: U. S. Weather Bureau



Mean Maximum Temperature (°F) January

Figure 6-8

Source: U. S. Weather Bureau

EVAPORATION AND TRANSPIRATION

The hydrologic cycle (Figure 6-9) illustrates that a part of precipitation is returned to the atmosphere as vapor. The process of evaporation occurs from: rain drops as they fall; lake surfaces; the surface of plants and other surfaces. Transpiration from plants is another important evaporative mechanism to be considered. Only a small part of the water taken in by plant roots remains in the plant tissues. The remainder is returned to the atmosphere through the process of transpiration. This process is the principal mechanism by which water is returned to the atmosphere.

Evaporation and transpiration are important factors to be considered in the design of water storage reservoirs, especially in arid regions. In times of drought, evaporation can surely deplete water supplies. Figure 6-10 illustrates average annual lake evaporation in Arkansas.

Meteorogical factors affecting rate of evaporation are: solar radiation, air temperature, vapor pressure and possibly atmospheric pressure. Solar radiation is one of the more important factors affecting evaporation, therefore, evaporation will vary with latitude, season, time of day and sky conditions.

In Arkansas very little evaporation occurs during the winter months, for example, the mean evaporation for the month of December, at the Russellville, Arkansas station is 1.11 inches. Conditions are more conducive for evaporation during the summer months and the mean evaporation for the month of August at Russellville is 6.47 inches. In comparison, Russellville's average annual lake evaporation is approximately 44 inches whereas the desert southwest, near Yuma, Arizona, has approximately 78 inches.

HYDROLOGIC CYCLE

The hydrologic cycle illustrates four basic phases of interest to the hydrologist: precipitation, evaporation and transpiration, streamflow, and groundwater.

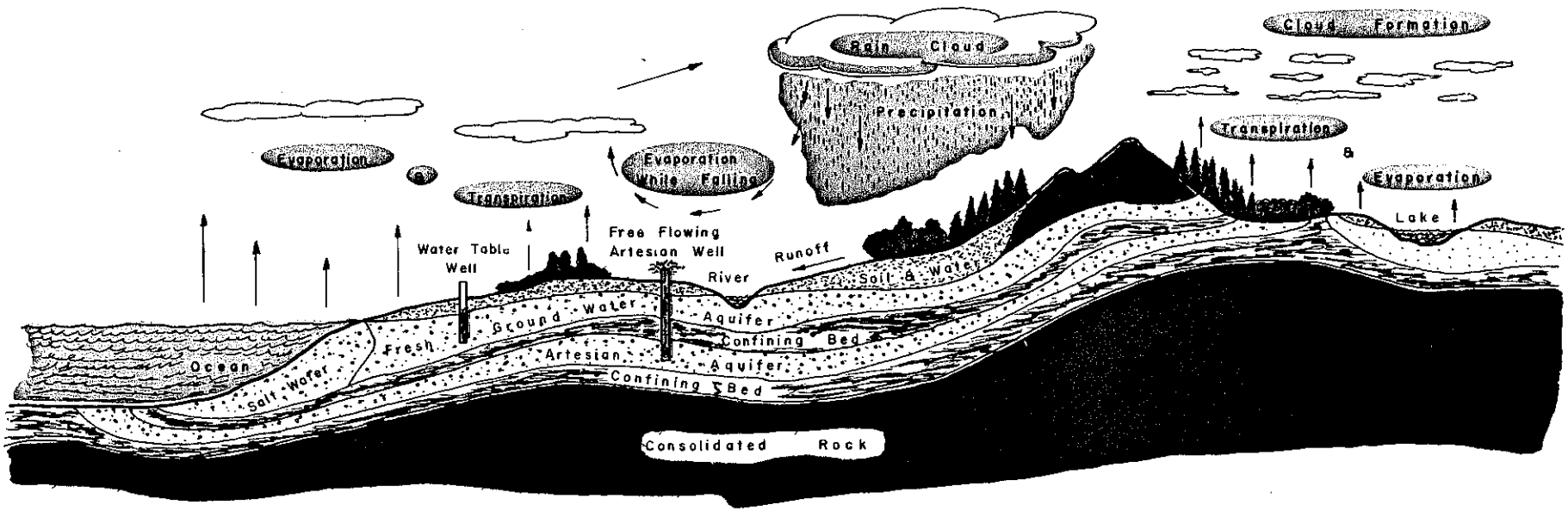
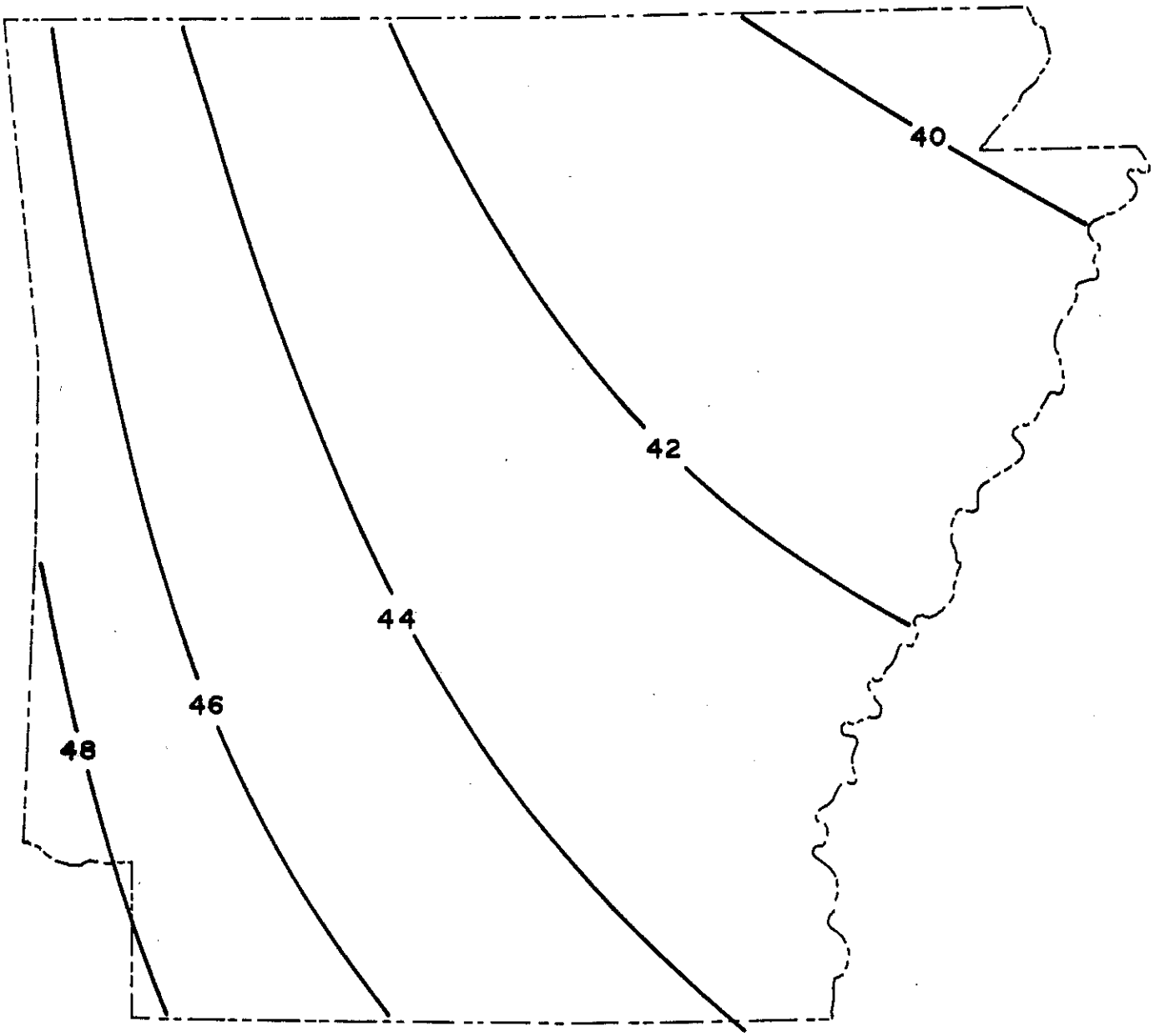


Figure 6-9



AVERAGE ANNUAL LAKE EVAPORATION
(INCHES)

Figure 6-10

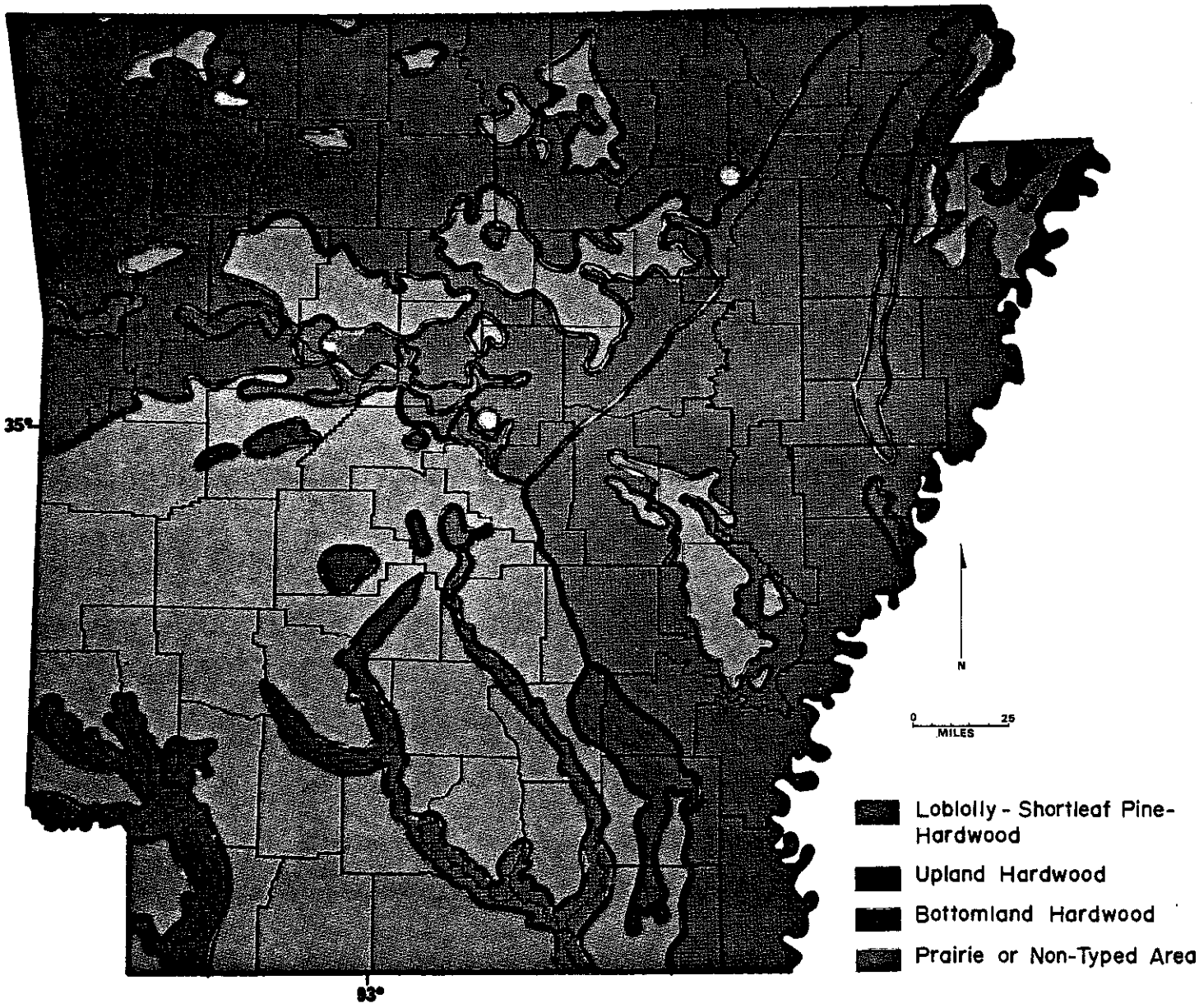
U. S. Weather Bureau

VEGETATION

Trees are the major natural vegetation of the state, occupying all but a few areas which are in natural prairie. About 200 species of trees are native to the state. Introduced and hybrid varieties add nearly another one hundred to the total present. The most densely forested region is west of the Mississippi Alluvial Plain and is divided into two sections at the southern edge of the Arkansas River Valley. The northern section, consisting of the Ozark highlands and the Arkansas River Valley, is primarily hardwood forest. The oak-hickory association predominates; however, there are several large areas of mixed forest, the oak-hickory-shortleaf pine association. Many other trees are also found in this section including maple, elm, ash, black walnut, redcedar, and sycamore. A mixed forest, with oak-loblolly and shortleaf pine the dominant association, is characteristic of the southern section, which contains the Ouachita highlands and the West Gulf Coastal Plain. Similar hardwood species are found in both the northern and southern sections. The major difference between the two forested areas is the much greater concentration of pine in the south. Bottomland areas south of the Ozarks, such as along the Arkansas, Ouachita, and Red rivers, have the oak-gum-cypress association.

In the eastern part of the state much more of the land has been cleared for agriculture. Most forest vegetation is limited to swamps and other poorly drained areas. The main association in the east is the oak-gum-cypress. Other trees include species of ash, tupelo, willow, elm, cottonwood, hickory, and maple. The main exception in the east is Crowley's Ridge which is some 200 feet higher than the surrounding alluvial plain. Due to increased slope and poorer soil conditions, Crowley's Ridge has upland hardwood forest similar to that in the northwestern part of the state. (See map page 53 for locations of forest types.

Originally, prairie was much more extensive over the state, but through climatic variations and the effects of human occupance the various forest types have become the dominant vegetation. Only two major areas now have prairie as the natural vegetation. They are the Grand Prairie between the Arkansas and White rivers in the southeast and the prairie in the western Arkansas River Valley. The land use in the Grand Prairie area is agricultural, with rice and soybeans being the major crops. The Cherokee Prairie in western Arkansas River Valley is used for pasture and meadow. The Soil Association map page 58 shows the extent of the prairie areas in Arkansas.



FOREST TYPES

Source: Atlas of Arkansas, Arkansas Department of Planning

Figure 6-11

Commercial forest land by forest type and county, 1969

COUNTY	ALL TYPES	LOBLOLLY-SHORTLEAF PINE	OAK-PINE	OAK-HICKORY	OAK-GUM-CYPRESS	ELM-ASH-COTTON-WOOD
	Thousand acres					
Arkansas	207.2	-	-	44.8	145.6	16.8
Ashley	410.4	205.2	79.8	57.0	68.4	-
Baxter	254.8	-	9.8	245.0	-	-
Benton	219.6	-	-	219.6	-	-
Boone	195.5	-	-	195.5	-	-
Bradley	354.0	123.9	76.7	76.7	76.7	-
Calhoun	348.0	133.4	69.6	63.8	81.2	-
Carroll	239.4	11.4	22.8	205.2	-	-
Chicot	75.6	-	-	4.2	50.4	21.0
Clark	423.4	116.0	127.6	110.2	69.6	-
Clay	65.0	-	-	19.5	45.5	-
Cleburne	240.7	33.2	58.1	141.1	8.3	-
Cleveland	319.0	110.2	58.0	75.4	69.6	5.8
Columbia	379.5	144.9	96.6	55.2	82.8	-
Conway	137.5	12.5	25.0	87.5	12.5	-
Craighead	45.5	-	-	14.0	24.5	7.0
Crawford	208.0	29.2	8.2	170.6	-	-
Crittenden	32.0	-	-	-	19.2	12.8
Cross	49.5	-	-	22.0	27.5	-
Dallas	372.6	118.8	102.6	70.2	81.0	-
Desha	143.0	-	-	-	117.0	26.0
Drew	387.6	91.8	81.6	112.2	96.9	5.1
Faulkner	156.8	-	-	156.8	-	-
Franklin	211.2	22.2	30.6	158.4	-	-
Fulton	247.0	26.0	-	221.0	-	-
Garland	335.5	115.5	115.5	104.5	-	-
Grant	346.8	76.5	96.9	81.6	91.8	-
Greene	53.3	-	4.1	36.9	8.2	4.1
Hempstead	286.7	109.8	79.3	42.7	54.9	-
Hot Spring	294.8	80.4	87.1	107.2	20.1	-
Howard	254.8	93.1	88.2	49.0	19.6	4.9
Independence	244.8	14.4	14.4	216.0	-	-
Izard	240.0	19.2	19.2	192.0	9.6	-
Jackson	65.0	-	-	39.0	26.0	-
Jefferson	193.5	31.5	31.5	49.5	72.0	9.0
Johnson	298.1	36.6	31.8	222.0	7.7	-

Forest Statistics for Arkansas Counties.

TABLE 6-3

COUNTY	ALL TYPES	LOBLOLLY-SHORTLEAF PINE	OAK-PINE	OAK-HICKORY	OAK-GUM-CYPRESS	ELM-ASH-COTTON-WOOD
	Thousand acres					
Lafayette	212.8	78.4	56.0	22.4	44.8	11.2
Lawrence	108.8	-	-	64.0	44.8	-
Lee	87.4	-	-	9.2	55.2	23.0
Lincoln	142.8	20.4	15.3	61.2	35.7	10.2
Little River	192.5	38.5	77.0	33.0	38.5	5.5
Logan	254.2	80.6	49.6	111.6	12.4	-
Lonoke	91.8	-	-	32.4	59.4	-
Madison	356.4	-	10.8	345.6	-	-
Marion	282.0	14.1	-	267.9	-	-
Miller	217.0	56.0	56.0	21.0	63.0	21.0
Mississippi	34.8	-	-	-	17.4	17.4
Monroe	150.4	-	4.7	18.8	126.9	-
Montgomery	410.4	165.3	114.0	131.1	-	-
Nevada	300.0	102.0	54.0	90.0	54.0	-
Newton	478.0	32.4	32.4	413.2	-	-
Ouachita	384.3	85.4	109.8	85.4	103.7	-
Perry	273.6	102.6	119.7	45.6	5.7	-
Phillips	81.6	-	-	15.3	61.2	5.1
Pike	319.0	139.2	110.2	63.8	-	5.8
Poinsett	65.0	-	-	20.0	20.0	25.0
Polk	435.0	104.4	168.2	162.4	-	-
Pope	338.4	54.7	44.6	239.1	-	-
Prairie	140.4	-	-	46.8	93.6	-
Pulaski	252.0	22.4	50.4	117.6	56.0	5.6
Randolph	186.2	-	-	172.9	13.3	-
St. Francis	65.0	-	-	-	60.0	5.0
Saline	372.6	81.0	91.8	167.4	27.0	5.4
Scott	448.2	226.8	75.6	140.4	5.4	-
Searcy	310.6	-	14.9	295.7	-	-
Sebastian	134.4	6.4	6.4	96.0	19.2	6.4
Sevier	269.5	78.4	39.2	78.4	58.8	14.7
Sharp	255.3	11.1	11.1	233.1	-	-
Stone	322.0	27.6	27.6	266.8	-	-
Union	572.4	199.8	118.8	118.8	135.0	-
Van Buren	303.8	39.2	34.3	230.3	-	-
Washington	318.8	-	10.2	308.6	-	-
White	222.6	-	21.2	159.0	42.4	-
Woodruff	77.4	-	-	-	73.1	4.3
Yell	403.2	145.6	100.8	95.2	61.6	-
All Counties	18,206.7	3,668.0	3,039.6	8,446.3	2,774.7	278.1

TABLE 6-3

SOIL ASSOCIATIONS

The following soil association descriptions are for those soil associations shown on the map, page 58 . Additional descriptions of soil associations can be found on the back of the map.

Ozark Highlands Limestone Soils. These soils have developed chiefly on the limestones of the Springfield and Salem plateaus. Elevations range between 500 and 1,500 feet and most of the land is in slope. Terrain varies from the relatively flat areas in parts of Washington and Benton counties to the very rugged hills of Carroll County. Soils have developed chiefly under deciduous forest with some prairie in the extreme western area. Subsoils are slowly to moderately permeable, grayish brown to yellowish brown clays. Soils are mainly silt, loam, relatively deep in the valleys and on flatter areas but very thin on the steeper hillsides. They are used for general farming, especially grazing of beef cattle, and for orchards and vineyards.

Ozarks Highlands Sandstone-Limestone Soils. This is a small area found mainly in Izard, Fulton, and Sharp counties. The hills and valleys are eroded from interbedded sandstone and limestone on the Salem Plateau. Clay and sandy loam subsoils are overlain by loamy grayish brown and yellowish brown soils. Mixed hardwoods and shortleaf pine are the natural vegetation and general farming predominates.

Boston Mountain Soils. The Boston Mountains are the southernmost edge of the Ozarks and range generally from 1,500 to 2,300 feet elevation. Much of the area is very rugged and several sections have over 1,000 feet local relief. Relatively level land is confined to ridge tops which are remnants of the old plateau surface and the valley floors. Most of the area is heavily forested, chiefly deciduous trees with shortleaf pine appearing in the east and on the south. The Ozark National Forest is situated in the heart of the area. The soils are sandy loams and clay loams, medium textured, and generally well drained. Woodland and pasture with some general farming are major uses.

Arkansas Valley Soils. Sandstone and shale are the parent materials for soils found on the narrow ridges and in the wide valleys of the Arkansas Valley section of the Ouachitas. The valleys stand at 300 to 500 feet and ridges rise 1,000 to 2,000 feet above them. Deciduous forest with some prairie and stands of shortleaf pine increasing southward are the natural vegetation. Soil conditions vary considerably from valley floor to hillside but most soils are slowly to moderately permeable and of medium texture. Sandy, silty, and clay loams vary from brown to yellow and red in color. Pasture, general farming, and some specialty crops occupy the non-forested land.

Cherokee Prairies Soils. These occupy scattered areas in the western Arkansas Valley, developing over sandstone and shale and under prairie. The soils are deep and of medium texture and are a dark silt loam. Grazing is the major use.

Ouachita Mountains Soils. The main Ouachita area consists of generally parallel east-west ridges and valleys with elevations ranging from 500 to 2,500 feet. Shale, sandstone, novaculite, and quartzite are common surface rocks. The soils are of medium texture and are of moderate permeability. The area is forested; pines and bottomland hardwoods predominate. Soils are mainly silty clay and silty loam, deep in the valleys and very shallow and stony on the ridge tops. The Ouachita National Forest comprises considerable acreage. Elsewhere, livestock grazing and general farming are the chief agricultural pursuits and there is much timber harvesting.

Blackland Prairies Soils. In southwestern Arkansas, scattered prairies occupied areas of chalk and calcareous marls. Gray clay subsoils are overlain by deep, dark clay and silt loam soils. Pasture and field crops are the chief uses.

Forested Coastal Plain Soils. Central south Arkansas consists of a sandy coastal plain of rolling terrain broken by stream valleys. Most of the area is gently to moderately sloping and pine forest dominates except along streams. Most subsoils are sandy or silty clay loams, relatively deep. Soils are largely sandy loams with some silt and clay loams. Most are reddish, yellowish, or brownish. Considerable emphasis is upon harvesting both the pines and hardwoods. Pastures, truck and field crops are major agricultural uses.

Bottomland and Terrace Soils. This soil association is found along all major streams but especially is extensive in the Red, Ouachita, Saline, Arkansas, Black, Lower White, and Mississippi river valleys. The deep alluvial material varies from coarse to fine texture and thus from rapid to slow permeability. The land is level to only gently undulating and there is much wet land. Bottomland hardwoods are the major natural vegetation. Chief agricultural uses are for cotton, rice, soybeans, and pasture.

Loessial Plains Soils. In some areas of eastern Arkansas, especially on the west side of Crowleys Ridge, are broad alluvial plains capped with wind-deposited silt. Most of the soils are deep, medium textured, and slowly permeable. The subsoils are mainly clay and often compact. A variety of crops, but chiefly cotton and rice, are raised and pastures are extensive.

Eastern Prairie Soils. The prairies of eastern Arkansas are mainly in Arkansas and Prairie counties; the largest is called the Grand Prairie. The terrain is nearly level. The clay subsoils are generally compact. The silt loam soils are used for rice, cotton, soybeans, and pasture.

Loessial Hills Soils. Crowleys Ridge and smaller ridges of eastern Arkansas are capped with wind-blown silt varying in depth from a few to as much as seventy feet. The area is in moderate slope and there has been much soil erosion. The largely silt loam soils are deep, of medium texture, and are moderately permeable. Pasture is the chief use.

SOIL SURVEY INTERPRETATIONS

Detail soil survey interpretations are available for most of the major soils shown on the state soil association map. The interpretations give estimated soil properties and the suitability of the soil for different uses. These interpretations are available through the U. S. Department of Agriculture Soil Conservation Service.

Erosion and Sediment Producing Areas

Sediment is the major pollutant of our lakes, streams, and rivers. It reduces the life of water supply and flood control reservoirs, destroys fish and wildlife habitat, interferes with navigation, destroys recreation potential and reduces esthetic values. Because a large portion of the state is forest and pastureland, the average erosion rate is dominantly low or moderate over most of the area. Exceptions are the Crowley Ridge area in east Arkansas, and the Blacklands of the southwest, where erosion rates and sediment production rates are moderate to high.

Sediment damages from excessive erosion fall in two main categories. First is the physical loss to the site from which it eroded, and the physical damage to the site of deposition. Second is the loss of fertilizers, weed controlling agents and other chemicals that are carried off of the fields and pastures with the silt; and the potential damage of these chemicals to the environment of the site of deposition.

Figure 6-13, page 62, shows the general areas where high, moderate, and low erosion rates and paralleling sediment production exist at present and can be expected to exist in the period to 1985 or beyond. The different areas are discussed in the paragraphs that follow.

Soil Loss Rates:

Soil losses are normally measured in tons of dry sediment lost per acre per year. The average rates are ranges, and do not reflect critical, often transitory point-sources of sediment such as highway construction, urban fringe developments, and the like. Such areas may yield high or very high amounts of sediment - measurable in tens of tons per acre - within broad areas having acceptable levels of soil loss.

Green Area

Most of the land in this area has a good to excellent cover of trees or grass. The average annual sediment production is probably less than 0.5 ton per acre, and is, practically speaking, little different than the rates that probably existed before settlement. Locally, in areas that are cultivated, the rates are on the order of 10 or more tons per acre; poorly managed pastures and woodlands may produce sediment at rates as high as 3 or 4 tons per acre.

Yellow Area

Generally, east of a line from the Missouri state line to Little Rock, along the foothills of the Ozark uplands; from Little Rock southeasterly to the Louisiana state line south of Hamburg; on the bottomlands of the Arkansas River from Little Rock west to Fort Smith; and on the bottomlands of the Red River, most of the land is used for cultivated crops. In these areas, the average annual sediment production rate is about 3 to 5 tons per acre. Because of the nearly level topography, much of the sediment is redeposited near its origin. A small part of this area having steeper slopes but that is used for row crops probably has sediment production rates as high as 8 or 10 tons per acre; locally, production exceeds 20 tons per acre.

In the remainder of the yellow area, lying west of the generalized line described above, most of the land has a fair to good cover of grass or trees. The average annual soil loss is less than 2 tons per acre. The rate of sediment production is as high as 3 to 5 tons per acre from poorly managed woodlands or pasture. Locally, plowed lands yield sediment in excess of 10 tons per acre.

Red Area

About half the area has a cover of trees or grass. The land is sloping; much of it is steep. It is highly erodible when plowed. The average annual erosion rate is 0.5 to 3 tons per acre for the area as a whole, but plowed tracts yield sediment in excess of 10 tons per acre. The high erosion rates are compounded by the extreme difficulty of stabilizing the areas after they are plowed or otherwise disturbed. Until they are stabilized, they continue to yield sediment at very high rates.

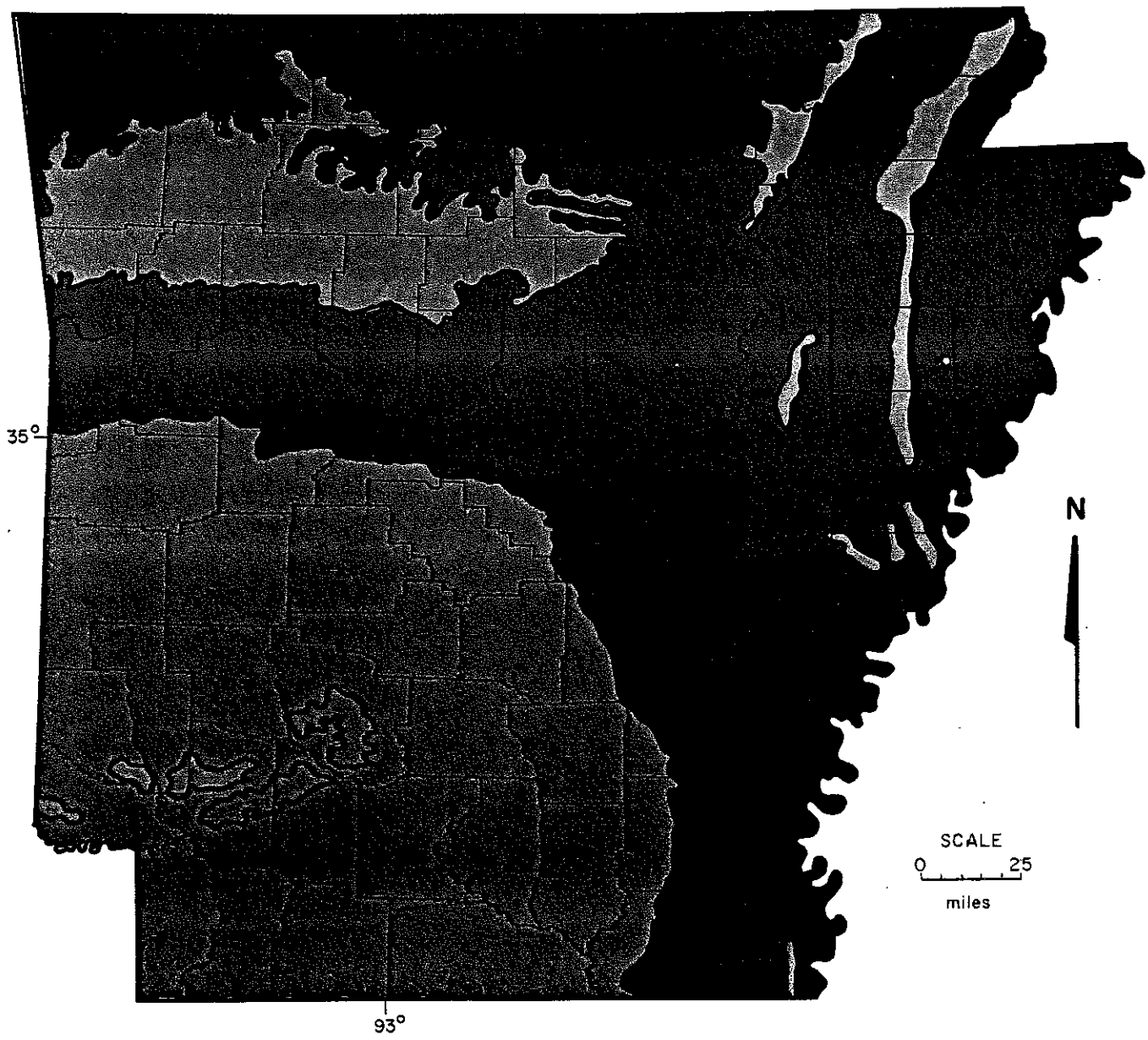
Construction Sites

Sites under construction or other development produce enormous amounts of sediment and associated pollutants. Unprotected roadside slopes and ditches are probably the major source of sediment in the state. Retirement-type developments have a poor record in protecting the soil resource and controlling accelerated sediment production from disturbed areas. Most of these developments are located in scenic areas. These are typically rough, wooded, steep areas. These are very fragile landscapes and disturbance results in high yields of sediment unless the development is carefully planned. Access roads; proposed, roughed out streets and other facilities; and random rather than unitized development are major offenders in environmental damage. Legislation is needed to provide controls that will minimize irresponsible development.

Reducing Erosion and Sediment

Erosion can be reduced on cropland with improved management of crop residues, conservation cropping systems, cross-slope farming, land forming, terracing, contour cultivation, shaping and vegetating waterways, etc. Technical help is available from state and federal organizations to make these improvements.

Erosion rates on grassland and woodland can be reduced through proven management practices. Erosion on development areas can be reduced by better planning to locate streets on the approximate contour and protecting disturbed areas with temporary or permanent vegetation and mulching. Diversion terraces and sediment basins should be used as needed. Unprotected roadsides commonly require shaping and vegetating to control sediment production.



EROSION AND SEDIMENT PRODUCING AREAS

Figure 6-13

HIGH – EROSION AND SEDIMENT PRODUCING AREAS

MODERATE – EROSIN AND SEDIMENT PRODUCING AREAS

LOW – EROSION AND SEDIMENT PRODUCING AREAS

NOTE: The designations shown on the map are based on present land use and predicted land use over the next 10 years.

CHAPTER VII

SOCIO-ECONOMIC

ECONOMIC DESCRIPTION

Natural Resources

The State of Arkansas comprises approximately 33,986,560 acres with about 25 percent devoted to cropland; 11 percent devoted to pasture and range, and 50 percent in forest. The remaining 14 percent consists of federal land, urban and built-up areas, and small bodies of water.

Agricultural land is one of the most valuable resources in the state. The principal agricultural crops grown in the state are soybeans, cotton, rice and hay. Other leading farm products are broilers, cattle, egge, milk, turkeys and swine. Such agriculture products as grain, truck crops, and fruits are of lesser importance.

Forests are also an important source of income to the people of Arkansas. Arkansas' forests contribute to our environmental and recreation needs as well as providing raw materials to the largest manufacturing industry in the state. The state's forests supplied about 487 million cubic feet of raw material to 590 primary and 106 secondary manufacturing plants within Arkansas in 1972. Approximately two-thirds of the 1972 timber harvest was veneer and saw logs and almost one-third of the timber harvest was pulpwood.

An abundance of recreation opportunities exist in the State of Arkansas. Approximately 33 major lakes provide over 375,000 surface acres of fishable water. Many of these lakes offer water skiing, swimming, boating and camping facilities. In addition to the major lakes, there are more than 800 natural oxbow and cut-off lakes and numerous private lakes and reservoirs. The state also has more than 9,000 miles of fishable streams and rivers.

Hunting is one of the major recreational activities in Arkansas. The extensive forests of the state support good populations of native wildlife species such as deer, wild turkey, squirrels and rabbits. The state is famous for its excellent migratory waterfowl hunting. The majority of the state lies in the Mississippi flyway, and large concentrations of migratory waterfowl use the lakes, streams and flooded woodlands during the winter months. The Grand Prairie and Delta farmlands provide an abundance of food for the waterfowl.

Mineral production in the state exceeded a value of 200 million dollars in 1969. The petroleum industry accounted for more than 50 million dollars to lead all minerals. The fuel minerals, such as petroleum, natural gas, natural gas liquids and coal account for the largest percentage of the total value. Other important minerals in the state include bromide, barite, clay, lime, sand and gravel, stone and gypsum.

Industrial Development

In 1972 there were more than 1750 manufacturing plants in Arkansas. Those employed in manufacturing totaled 169,691 in 1970. Employment in industry has experienced a continuous growth since about 1940. In 1940 only 10 percent of the labor force were working in manufacturing plants; by 1960 20 percent were employed in manufacturing. The percentage employed by manufacturing is expected to continue to increase bringing Arkansas closer to the national average. In comparison, the number employed in agriculture has steadily declined since 1940. In 1940 about 51 out of 100 in the labor force were in the field of agriculture; by 1960 this figure had dropped to 16 of 100.

The total earnings to employees in the manufacturing industry in 1960 were $522 million as compared to $1,087,000,000 in 1970. Projected earnings for the year 1980 are estimated at $2 billion.

In 1972 the United States Geological Survey estimated that self-supplied industries used 209.1 million gallons of water per day, not including industrial water use from public water supplies. Industries in Arkansas that require large amounts of water are paper, food processing, chemical, petroleum and lumber. Except for food processing plants, most of these industries are located in the Gulf Coastal Plains of Arkansas. Much of the industrial water in the Coastal Plains area comes from groundwater supplies, while in the Interior Highlands, surface water is the major source.

Agricultural Development

In 1967 approximately 37 percent of the state's land, totaling over 12 million acres, was devoted to agriculture. This was an increase of about 400,000 acres of cropland and pasture over the 1957 figures. In Arkansas the total number of farms have decreased over the past several years; however, the size of farms have steadily increased. The amount of cash receipts from farm marketings almost doubled from 1962 to 1972, showing an increase from $769,411 in 1962 to $1,403,735 in 1972. Livestock and livestock products accounted for about 48 percent of the total cash receipts in 1972, while crops accounted for 52 percent.

Soybeans are the single-most important crop in Arkansas, with cotton second, rice third and wheat fourth. Major crops, based on percentage of total cash receipts from crop marketings in 1972 were as follows: soybeans, 41 percent; cotton lint, 26 percent; rice, 20 percent; and wheat, 2 percent.

Agriculture is the single largest water using industry in the state, accounting for more than one-half the total.

HISTORICAL TRENDS

Population

Past census records show that Arkansas experienced steady population growth from 1890 to 1940. The 1890 census records indicated a population of 1,128,211 as compared to a 1940 population of 1,949,387. From 1940 to 1960 Arkansas experienced a population loss, resulting in a 1960 population of 1,786,272. The loss of population was caused by a reduction in the numbers employed in agriculture and a lack of industrial jobs to fill the employment needs. In 1940 approximately 51 out of every 100 in the labor force were employed in the agricultural industry. This figure had dropped to 16 out of every 100 by 1960. After 1960 a significant reversal began and Arkansas gained in population. By 1970 the population had almost returned to the 1940 level. Population projections indicate a state population of over 2.4 million by the year 1995. (See table 7-1 for 1970 populations by county and population projection for 1975, 1980, 1985, 1990, 1995 series I & II).

Employment

As was discussed in the preceding narrative, employment prior to 1940 was largely in the field of agriculture. From 1940 until the present the trend has been toward a decrease in agricultural employment and an increase in manufacturing employment. This trend has given Arkansas a broader based economy and has brought the state closer to the national average in percentage employed by the different industries.

Income

In the past, Arkansas has had one of the lower per capita incomes among states. But in recent years Arkansas' percentage increase in per capita income has exceeded that for the nation. This indicates that efforts are being made to improve the economy of the state by providing more and better jobs for the citizens.

Arkansas' per capita income for 1960 (in 1970 dollars) was $1,804 and increased to $2,864 in 1970. This was over a 50 percent increase. During the same period of time the Nation's per capita income increased approximately 35 percent. Arkansas' per capita income is expected to reach $4,356 by the year 1980.

TABLE 7-1a

ARKANSAS PROJECTIONS OF TOTAL POPULATION,
BY COUNTY, 1975-1995 SERIES I

County	1970 Census	Projections				
		1975	1980	1985	1990	1995
Arkansas	23,347	23,517	23,785	24,037	24,127	24,326
Ashley	24,976	25,577	26,242	26,924	27,536	28,216
Baxter	15,319	17,287	19,315	21,397	23,581	26,266
Benton	50,476	57,213	65,515	75,460	87,012	99,702
Boone	19,073	20,413	21,909	23,534	25,172	26,980
Bradley	12,778	12,565	12,368	12,147	11,854	11,634
Calhoun	5,573	5,705	5,894	6,094	6,287	6,479
Carroll	12,301	12,644	12,993	13,339	13,687	14,057
Chicot	18,164	18,053	18,022	17,995	17,892	17,825
Clark	21,537	22,355	23,002	23,735	24,863	25,772
Clay	18,771	18,226	17,731	17,223	16,618	16,120
Cleburne	10,349	10,972	11,581	12,174	12,696	13,362
Cleveland	6,605	6,620	6,650	6,682	6,705	6,730
Columbia	25,952	27,024	28,102	29,057	29,899	30,976
Conway	16,805	17,458	18,297	19,343	20,495	21,538
Craighead	52,068	54,732	57,457	60,016	62,431	65,329
Crawford	25,677	27,720	30,175	33,071	36,268	39,538
Crittenden	48,106	49,907	52,164	54,625	56,956	59,412
Cross	19,783	20,089	20,486	20,906	21,257	21,642
Dallas	10,022	10,234	10,497	10,732	10,889	11,117
Desha	18,761	18,525	18,368	18,168	17,842	17,619
Drew	15,157	15,478	15,796	16,060	16,286	16,581
Faulkner	31,572	36,561	42,330	49,232	57,788	67,216
Franklin	11,301	11,653	12,072	12,568	13,101	13,594
Fulton	7,699	8,205	8,759	9,376	10,007	10,685
Garland	54,131	58,230	62,805	67,779	72,942	78,589
Grant	9,711	10,495	11,432	12,516	13,695	14,924
Greene	24,765	24,924	25,126	25,288	25,302	25,438
Hempstead	19,308	19,534	19,872	20,251	20,616	20,957
Hot Spring	21,963	22,323	22,725	23,037	23,157	23,466

- continued -

TABLE 7-1a
ARKANSAS PROJECTIONS . . . 1975-1995 SERIES I - (Continued.)

County	1970 Census	Projections				
		1975	1980	1985	1990	1995
Howard	11,412	11,559	11,722	11,866	11,980	12,126
Independence	22,723	23,567	24,564	25,655	26,756	27,871
Izard	7,381	7,660	7,931	8,180	8,406	8,684
Jackson	20,452	20,194	19,927	19,590	19,121	18,802
Jefferson	85,329	88,730	92,224	95,318	97,644	100,991
Johnson	13,630	14,190	14,794	15,417	16,023	16,684
Lafayette	10,018	10,283	10,637	11,023	11,362	11,725
Lawrence	16,320	16,223	16,127	15,973	15,710	15,561
Lee	18,884	18,741	18,699	18,570	18,302	18,159
Lincoln	12,913	12,768	12,706	12,616	12,440	12,324
Little River	11,194	12,051	13,089	14,325	15,722	17,115
Logan	16,789	16,881	17,029	17,260	17,545	17,739
Lonoke	26,249	26,981	27,972	29,186	30,484	31,645
Madison	9,453	9,513	9,621	9,770	9,905	10,021
Marion	7,000	7,475	7,955	8,414	8,847	9,380
Miller	33,385	34,638	36,008	37,430	38,782	40,262
Mississippi	62,060	61,305	60,818	60,147	58,925	58,166
Monroe	15,657	15,527	15,445	15,333	15,139	15,012
Montgomery	5,821	5,970	6,100	6,220	6,313	6,442
Nevada	10,111	10,175	10,285	10,417	10,520	10,625
Newton	5,844	5,822	5,824	5,847	5,873	5,880
Ouachita	30,896	32,003	33,246	34,330	35,079	36,210
Perry	5,634	5,920	6,259	6,658	7,083	7,500
Phillips	40,046	39,664	39,467	39,240	38,747	38,429
Pike	8,711	9,064	9,427	9,799	10,166	10,566
Poinsett	26,822	26,354	25,969	25,527	24,902	24,444
Polk	13,297	13,890	14,536	15,234	15,968	16,716
Pope	28,607	32,509	37,123	42,451	48,509	55,355
Prairie	10,249	10,240	10,256	10,264	10,229	10,224
Pulaski	287,189	310,006	336,064	363,889	390,832	422,129

- continued -

TABLE 7-1a
ARKANSAS PROJECTIONS . . . 1975-1995 SERIES I - (Continued.)

County	1970 Census	Projections				
		1975	1980	1985	1990	1995
Randolph	12,645	12,620	12,624	12,647	12,578	12,561
St. Francis	30,799	31,038	31,476	31,923	32,193	32,551
Saline	36,107	40,103	45,072	51,064	57,857	65,095
Scott	8,207	8,534	8,892	9,311	9,780	10,218
Searcy	7,731	7,766	7,867	7,998	8,115	8,214
Sebastian	79,237	84,974	91,628	99,036	106,692	114,930
Sevier	11,272	11,778	12,385	13,102	13,884	14,627
Sharp	8,233	9,304	10,441	11,703	13,129	14,754
Stone	6,838	7,022	7,210	7,427	7,624	7,834
Union	45,428	46,855	48,606	50,370	51,786	53,510
Van Buren	8,275	8,751	9,281	9,868	10,481	11,119
Washington	77,370	89,440	103,115	118,617	136,529	157,358
White	39,253	41,658	44,340	47,173	50,058	53,195
Woodruff	11,566	11,210	10,910	10,599	10,245	9,939
Yell	14,208	15,116	16,193	17,419	18,751	20,098
STATE	1,923,295	2,020,311	2,133,334	2,256,972	2,383,977	2,528,880

Source: Census data from U.S. Bureau of the Census, and projections prepared by the Industrial Research and Extension Center, University of Arkansas, Little Rock, June 1973.

TABLE 7-1b

ARKANSAS PROJECTIONS OF TOTAL POPULATION,
BY COUNTY, 1975-1995 SERIES II

County	1970 Census	Projections				
		1975	1980	1985	1990	1995
Arkansas	23,347	23,441	23,531	23,558	23,437	23,460
Ashley	24,976	25,488	25,943	26,349	26,681	27,125
Baxter	15,319	17,246	19,156	21,064	23,054	25,534
Benton	50,476	57,027	64,780	73,867	84,377	95,942
Boone	19,073	20,351	21,686	23,088	24,493	26,073
Bradley	12,778	12,526	12,241	11,912	11,513	11,217
Calhoun	5,573	5,683	5,816	5,940	6,046	6,170
Carroll	12,301	12,609	12,871	13,099	13,328	13,598
Chicot	18,164	17,990	17,816	17,601	17,303	17,094
Clark	21,537	22,262	22,705	23,182	23,994	24,651
Clay	18,771	18,175	17,557	16,903	16,174	15,583
Cleburne	10,349	10,943	11,478	11,970	12,395	12,967
Cleveland	6,605	6,598	6,574	6,538	6,495	6,468
Columbia	25,952	26,922	27,768	28,424	28,929	29,725
Conway	16,805	17,403	18,098	18,940	19,874	20,725
Craighead	52,068	54,523	56,747	58,678	60,453	62,752
Crawford	25,677	27,633	29,844	32,379	35,187	38,071
Crittenden	48,106	49,713	51,514	53,361	55,050	56,937
Cross	19,783	20,017	20,245	20,444	20,570	20,772
Dallas	10,022	10,201	10,386	10,519	10,568	10,709
Desha	18,761	18,458	18,154	17,772	17,274	16,921
Drew	15,157	15,418	15,605	15,706	15,756	15,909
Faulkner	31,572	36,415	41,780	48,049	55,710	64,208
Franklin	11,301	11,622	11,957	12,338	12,758	13,151
Fulton	7,699	8,182	8,676	9,207	9,747	10,339
Garland	54,131	58,061	62,197	66,561	71,074	76,081
Grant	9,711	10,460	11,298	12,237	13,259	14,333
Greene	24,765	24,839	24,837	24,746	24,530	24,472
Hempstead	19,308	19,471	19,664	19,844	19,992	20,167
Hot Spring	21,963	22,246	22,467	22,556	22,467	22,595

- continued -

TABLE 7-1b
ARKANSAS PROJECTIONS . . . 1975-1995 SERIES II - (Continued.)

County	1970 Census	Projections				
		1975	1980	1985	1990	1995
Howard	11,412	11,524	11,609	11,653	11,665	11,729
Independence	22,723	23,494	24,304	25,143	25,990	26,878
Izard	7,381	7,638	7,853	8,029	8,182	8,395
Jackson	20,452	20,128	19,709	19,193	18,567	18,124
Jefferson	85,329	88,384	91,105	93,212	94,529	96,980
Johnson	13,630	14,148	14,644	15,125	15,587	16,119
Lafayette	10,018	10,248	10,516	10,783	10,991	11,249
Lawrence	16,320	16,172	15,956	15,662	15,277	15,027
Lee	18,884	18,673	18,475	18,137	17,652	17,357
Lincoln	12,913	12,725	12,565	12,351	12,050	11,843
Little River	11,194	12,009	12,936	14,002	15,200	16,408
Logan	16,789	16,834	16,859	16,919	17,034	17,096
Lonoke	26,249	26,891	27,654	28,563	29,557	30,447
Madison	9,453	9,487	9,526	9,586	9,634	9,680
Marion	7,000	7,456	7,885	8,275	8,639	9,106
Miller	33,385	34,519	35,605	36,640	37,579	38,707
Mississippi	62,060	61,087	60,109	58,845	57,088	55,909
Monroe	15,657	15,473	15,272	15,007	14,664	14,426
Montgomery	5,821	5,953	6,040	6,104	6,142	6,225
Nevada	10,111	10,143	10,178	10,207	10,200	10,222
Newton	5,844	5,806	5,766	5,733	5,706	5,672
Ouachita	30,896	31,889	32,867	33,607	33,996	34,818
Perry	5,634	5,903	6,194	6,525	6,881	7,234
Phillips	40,046	39,520	39,009	38,381	37,486	36,872
Pike	8,711	9,039	9,339	9,625	9,906	10,230
Poinsett	26,822	26,264	25,671	24,985	24,155	23,531
Polk	13,297	13,852	14,397	14,954	15,541	16,159
Pope	28,607	32,393	36,682	41,521	46,976	53,177
Prairie	10,249	10,208	10,145	10,052	9,920	9,839
Pulaski	287,189	308,867	332,094	356,014	378,764	405,900

- continued -

TABLE 7-1b
ARKANSAS PROJECTIONS . . . 1974-1995 SERIES II - (Continued.)

County	1970 Census	Projections				
		1975	1980	1985	1990	1995
Randolph	12,645	12,585	12,500	12,410	12,245	12,147
St. Francis	30,799	30,923	31,101	31,216	31,159	31,250
Saline	36,107	39,966	44,531	49,889	55,931	62,398
Scott	8,207	8,509	8,802	9,128	9,502	9,856
Searcy	7,731	7,744	7,787	7,839	7,881	7,919
Sebastian	79,237	84,684	90,590	96,970	103,550	110,715
Sevier	11,272	11,742	12,252	12,830	13,466	14,078
Sharp	8,233	9,281	10,351	11,509	12,814	14,313
Stone	6,838	7,002	7,137	7,280	7,407	7,556
Union	45,428	46,701	48,080	49,337	50,215	51,489
Van Buren	8,275	8,727	9,195	9,696	10,220	10,774
Washington	77,370	89,083	101,793	115,894	132,028	150,900
White	39,253	41,514	43,825	46,155	48,499	51,133
Woodruff	11,566	11,172	10,788	10,376	9,929	9,557
Yell	14,208	15,070	16,022	17,070	18,215	19,382
STATE	1,923,295	2,013,353	2,109,109	2,209,264	2,311,107	2,432,575

Source: Census data from U.S. Bureau of the Census, and projections prepared by the Industrial Research and Extension Center, University of Arkansas, Little Rock, June 1973.

The Division of Soil and Water Resources has contracted with the University of Arkansas, Arkansas Water Resources Research Center, to develop economic projections that will enable the Division to determine future water use. The economic projections are computerized so that they may become an integral part of the Arkansas Water Resources Management Information System.

ECONOMIC PROJECTIONS FOR WATER RESOURCE PLANNING AREAS IN ARKANSAS

by

JOSEPH A. ZIEGLER
ARKANSAS WATER RESOURCES RESEARCH CENTER
UNIVERSITY OF ARKANSAS

Under Contract With
Soil and Water Resources Division
Department of Commerce, State of Arkansas

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I. INTRODUCTION

In the fall of 1974 the U. S. Water Resources Council (WRC) published its Series E OBERS Projections of Regional Economic Activity in the United States. The report contains projections to the year 2020 of population, personal income, employment, earnings, output, and general agricultural land use for the nation, functional economic areas, water resource regions and sub-areas, and states. It is the result of a program of economic measurement, analysis and projection conducted by the Office of Business Economics (OBE) of the Department of Commerce and the Economic Research Service (ERS) of the Department of Agriculture with the assistance of the U. S. Forest Service. The program was initiated by the WRC in 1964 and has since acquired the acronym of OBERS signifying a united effort by OBE and ERS in which an integrated set of projections were developed under a common set of assumptions and procedures. Even though the OBE has since been renamed the Bureau of Economic Analysis (BEA) the program has maintained its original name.

The primary objective of this study is to use the OBERS projections as a basis for developing baseline projections of the economic data which would be useful in the water resource program in Arkansas. In particular, this study develops short, intermediate, and long term projections by Water Resource Planning Areas (WRPA) within Arkansas of the following variables: population, personal income, per capita income, earnings by industry, production indexes for mining and manufacturing industries, total employment, agricultural production by major crop, livestock, and the use of irrigated and nonirrigated cropland.

Since the OBERS methodology is used as the basis for these projections it is summarized in the next section of this report. Section II also contains information on how the OBERS state projections are disaggregated to the WRPAs. Section III contains an evaluation of the OBERS methodology while Section IV describes how the projections may be accessed from the computer tape. Finally, a printout of the projections is contained in another booklet.

II. SUMMARY OF OBERS METHODOLOGY[1]

The OBERS projections are made in two major steps: (1) the national economy is projected in industrial detail to provide control totals for regional projections and (2) these projected national totals are distributed regionally in accordance with projected trends in the regional distributions of economic activity. In general these projections are based on the extension of past relationships believed to have relevance for the future.

A. National Projections

1. General Assumptions

The OBERS projections are based on secular trends and ignore the cyclical fluctuations which characterize the shortrun activity of the economy. The general assumptions which underlie the national projections are:

(1) Growth of population will be conditioned by a decline of fertility rate from those of the 1962-65 period.

(2) Reasonably full employment, represented by a 4-percent unemployment rate, will prevail at the points for which projections are made; as in the past, unemployment will be disproportionately distributed regionally, but the disproportion will be diminishing.

(3) At projection dates, there will be no direct effects on the projections due to foreign conflicts.

(4) Continued technological progress and capital accumulation will support a growth in private output per man-hour of 2.9 percent annually.

(5) The new products and services that will appear will be accomodated within the existing industrial classification system and, therefore, no new industrial classifications are provided.

(6) Growth in output can be achieved without ecological disaster or serious deterioration, although diversion of resources for pollution control will cause changes in the industrial mix of output.

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[1] Sections A and B are essentially extracted from OBERS PROJECTIONS, Volume I: Concepts, Methodology, and Summary Data. Washington: Water Resources Council, 1974 and "State Projections of Income, Employment, and Population to 1990", Survey of Current Business, April, 1974, pp. 19-45.

2. Gross National Product

The initial step in preparing the national projections is to project the Gross National Product (GNP). The GNP is the market value of goods and services produced by the nation's economy in the current year. It is projected as the product of the projected man-hours worked and output/man-hour. In turn, these variables are a function of projected total population, working-age population, labor force participation, military strength, hours worked per year per man, and GNP per man-hour. The GNP projections are in terms of constant dollars with 1967 serving as the base year. Appendix A contains a more technical treatment of the derivation of the GNP as well as personal income and earnings.

3. Personal Income and Earnings

Personal income is the income received from all sources. It is comprised of wage and salary disbursements, proprietor's income, other labor income, property income and transfer payments, less personal contributions for social insurance. Earnings, on the other hand, are merely the sum of income accruing to persons from wage and salary disbursements, proprietor's income, and other labor income.

Projected personal income is derived from the relationship between real personal income and real GNP. A mathematical curve is fitted to historical relationships and extended to 2020. The projected share is applied to the projected real GNP series to derive projected constant dollar personal income. In a similar manner the percentage relationship of real earnings of persons to real personal income is determined historically and then projected. The projected share is applied to the projected real personal income to yield projected constant dollar earnings.

4. Population

The population projections are based on estimates of the following three factors: (1) the amount and composition of net immigration; (2) age-specific survival rates for mortality; and (3) age-specific birth rates for fertility. There is little disagreement concerning expectations for the first two factors. As for the third factor, it is assumed that the downward trend in fertility rates from 3,767 per 1,000 women in 1957 to 2,477 in 1968 to approximately 2,200 in 1971 will continue to gradually decline toward a total fertility level of 2,110 by the year 2,000. Population projections based on this fertility assumption correspond to the Series E projections by the Census Bureau.

5. Employment

Projected total civilian employment is dependent on projections for the working age population, total labor force participation, size of the armed forces, and the unemployment rate. The working age population

is a sub-set of the total population and, therefore, the corresponding assumptions apply concerning its future levels. It is anticipated that, due primarily to the increasing participation of women, the labor force participation rate will increase slightly from historical levels of approximately 57 percent of the working age population to between 58 and 60 percent for the projected years. Moreover, based on the President's 1974 budget message to Congress it is assumed that the armed forces will be cut to below 3,000,000. It is further anticipated that in the long run economic policy will be sufficient to generate jobs for 96 percent of the labor force, i.e., it is assumed a 4 percent unemployment rate will hold for the projected years.

Calculations of the variables mentioned above enables a projection for total civilian employment. The product of the projected working-age population and labor force participation is the total labor force. Subtraction of the estimated military manpower requirements yields the civilian labor force which, when multiplied by the expected employment rate, yields total civilian employment.

6. National Industrial Structure

It is necessary that regional economic projections be made in substantial industrial detail in order to maximize their reliability and, accordingly, it is necessary to disagregate the national measures to obtain controls for individual industries prior to their regional projection. At the national level three economic series are needed in industrial detail. Projections of gross product originating (GPO) are needed as an intermediate control in deriving the projections of earnings and employment by industry which are needed as national control totals for allocation to regions. The industrial breakdown used is shown in Table 1. A description of the standard industrial classification (SIC) categories used is given in Appendix B.

Historical trends in the industrial distribution of GPO (each industry expressed as a percent of the all-industry total), earnings of persons, and employment are calculated and extended to 2020. Application of the projected shares to the projected all-industry totals of GNP, earnings of persons, and employment yields absolute values of them by industry.

The national projections of agricultural GPO, earnings, and employment are initially made as part of the procedure for all industries, but these are reconciled with projected agricultural production. These production projections are derived from a product by product analysis of historical patterns of consumption under specified assumptions relating to population growth, per capita consumption, and foreign trade. The projections assume a Series E population growth profile and take no account of the sharp increase in the world demand for this nation's agricultural products.

Projections of agricultural employment and earnings are related to the projected levels of output and an assumed increase in productivity per man-hour. Generally, employment is related to national output through

TABLE 1.--INDUSTRIAL GROUPINGS WITH STANDARD INDUSTRIAL CLASSIFICATION CODES

Agriculture, forestry and fisheries:	
Agriculture	01, 07.
Forestry and fisheries	08, 09.
Mining:	
Metal	10.
Coal	11, 12.
Crude petroleum and natural gas	13.
Nonmetallic, except fuels	14.
Contract construction	15-17.
Manufacturing:	
Food and kindred products	20.
Textile mill products	22.
Apparel and other fabric	23.
Lumber and products and furniture	24, 25.
Paper and allied products	26.
Printing and publishing	27.
Chemicals and allied products	28.
Petroleum refining	29.
Primary metals	33.
Fabricated metals and ordnance	34, 19.
Machinery, excluding electrical	35.
Electrical machinery and supplies	36.
Motor vehicles and equipment	371.
Transportation equipment, excluding motor vehicles	37 except 371.
Other manufacturing	21, 30-32, 38, 39.
Transportation, communications, and public utilities:	
Railroad transportation	40.
Trucking and warehousing	42.
Other transportation and services	41, 44, 47.
Communications	48.
Utilities (electric, gas, sanitary)	49.
Wholesale and retail trade	50, 52-57, 59.
Finance, insurance and real estate	60-67.
Services:	
Lodging places and personal services	70, 72.
Business and repair services	73, 75, 76.
Amusement and recreation services	78, 79.
Private households	88.
Professional services	80, 81, 82, 84, 86, 89.
Government:	
Civilian government:	
Federal government	91 except Fed. military.
State and local government	92, 93.
Armed forces	Part of 91.

Source: Executive Office of the President, Bureau of the Budget, Standard Industrial Classification Manual, 1967. Descriptions of the SIC codes are contained in Appendix B.

a computation of man-hours required for major categories of production. Projections of agricultural income are derived indirectly from projected national demands for food and fiber. Income estimates are based on price relationships extended to 1980, which are then assumed to prevail to 2020. These estimates are reconciled with those developed independently and derived from the disaggregation of the GNP described previously. A basic assumption is that agriculture, as well as other industries, will trend toward a uniform earnings per worker. Income estimates based solely on production deviate somewhat from this assumption and, as a consequence, income estimates are adjusted to make earnings among industries more comparable.

B. Regional Projections

1. General Assumptions

Having developed national control totals for projected population, personal income, earnings, employment, and production, regional projections may be made. In addition to the general assumptions made in part A, the following assumptions are made in deriving regional projections.

(1) The factors that have influenced historical shifts in "export" industry location will continue into the future but the sharpness of the shifts will diminish.

(2) Trends toward area self-sufficiency in local-service industries will continue.

(3) Workers will migrate to areas of economic opportunities and away from slow-growth, or declining areas.

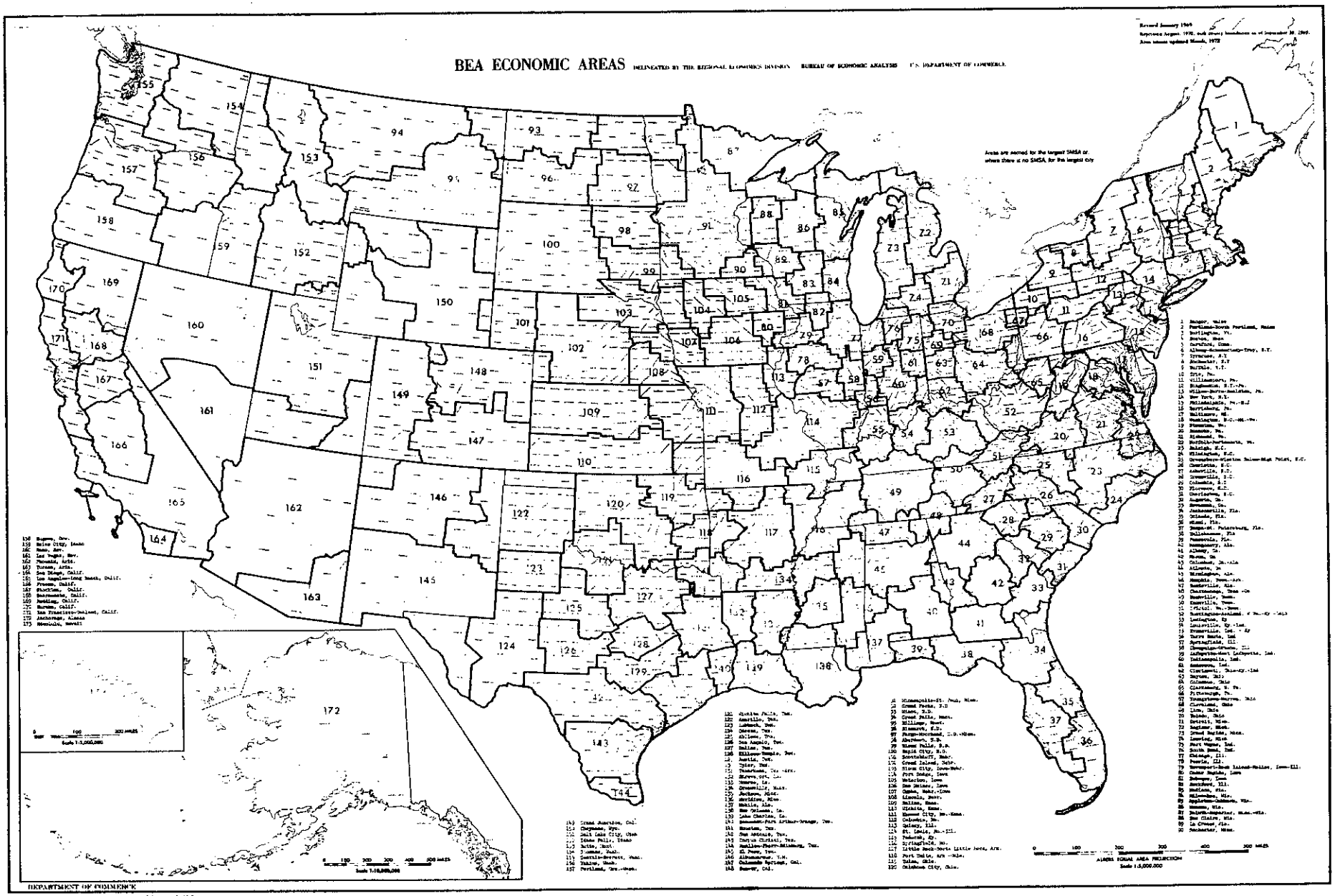
(4) Regional earnings per worker and income per capita generally will continue to converge toward the national average.

(5) Regional employment/population ratios will tend to move toward the national ratio except in "retirement" areas.

2. Economic Areas

a. Personal Income and Earnings

Before developing state estimates of the economic projections, the national industrial totals are allocated to economic areas delineated by the Bureau of Economic Analysis (BEA). Each of these BEA areas, shown in Figure 1, consists of an urban center and surrounding counties in which economic activity is focused, directly or indirectly, on the activity of the center. Each area combines place of residence and place of work of the labor force as nearly as possible so that there is a minimum of commuting across area boundaries.


BEA ECONOMIC AREAS
DEPARTMENT OF COMMERCE

Each economic area has two types of industries. The export industries produce goods and services that are for the most part exported to other areas, providing the earnings with which the area purchases the specialized goods and services of other areas. Residentiary industries produce most of the services and some of the goods required by local business as intermediate products and by the household sector. Each economic area approaches self-sufficiency with respect to its residentiary industries.

There is considerable similarity among economic areas in the inter-industry relationships among residentiary industries and between export and residentiary industries within each area. Moreover, these relationships within areas exhibit substantial stability over time, although they do change as a result of secular trends and developmental thresholds (points at which local markets for intermediate or consumer products become large enough for local production to supplant all or a portion of imports). These characteristics of similarity and stability make the BEA economic areas superior for projection purposes to other geographic areas delineated in accordance with noneconomic criteria.

Because of the functional relationship between export and residentiary industries, labor earnings are projected first for the export industries in each area. These projections are made industry by industry for each economic area, on the basis of projections of the trend in the area's share of total national earnings in each industry. The trends in the shares are projected into the future by fitting least squares regression lines to the logarithms of time and extending the curves through the projection years. These projected shares are modified judgmentally in some cases and, after being forced to total 100 percent, are applied to national industrial totals to get projected absolute values.

Projected earnings for each residentiary industry in each area are derived as follows: First, regional location quotients (LQ) are projected for each industry. A LQ is the ratio of the industry's share of total area earnings to the industry's share of total national earnings. Generally, it is projected by extending historical trends into the future. The projected LQ for each residentiary industry is then multiplied by the projected national ratio of earnings in that industry to total national earnings. This computation gives the projected share of the residentiary industry in the area's total all-industry earnings. These shares are summed for all residentiary industries in the area and this sum is then subtracted from unity to give the export industry share. The division of this share into the projected absolute value of export industry earnings--already calculated--yields projected total all-industry earnings for the area. To this total is applied the projected share of each residentiary industry in the area's total all-industry earnings to obtain the projected absolute value of earnings in each residentiary industry in each area. The sum of the area values for each residentiary industry is forced to equal the previously projected national total for the industry, thereby keeping the projected series within the framework of the national projections.

Total labor earnings make up about 80 percent of total personal income. To complete the projections, property income, transfer payments,

and personal contributions to social insurance (which are netted out of personal income) are projected by a procedure similar to that used for the residentiary industries.

b. Employment and Population

All-industry employment is projected for the BEA areas by applying the projected trend in an area's employment relative to that of the nation as a whole to the previously projected national all-industry employment figures. Area population is for the most part projected as a function of area employment. However, in order to reflect properly changes in population which are not directly related to economic opportunity, the population in each economic area is grouped into three age categories and each category is projected separately. The three groups are: (1) the labor pool (ages 15-64); (2) the pre-labor pool (ages 0-14); and (3) the post labor pool (ages 65 and over).

Population in the labor pool is projected as a function of area employment by means of trending the 1970 regional ratio of labor pool to employment towards, but not equal to, the national ratio of labor pool to employment. The previously projected employment in an area multiplied by the projected labor pool-employment ratio yields projected population in the 15-64 years age group.

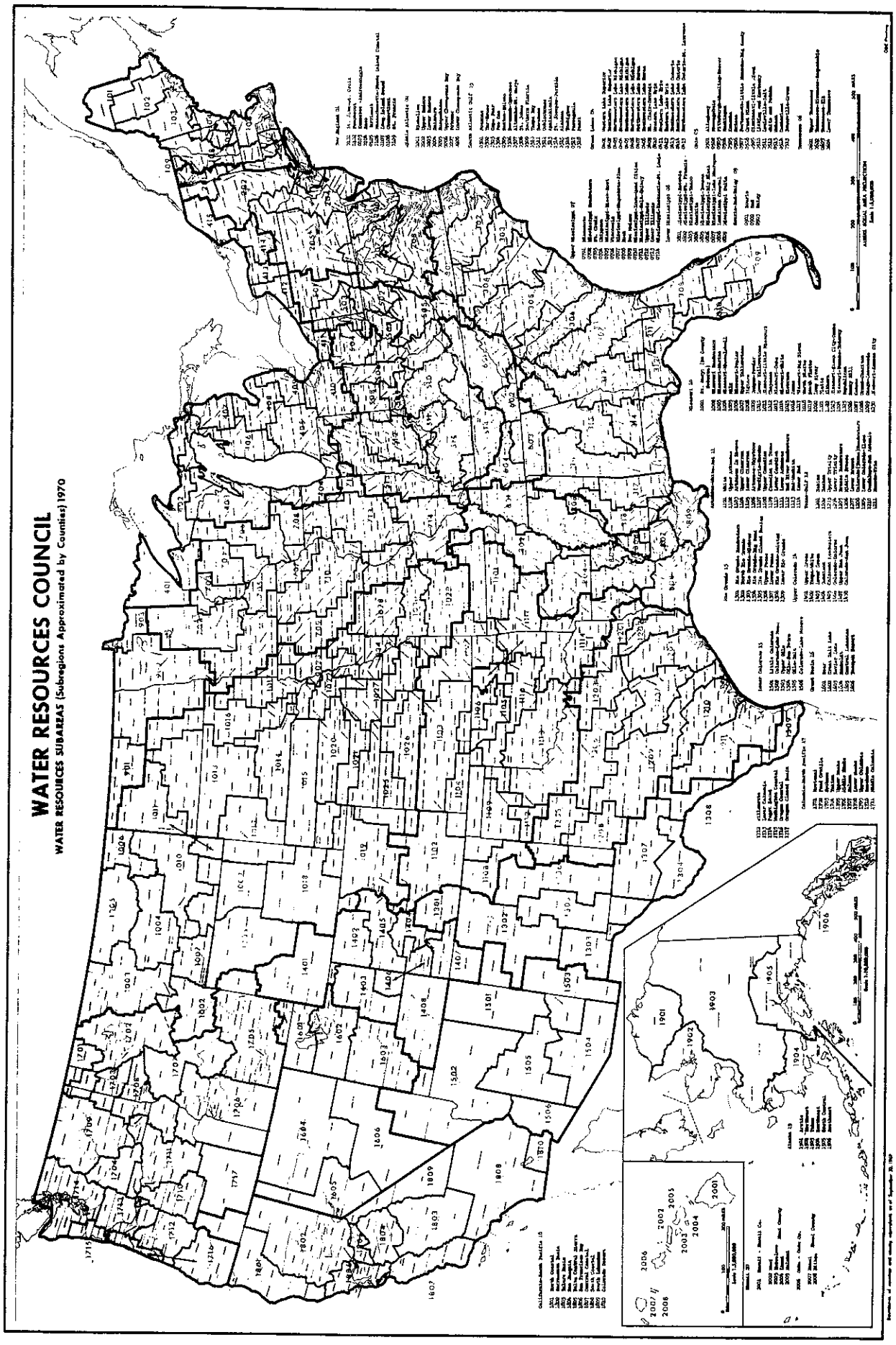
The pre-labor pool population is projected as a function of the labor pool using the same approach as was used in projecting the labor pool. The post-labor pool for each decade is projected in terms of population aged 55 and over at the preceding decade. The population 55-64 is broken out of the labor pool population at each point using regional percent shares trended to the national percent share in order to provide the necessary estimates of population aged 55 and over.

3. Water Resource Planning Areas Within the State of Arkansas

a. Income, Employment, and Population

As shown in Figure 1, various portions of Arkansas are contained in seven of the designated BEA areas but only one area, i.e., Little Rock, is contained wholly within the state boundaries. Moreover, all of the Water Resource Planning Areas designated by the Water Resources Council and shown in Figure 2 overlap state boundaries and do not conform geographically to the BEA areas. Therefore, to derive projections for those portions of the WRPAs contained in Arkansas it is necessary to separate BEA area data into state segments, sum to obtain state totals, and then disaggregate to those WRPAs shown in Figure 3.

The separation of BEA area data into state segments is done by projecting Arkansas' share of each area's earnings, industry by industry, and of total employment and population on the basis of historical trends in


WATER RESOURCES COUNCIL
WATER RESOURCES SUBAREAS (Subregions Approximated by Counties) 1970

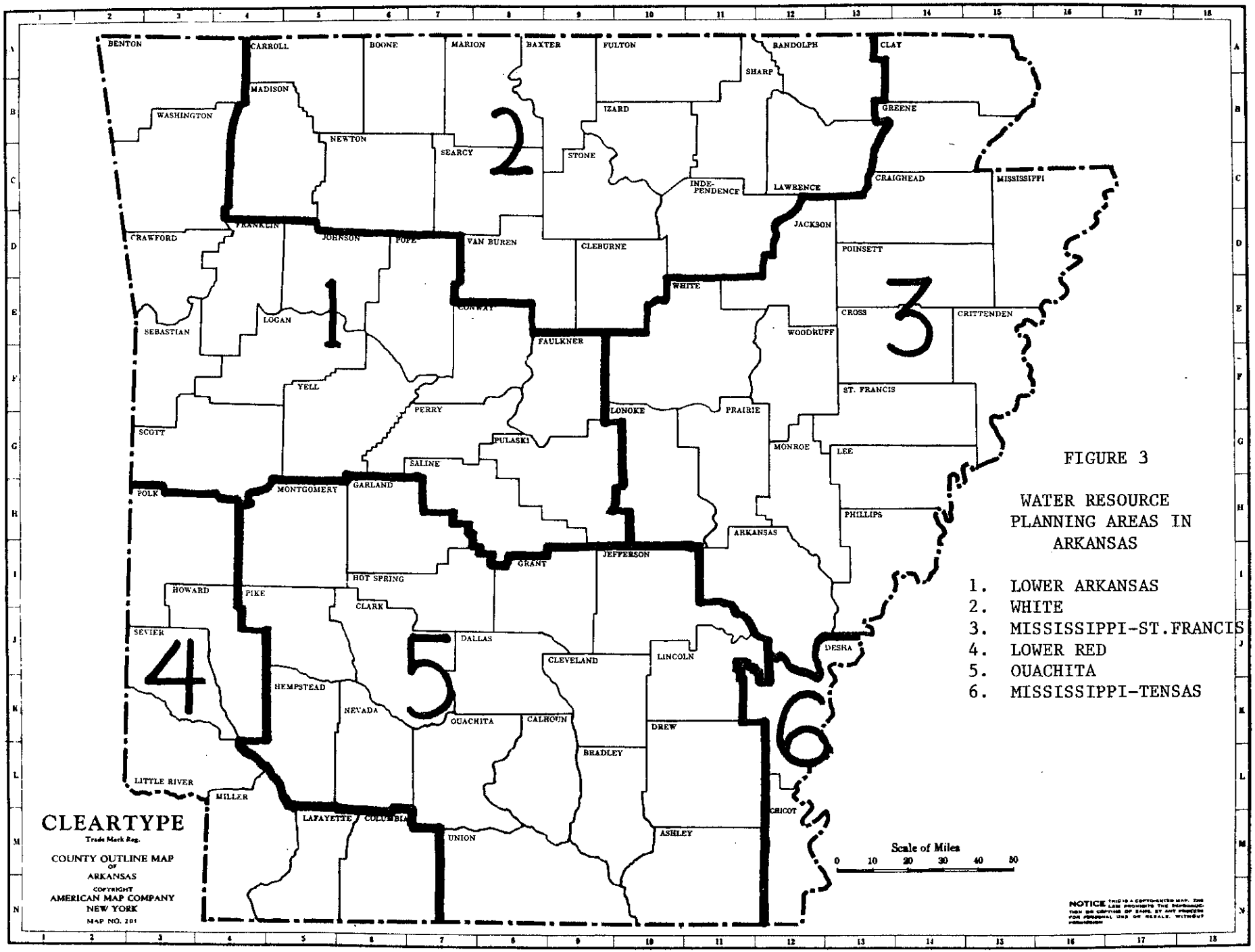


FIGURE 3

WATER RESOURCE PLANNING AREAS IN ARKANSAS

1. LOWER ARKANSAS
2. WHITE
3. MISSISSIPPI-ST.FRANCIS
4. LOWER RED
5. OUACHITA
6. MISSISSIPPI-TENSAS

shares. Projected Arkansas' shares are applied to area totals of income, employment, and population to obtain absolute values for each State segment. The foregoing procedure is applied to both the export and residentiary industries (with the exception of agriculture) as the disaggregation of area totals into State segments violates the functional structure between export and residentiary industries that holds for the BEA areas. The totals for each of the state segments are then summed to obtain state totals. The state totals are then disaggregated to the WRPAs shown in Figure 3 by applying the same methodology used to separate the BEA area data into state segments.

b. Agricultural Production and Land Use

State and Water Resource Planning Area projections of the agricultural sector are based on the same framework of assumption as the other industrial sectors. The agricultural projection system is based largely on the extension of historical trends and the use of a land availability check to indicate the adequacy of the resources within the regions to produce the projected output.

Projections of agricultural output for geographic areas are developed through a three stage process: (1) the distribution of projected national output to Arkansas; (2) the disaggregation of Arkansas' totals (percentage of national totals) to WRPAs in the State; and (3) conversion of output projections expressed in percentage terms to quantity estimates.

The distribution of projected national output in Arkansas is based on an extension of historical ratio trends (Arkansas production relative to national production--1947-1970) on a crop by crop basis. Measures of physical output are then obtained by applying the projected percentage to the national aggregate of the various products. The transformation of these Arkansas totals to the WRPAs within the State entails a similar procedure.

A land availability check is applied to determine whether resources within the State are sufficient to produce the protected crop output. The derived demand for cropland for each of the projection points at the State level is estimated by dividing projected crop production by projected yields. The supply of cropland is considered to be a function of the existing cropland base, increases resulting from land use shifts, resource development, and reductions resulting from the shift of land from agricultural to nonagricultural use. In Arkansas, the land availability check indicates sufficient land to produce the projected output. The derived State demand for cropland is distributed to the WRPAs by projecting the historical shares of each WRPA and multiplying these shares by the projected State totals.

c. Production Measure

The projected earnings figures for mining and manufacturing industries can be coverted into indexes which approximate production. These indexes are computed by first projecting the relationship between real earnings and gross product originating in each of the industries nationally. These numbers are then multiplied by each earnings value for each industry in an area. To express the results as an index of production each value in each line is divided by the value for the chosen base year (1970) and then multiplied by 100. The fact that the indexes are based on constant dollar relationships mean that they are essentially approximations of physical output.

III. EVALUATION OF OBERS METHODOLOGY

There are many methodologies that could be used in making the types of projections developed in this study. The type of methodology selected is usually dictated in the final analysis by the availability of reliable historical data on which to base the projections. As is often the case the most sophisticated methodology cannot be employed because of the lack of appropriate data. The ultimate evaluation of the methodology, therefore, must rest on its reasonableness relative to the techniques that could be utilized and to the availability of data. The OBERS methodology will be evaluated on this basis.

Ideally, economic projections for the state and for WRPAs should be developed from a knowledge of the structure of the state economy and that of its various water resource regions. The development of such a model would not only incorporate inter-industry relationships which exist in the state but also specify the structure of the relationship between Arkansas' economy and that of the rest of the world. A fully developed model could also incorporate an agricultural sector and be made capable of projecting the same variables as are projected in this study.

Unfortunately a reliable model of this type is not currently available. The absence of such a structural model means that less sophisticated, although not necessarily less accurate, methods of projection must be used. The OBERS methodology does not specify a structural model of the type just described but extends past relationships believed to have future relevance for the measures being projected. The use of this methodology implies that the underlying economic structure which existed in the past will remain reasonably stable into the future. As long as this structure does remain stable the trend or baseline projection technique used by OBERS will yield reasonable projections. To the extent, however, that the structure which governed past relationships noticably changes in the future the baseline technique may yield unreasonable projections.

To be sure, the OBERS methodology allows for some changes in future relationships. It is based on the general assumption that historical forces will continue to shape future relationships but that some significant changes are expected to occur. The specific assumptions employed are enumerated in Section II. Nevertheless, the methodology may yield unreasonable projections if these assumptions prove erroneous or if unanticipated major structural changes materialize. In agriculture, for example, it is possible to envision a future in which the increasing demand for agricultural products results in market prices which will make the present price supports irrelevant to production decisions. Under these circumstances it is likely that this program as well as various acreage control programs will be phased out, thus eliminating some of the major influences on past agriculture production. Future decisions on prices, output, and land use would be made under more competitive market conditions than in the past. The question of whether the old agricultural programs will, in fact, be eliminated in the near future and, if so, whether they would

be replaced by other federal programs is a difficult one to answer at best. The OBERS methodology does not consider explicitly these possible structural changes and their impact on future decisions in the agricultural sector. Nor does it explicitly incorporate other possible structural changes in the economy, e.g., the shortage of energy supplies and the impact of environmental regulations. The failure to explicitly include some of these changes in the methodology is understandable in light of the uncertainty of their impact in the short run and the uncertainty of government policies in the longer run. But users of these projections should be made aware that major structural changes can have a major impact on the projections. The projections should be used with this in mind and should be updated regularly to incorporate new information.

As a general comment, it should be noted that long term projections are less reliable than short term and projections for small area are less reliable than for larger areas. The projections for 1980, therefore, should be considered more reliable than those for 2000, and the projections for the nation should be considered more reliable than those for Arkansas or the WRPA's within Arkansas. Projections for total production, total labor force, and total income are more reliable than those for a small industry grouping. The short term and more aggregate measures are more reliable than long term and less aggregate measures. This implies that the industry by industry projections for each of the WRPAs are the least reliable of all the projections made in this study. This is particularly so since the development of these projections necessitated the breakup of the functionally integrated BEA areas. The intra-area interindustry relationships are better defined and more stable for these areas than for the WRPAs.

More specifically, since the indexes of production for mining and manufacturing are likely to be used more intensively than the other projections in the development of water use requirements, they deserve additional analysis. As noted in the OBERS report, they have two shortcomings and should be used with caution.[2] First, they are calculated for no greater than 2-digit SIC industry level of disaggregation. Within each of these industrial categories there is an industry mix which varies from area to area. For the individual industries which make up that mix both the level and the trend of the GPO/earnings relationship may be different from the group of industries as a whole. The second shortcoming of the index lies in the fact that the method does not recognize the difference which may occur from region to region in the GPO/earnings relationship within a specific industry, even at a detailed level of industrial classification, because of regional differences in productivity or capital/labor ratios. However, in spite of these shortcomings the individuals responsible for developing these indexes believe that they are adequate for projecting water requirements.

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[2] OBERS PROJECTIONS, Volume I: Concepts, Methodology, and Summary Data. Washington: Water Resources Council, 1974, p. 34.

As noted previously, the ultimate evaluation of the OBERS methodology must be made with respect to its reasonableness relative to the availability of data and techniques. The scope of the OBERS project and the various data constraints prevented the use of the more sophisticated methodology outlined in this section. Moreover, discussions with individuals in the state who are familiar with its regions and economy reveal that the projections in this study appear reasonable.

IV. DESCRIPTION OF TAPE PACKAGE

Economic and agricultural data used in this research is available on 9-track, 1600 BPI tape. In addition to the data, computer programs are provided on the tape to present the projection data in tabular form. Data and programs are contained in nine separate files.

Some files contain data that are also contained in another file. For example, File 1 and 4 both contain economic data projections. File 4, however, contains additional data which are used by the program in File 3 to produce tabular output of the data and is designed specifically for this purpose. File 1, on the other hand, contains only the projection data structured for general use.

Descriptions and parameters of each file are presented below.

FILE 1

POPULATION, EMPLOYMENT, PERSONAL INCOME AND EARNINGS BY SELECTED INDUSTRIAL SECTORS THOUSANDS OF 1967 DOLLARS

This file contains projections data for the years 1980, 1990, 2000, and 2020. Each file record contains a region - identification field, an item - identification field, and data for the five projection years. The order of data in each record is as follows:

VARIABLE NAME	DESCRIPTION
IREGON	Two digit integer specifying a WRPA (See list below)
ITEM	Two digit integer specifying the projected variable (i.e., population, employment, etc.-see below for complete listing of items)
DATA (I,J,K)	Array of projection data. I indicates the region, J the items and K the projection years.

The eight WRPA regions are as follows:

REGION NO. (IREGON)	WRPA REGION
1	United States
2	Arkansas - State Total
3	Mississippi - St. Francis & Crittenden
4	Ouachita
5	Mississippi - Tensas
6	White
7	Lower Arkansas & Benton County
8	Lower Red

The following is a description of the data items projected:

ITEM NO. (J)	ITEM - DATA (I,J,K)	UNITS[3]
1	Total Population	-
2	Total Personal Income	$M
3	Per Capita Personal Income	$
4	Total Employment	-
5	Total Earnings	$M
6	Agriculture, Forestry & Fisheries	$M
7	Agriculture	$M
8	Forestry and Fisheries	$M
9	Mining	$M
10	Coal Mining	$M
11	Crude Petroleum & natural gas	$M
12	Mining Excluding Fuels	$M
13	Metal Mining	$M
14	Mining and Quarrying of Nonmetallic Minerals	$M
15	Contract Construction	$M
16	Manufacturing	$M
17	Food and Kindred Products	$M
18	Textile Mill Products	$M
19	Apparel & other fabricated textile products	$M
20	Printing, Publishing & Allied	$M
21	Chemicals and Allied Products	$M
22	Lumber and Furniture	$M
23	Machinery	$M
24	Machinery Except Electrical	$M
25	Electrical Machinery	$M
26	Transportation Equipment	$M
27	Motor Vehicles & Equipment	$M
28	Transportation Excluding Motor Vehicles	$M
29	Other Manufacturing	$M
30	Paper and Allied Products	$M
31	Petroleum Refining & Related Products	$M
32	Primary Metals Industries	$M
33	Fabricated Metal & Ordnance	$M
34	Miscellaneous Manufacturing	$M
35	Transportation Comm., & Pub. Utilities	$M
36	Transportation	$M
37	Railroad Transportation	$M
38	Motor Freight Trans. & Warehousing	$M
39	Other Transportation Services	$M
40	Communications	$M
41	Electric, Gas, & Sanitary Services	$M
42	Wholesale and Retail Trade	$M
43	Finance, Insurance and Real Estate	$M
44	Services	$M
45	Business Services	$M
46	Lodging Places & Personal Services	$M

47	Business & Repair Services	$M
48	Amusements & Rec. Services	$M
49	Private Households	$M
50	Professional Services	$M
51	Total Government	$M
52	Civilian Government	$M
53	Federal Government	$M
54	State and Local	$M
55	Federal Military	$M

[3]All items except (1) - Total Population, (3) - Per Capita Income, and (4) - Total Employment are in thousands of 1967 dollars with the exception of Region 1 (United States) which is in millions of 1967 dollars. Total Per Capita Income for all regions is in 1967 dollars. For Region 1 (United States), Total Population and Total Employment are in thousands of persons, Regions 2-8 are in persons.

Reading File 1

The following is an example of how File 1 may be read in FORTRAN.

```
      DIMENSION     DATA(8,55,5)
      DO  10  I=  1,8
      DO  20  J=  1,55
      READ(i,1)  IREGON, ITEM, (DATA(I,J,K),  K=1,5)
1     FORMAT(2I2,5F10.0)

20    CONTINUE

10    CONTINUE

      DCB=(RECFM=FB,LRECL=54,BLKSIZE=54),DSN=POP.EMP.ERN.
```

FILE 2

PROJECTED AGRICULTURAL PRODUCTION AND USE OF HARVESTED CROPLAND IN FARMS

This file contains projections data for the years 1980, 1985, 2000 and 2020. Each file record contains a region identification field, an item identification field, and data for the four projection years. The order of data in each record is as follows:

VARIABLE NAME	DESCRIPTION
IREGON	Two digit interger specifying a WRPA (see list below)
ITEM	Two digit integer specifying the projected variable (i.e., total soybean production, total beef production, irrigated cotton acres harvested, etc. - see below for complete listing of items)

DATA(I,J,K) Array of projection data. I corresponds with the WRPA region, J compounds with the item and K with the projection years.

The eight WRPA regions are as follows:

REGION NO. (IREGON)	WRPA REGION
1	Arkansas - State Total
2	Lower Arkansas & Benton County
3	White
4	Mississippi - Tensas
5	Ouachita
6	Mississippi - St. Francis
7	Crittenden County
8	Lower Red

The following is a description of the data items and units.

ITEM NO.	ITEM - DATA(I,J,K)	UNITS
1	Grain Sorghum Production	M Bushels
2	Wheat Production	M Bushels
3	Rice Production	M Bushels
4	Soybeans Production	M Bushels
5	Cotton Production	M Bales
6	Beef and Veal Production	M Pounds
7	Pork Production	M Pounds
8	Broiler Production	M Pounds
9	Turkey Production	M Pounds
10	Egg Production	M Dozens
11	Grain Sorghum Acres Harvested	M Acres
12	Wheat Acres Harvested	M Acres
13	Rice Acres Harvested	M Acres
14	Soybeans Harvested	M Acres
15	Cotton Acres Harvested	M Acres
16	Rice Irrigated Acres Harvested	M Acres
17	Soybeans Irrigated Acres Harvested	M Acres
18	Cotton Irrigated Acres Harvested	M Acres

Reading File 2

The following is an example of how File 2 may be read in FORTRAN

```
      DIMENSION    DATA(8,18,4)
      DO  10  I=1,8
      DO  20  J=1,18
      READ(i,1)IREGON,ITEM,(DATA(I,J,K),K=1,4)
    1 FORMAT(2I2,4F10.1)

   20 CONTINUE

   20 CONTINUE
           DCB=(RECFM=FB,LRECL=44,BLKSIZE=44),DSN=AGG.PRO.ACR.
```

FILE 3

File 3 contains a FORTRAN program in source form to generate tabular output of the population, employment, and earnings projection data. Data for this program is in File 4. Output includes table headings, column headings and line descriptions.

The following sequence of IBM-370, CALL-OS statements will generate the tabular output:

```
     (USERS JOB CARD)
//   EXEC  FORTGCLG
//FORT.SYSIN  DD  UNIT=9-TRACK,VOL=(,RETAIN,SER=ZIEG01),LABEL=3,

//        DSN=POP.EMP.ERN.PROG,DISP=OLD
//GO.FT05F001  DD  UNIT=9-TRACK,VOL=SER=ZIEG01,LABEL=4,DISP=OLD,
//        DSN=POP.EMP.ERN.DATA
//*
//
```

File 3 parameters are
DCB=(RECFM=FB,LRECL-80,BLKSIZE=80),DSN=POP.EMP.ERN.PROG.

FILE 4

File 4 contains the data utilized by the program of File 3 to generate tabular population, employment and earnings projection data. In addition to the numerical projection data, this file contains alphabetic data for table headings and projection item descriptions.

Although the projection data of File 4 are the same as that in File 1 they are represented quite differently. File 4 is structured specifically for use with the program in File 3 and it is not anticipated that it will be used for any other purpose.

File 4 parameters are:
DCB=(RECFM=FB,LRECL=80,BLKSIZE=80),DSN=POP.EMP.ERN.DATA

FILE 5

File 5 contains a FORTRAN program in source form to generate tabular output of the crop and livestock production and the cropland harvested projection data. Data for this program are stored in File 6. Output is by WRPA and contains table headings, column headings and line item descriptions.

The following sequence of IBM-370, CALL-OS statements will generate the tabular output:

```
(Users Job Card)

//    EXEC FORTGCLG
¢/FORT.SYSIN  DD  UNIT=9-TRACK,VOL=(,RETAIN,SER-ZIEGO1),LABEL=5,
//    DISP=OLD,DSN=AGG.PRO.ACR.PROG.
//GO.FTO5FOO1  DD  UNIT-9TRACK,VOL=SER-ZIEGO1,LABEL=6,DISP=OLD,
//    DSN=AGG.PRO.ACR.DATA
/*
//
```

File 5 parameters are:
DCB=(RECFM=FB,LRECL=80,BLKSIZE=80),DSN=AGG.PRO.ACR.PROG

FILE 6

File 6 contains the data utilized by the program of File 5 to generate tabular output of agricultural production and cropland harvested projection data. In addition to the numerical projections data, this file contains alphabetic data for table and column headings and line item descriptions.

Although the projection data of File 6 and File 2 are the same, File 6 contains additional information about data units, column headings etc. File 6 is structured specifically for use with the program in File 5 and it is not anticipated that it will be used for any other purpose.

File 6 parameters are:
DCB=(RECFM=FB,LRECL=80,BLKSIZE=80),DSN=AGG.PRO.ACR.DATA

FILE 7

PRODUCTION INDEXES - SELECTED INDUSTRIES, 1970=100

File 7 provides indexes of production for selected mining and manufacturing industries. 1970 is the base year production. Projection years are 1980, 1990, 2000 and 2020.

Each file record contains a region-identification field, an item-identification field and data for the four projection years. The order of data in each record is as follows:

VARIABLE NAME	DESCRIPTION
IREGON	Two digit interger specifying a WRPA (See list below)
INDSRY	Two digit integer specifying the industry for which the index is computed.
IDATA(I,J,K)	Array of projected indexes. I indicates the region, J the items and K the projection years.

The eight WRPA regions are as follows:

REGION NO. (IREGON)	WRPA REGION
1	United States
2	Arkansas-State Total
3	Mississippi-St. Francis & Crittenden
4	Ouachita
5	Mississippi-Tensas
6	White
7	Lower Arkansas & Benton County
8	Lower Red

The following is a description of the industries for which indexes of production were projected:

INDUSTRY NO. (J)	INDUSTRY-DATA(I,J,K)
1	Mining
2	Coal Mining
3	Crude Petroleum and Natural Gas
4	Mining Excluding Fuels
5	Metal-Mining
6	Mining and Quarrying of Nonmetallic Minerals
7	Manufacturing
8	Food and Kindred Products
9	Textile Mill-Products
10	Apparel and Other Fabricated Textile Products
11	Printing, Publishing and Allied Industries
12	Chemicals and Allied Products
13	Lumber and Furniture
14	Machinery
15	Machinery Except Electrical
16	Electrical-Machinery
17	Transportation Equipment
18	Motor Vehicles and Motor Vehicles Equipment
19	Transportation Excluding Motor Vehicles
20	Other Manufacturing
21	Paper and Allied Products
22	Petroleum Refining and Related Products
23	Primary Metals Industries
24	Fabricated Metals and Ordnance
25	Miscellaneous Manufacturing

Reading File 7

The following is an example of how File 7 maybe read in FORTRAN:

```
      DIMENSION     DATA(8,25,4)
      DO  10  I=1,8
      DO  20  J=1,25
      READ(i,1)IREGON,INDSRY,      (I,J,K),K=1,4)
1     FORMAT(2I2,4I10)
20    CONTINUE
10    CONTINUE

      DCB=(RECFM=FB,LRECL=44,BLKSIZE=44),DSN=
```

FILE 8

File 8 contains a FORTRAN program in source form to generate tabular output of the projected indexes of production for selected industries. Output is by WRPA and includes table headings, column headings and industry descriptions. Data for this program is in File 9.

The following sequence of IBM-370, CALL-OS statements will generate the tabular output:

```
(Users Job Card)
//    EXEC  FORTGCLG
//FORT.SYSIN  DD  UNIT=9-TRACK,VOL=(,RETAIN,SER=ZIEG01),LABEL=8,
//    DSN=GROSS.PROD.PROG.DISP=OLD
//GO.FT05F001  DD  UNIT=9-TRACK,VOL=SER=ZIEG01,LABEL=9,DISP=OLD,
//    DSN=GROSS.PROD.PROG.DATA
/*
//
```

File 8 parameters are:

```
      DCB=(RECFM=FB,LRECL=80,BLKSIZE=80),DSN=GROSS.PROD.PROG
```

FILE 9

File 9 contains the data utilized by the program of File 8 to generate tabular output of projected indexes of production for selected industries. In addition to the numerical indexes, this file contains alphabetic data for table headings and industry descriptions.

Although the projected indexes of File 9 are the same as those in File 7, they are presented in a different format to facilitate tabular presentation. It is not anticipated that File 9 will not be used for any purpose other than data for File 8.

File 9 parameters are:

```
      DCB=(RECFM=FB,LRECL=80,BLKSIZE=80),DSN=GROSS.PROD.PROG.DATA
```

APPENDIX A

DERIVATION OF PROJECTED GNP AND NATIONAL PERSONAL INCOME AND EARNINGS

Year	(1) Population (000)	(2) Working age population (000)	(3) Total labor force participation rate %	(4) Total labor force (000)	(5) Armed forces (000)	(6) Civilian labor force (000)	(7) Unemployment rate %	(8) Civilian employment (000)	(9) Government civilian employment (percent of civilian employment)	(10) Government civilian employment (000)
1950	152,271	113,437	7.1	64,749	1,650	63,099	5.3	59,746	9.7	5,817
1955	165,931	119,440	57.7	68,896	3,049	65,847	4.4	62,942	10.9	6,838
1960	180,671	127,357	57.4	73,126	2,514	70,612	5.6	66,681	11.9	7,943
1965	194,303	138,746	56.5	78,358	2,723	75,635	4.6	72,179	13.3	9,623
1966	196,560	141,092	56.8	80,164	3,123	77,041	3.9	74,065	14.0	10,346
1967	198,712	143,562	57.2	82,170	3,446	78,724	4.0	75,608	14.8	11,183
1968	200,706	146,033	57.3	83,688	3,535	80,153	3.7	77,210	15.1	11,627
1969	202,677	148,538	57.7	85,686	3,506	82,180	3.8	79,032	15.3	12,061
1970	204,879	151,103	57.9	87,432	3,188	84,244	5.1	79,989	15.6	12,464
1971	207,049	153,715	57.6	88,493	2,817	85,676	6.0	80,501	15.9	12,805
Rate of increase 1950–1971	1.47%	1.46%	——	1.50%	2.58%	1.47%	——	1.43%	——	3.83%
1980	224,132	174,773	59.1	103,228	2,300	100,928	4.0	96,891	16.2	15,687
1990	246,639	190,077	59.9	113,925	2,300	111,625	4.0	107,160	17.3	18,492
2000	264,430	208,972	60.2	125,838	2,300	123,538	4.0	118,596	18.1	21,444
2010	281,968	225,343	60.5	136,363	2,300	134,063	4.0	128,700	18.2	23,463
2020	297,746	238,382	58.5	139,432	2,300	137,132	4.0	131,647	19.3	25,416
Rate of increase 1971–2020	0.74%	0.90%	——	0.93%	–0.41%	0.96%	——	1.01%	——	1.41%
Source of historical data	Census	Census	Implicit	BLS	BLS	BLS	Implicit	BLS	Implicit	BLS
Method of projection	Series E explained in P-25 No. 493	Series E explained in P-25 No. 493	BLS	Implicit	Assumed average level of 2,300,000	Col. 4 –Col. 5	Assumed 4%	Col. 6 –(Col. 7 × Col. 6)	Trend projections	Col. 8 × Col. 9

Year	(11) Private civilian employment	(12) Private economy hours worked per year per man	(13) Private economy gross product per man per hour (1958 dollars)	(14) Private economy gross product (millions of 1958 dollars)	(15) Government gross product (millions of 1958 dollars)	(16) Gross national product (millions of 1958 dollars)	(17) Personal income (percent of gross national product)	(18) Personal income (millions of 1958 dollars)	(19) Earnings (percent of personal income)	(20) Earnings (millions of 1958 dollars)
1950	53,929	2,127	2.78	319,400	35,888	355,288	77.3	274,571	82.6	226,835
1955	56,104	2,091	3.34	392,023	45,940	437,963	76.5	335,010	83.7	280,475
1960	58,738	2,027	3.68	438,589	49,093	487,682	79.9	389,653	82.1	319,781
1965	62,556	2,020	4.43	560,096	57,703	617,799	80.2	495,306	80.7	399,706
1966	63,719	2,018	4.64	596,316	61,771	658,087	80.0	526,651	81.1	427,362
1967	64,425	1,996	4.74	609,582	65,574	675,156	81.5	550,118	80.6	443,635
1968	65,583	1,977	4.92	638,310	68,339	706,649	82.3	581,861	80.5	468,304
1969	66,971	1,967	4.98	655,994	69,633	725,627	83.8	608,033	80.6	490,146
1970	67,525	1,936	4.99	652,540	69,545	722,085	86.4	623,558	79.5	495,643
1971	67,696	1,918	5.18	672,079	69,626	741,705	86.5	641,864	78.9	506,684
Rate of increase 1950–1971	1.09%	–0.49%	3.01	3.61%	3.21%	3.57%	——	4.13%	——	3.90%
1980	81,204	1,858	6.70	1,010,876	80,909	1,091,785	85.9	937,592	78.5	735,625
1990	88,668	1,794	8.92	1,418,908	93,776	1,512,684	88.0	1,330,844	77.6	1,033,258
2000	97,152	1,731	11.87	1,996,179	107,204	2,103,383	89.7	1,887,092	77.1	1,454,816
2010	105,237	1,671	15.79	2,776,688	116,615	2,893,303	91.2	2,637,651	76.7	2,023,835
2020	106,231	1,613	21.02	3,601,790	125,731	3,727,521	92.4	3,443,298	76.5	2,633,637
Rate of increase 1971–2020	0.92%	–0.35%	2.90%	3.49%	1.21%	3.35%	——	3.49%	——	3.42%
Source of historical data	BLS	BLS	Implicit	BEA	BEA	BEA	Implicit	BEA	BEA	BEA
Method of projection	Col. 8 –Col. 10	Trend projection	Trend projection	Col. 11 × Col. 12 × Col. 13	Col. 5 × (1958 salary rate) + Col. 9 × (1958 salary rate)	Col. 14 + Col. 15	Modified exponential trend projection	Col. 16 × Col. 17	Modified exponential trend projection	Col. 18 × Col. 19

APPENDIX B

BRIEF INDUSTRIAL DESCRIPTIONS
(Extracted From the 1967 Standard Industrial Classification Manual. Prepared by the Office of Statistical Standards, Bureau of the Budget, Executive Office of the President)

SIC 01--AGRICULTURAL PRODUCTION

This major group includes establishments (farms, ranches, dairies, greenhouses, nurseries, etc.) primarily engaged in the production of crops or plants, vines and trees (excluding forestry operations); and the keeping, grazing, or feeding of livestock for animal products (including serums), for animals increase, or value increase.

SIC 07--AGRICULTURAL SERVICES AND HUNTING AND TRAPPING

This major group includes establishments primarily engaged in performing agricultural, animal husbandry, and horticultural servies on a fee or contract basis. Commercial hunting and trapping and the operation of game preserves are also included.

SIC 08--FORESTRY

This major group includes establishments primarily engaged in the operation of timber tracts, forest nurseries, and related activities such as reforestation services and the gathering of gums, barks, balsam needles, maple sap, Spanish moss, and other forest products.

SIC 09--FISHERIES

This major group includes establishments primarily engaged in commercial fishing; the operation of oyster farms and the tonging and dredging of oysters; the gathering of sponges, seaweed, etc.; and the operation of fish hatcheries or fishing preserves.

SIC 10--METAL MINING

This major group includes establishments primarily engaged in mining, developing mines, or exploring for metallic minerals (ores).

SIC 11--ANTHRACITE MINING

This major group includes establishments primarily engaged in producing anthracite (hard coal). Included are mining operations, dredging operations, and preparation plants (also known as cleaning plants, breakers, and washeries) whether or not such plants are operated in conjunction with the mines served.

SIC 12--BITUMINOUS COAL AND LIGNITE MINING

This major group includes establishments primarily engaged in producing bituminous coal or lignite. Included are mining operations and preparation plants (also known as cleaning plants and washeries) whether or not such plants are operated in conjunction with the mines served.

SIC 13--CRUDE PETROLEUM AND NATURAL GAS

This major group includes establishments primarily engaged in (1) producing crude petroleum and natural gas, (2) recovering oil from sands and oil shale, and (3) producing natural gasoline and cycle condensate. Types of activities included are exploration, drilling, oil and gas well operation and maintenance, the operation of natural gasoline and cycle plants, and the mining and extraction of oil and oil sands and oil shale. This major group also includes such basic activities as emulsion breaking and desilting of crude petroleum to render the oil marketable.

SIC 14--MINING AND QUARRYING OF NONMETALLIC MINERALS, EXEPT FUELS

This major group includes establishments primarily engaged in mining or quarrying, developing mines, or exploring for nonmetallic minerals, except fuels. Also included are certain well and brine operations, and primary preparation plants, such as those engaged in crushing, grinding, washing, or other concentration.

SIC 15-17--CONTRACT CONSTRUCTION

This division includes establishments primarily engaged in contract construction. The term "construction" includes new work, additions, alterations, and repairs. Three broad types of contract construction activity are covered; namely (1) building construction by general contractors, (2) other construction by general contractors, and (3) construction by special trade contractors.

SIC 19--ORDNANCE AND ACCESSORIES

This major group includes establishments engaged in manufacturing artillery, small arms, and related equipment; ammunition, tanks and specialized tank parts; sighting and fire control equipment; and miscellaneous ordnance and accessories, not elsewhere classified.

SIC 20--FOOD AND KINDRED PRODUCTS

This major group includes establishments manufacturing foods and beverages for human consumption, and certain related products, such as manufactured ice, chewing fum, vegetable and animal fats and oils, and prepared feeds for animals and fowls.

SIC 21--TABACCO MANUFACTURES

This major group includes establishments engaged in manufacturing cigarettes, cigars, smoking and chewing tobacco, and snuff, and in stemming and redrying tobacco.

SIC 22--TEXTILE MILL PRODUCTS

This major group includes establishments engaged in performing any of the following operations: (1) preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine and cordage; (2) manufacturing broad woven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn; (3) dyeing and finishing fiber, yarn, fabric, and knit apparel; (4) coating, waterproofing or otherwise treating fabric; (5) the integrated manufacture of knit apparel and other finished articles from yarn; and (6) the manufacture of felt goods, lace goods, bonded-fiber fabrics, and miscellaneous textiles.

SIC 23--APPAREL AND OTHER FINISHED PRODUCTS MADE FROM FABRICS AND SIMILAR MATERIALS

This major group, known as the cutting-up and needle trades, includes establishments producing clothing and fabricating products by cutting and sewing purchased woven or knit textile fabrics and related materials such as leather, rubberized fabrics, plastics and furs.

SIC 24--LUMBER AND WOOD PRODUCTS, EXCEPT FURNITURE

This major group includes logging camps engaged in cutting timber and pulpwood, merchant sawmills, lath mills, shingle mills, cooperage stock mills, planing mills, and plywood mills and veneer mills engaged in producing lumber and wood basic materials; and establishments engaged in manufacturing finished articles made entirely or mainly of wood or wood substitutes.

SIC 25--FURNITURE AND FIXTURES

This major group includes establishments engaged in manufacturing household, office, public building, and restaurant furniture; and office and store fixtures.

SIC 26--PAPER AND ALLIED PRODUCTS

This major group includes the manufacture of pulps from wood and other cellulose fibers, and rags; the manufacture of paper and paperboard; and the manufacture of paper and paperboard into converted products such as paper coated off the paper machine, paper bags, paper boxes, and envelopes.

SIC 27--PRINTING, PUBLISHING, AND ALLIED INDUSTRIES

This major group includes establishments engaged in printing by one or more of the common processes, such as letterpress, lithography, gravure, or screen; and those establishments which perform services for

the printing trade, such as bookbinding, typesetting, engraving, photo-engraving, and electrotyping.

SIC 28--CHEMICALS AND ALLIED PRODUCTS

This major group includes establishments producing basic chemicals, and establishments manufacturing products by predominantly chemical processes. Establishments classified in this major group manufacture three general classes of product: (1) basic chemicals such as acids, alkalies, salts, and organic chemicals; (2) chemical products to be used in further manufacture such as synthetic fibers, plastics materials, dry colors, and pigments; (3) finished chemical products to be used for ultimate consumption such as drugs, cosmetics, and soaps; or to be used as materials or supplies in other industries such as paints, fertilizers, and explosives.

SIC 29--PETROLEUM REFINING AND RELATED INDUSTRIES

This major group includes establishments primarily engaged in petroleum refining, manufacturing paving and roofing materials, and compounding lubricating oils and greases from purchased materials.

SIC 30--RUBBER AND MISCELLANEOUS PLASTIC PRODUCTS

This major group includes establishments manufacturing from natural, synthetic, or reclaimed rubber, gutta percha, balata, or gutta siak, rubber products such as tires, rubber footwear, mechanical rubber goods, heels and soles, flooring, and rubber sundries. This group also includes establishments engaged in molding primary plastics for the trade, and manufacturing miscellaneous finished plastics products.

SIC 31--LEATHER AND LEATHER PRODUCTS

This major group includes establishments engaged in tanning, currying, and finishing hides and skins, and establishments manufacturing finished leather and artificial leather products and some similar products made of other materials. Leather converters are also included.

SIC 32--STONE, CLAY, GLASS, AND CONCRETE PRODUCTS

This major group includes establishments engaged in manufacturing flat glass and other glass products, cement, structural clay products, pottery, concrete and gypsum products, cut stone, abrasive and asbestos products, etc., from materials taken principally from the earth in the form of stone, clay and sand.

SIC 33--PRIMARY METAL INDUSTRIES

This major group includes establishments engaged in smelting and refining of ferrous and nonferrous metals from ore, pig, or scrap; in the rolling, drawing, and alloying of ferrous and nonferrous metals; in the manufacture of castings, forgings and other basic products of ferrous and nonferrous metals; and in the manufacture of nails, spikes, and insulated wire and cable. This major group also includes the production of coke.

SIC 34--FABRICATED METAL PRODUCTS, EXCEPT ORDNANCE MACHINERY, AND TRANSPORTATION EQUIPMENT

This major group includes establishments engaged in fabricating ferrous and nonferrous metal products such as metal cans, tinware, hand tools, cutlery, general hardware, nonelectric heating apparatus, fabricated structural metal products, metal stampings and a variety of metal and wire products not elsewhere classified.

SIC 35--MACHINERY, EXCEPT ELECTRICAL

This major group includes establishments engaged in manufacturing machinery and equipment, other than electrical equipment (Major Group 36) and transportation equipment (Major Group 37).

SIC 36--ELECTRICAL MACHINERY, EQUIPMENT, AND SUPPLIES

This major group includes establishments engaged in manufacturing machinery, apparatus, and supplies for the generation, storage, transmission, transformation, and utilization of electrical energy.

SIC 37--TRANSPORTATION EQUIPMENT

This major group includes establishments engaged in manufacturing equipment for transportation of passengers and cargo by land, air, and water. Important products produced by establishments classified in this major group include motor vehicles, aircraft, ships, boats, railroad equipment such as motorcycles, bicycles, and horse drawn vehicles.

SIC 38--PROFESSIONAL, SCIENTIFIC, AND CONTROLLING INSTRUMENTS: PHOTOGRAPHIC AND OPTICAL GOODS: WATCHES AND CLOCKS

This major group includes establishments engaged in manufacturing mechanical measuring, engineering, laboratory, and scientific research instruments; optical instruments, equipment and supplies, ophthalmic goods; photographic equipment and supplies; and watches and clocks.

SIC 39--MISCELLANEOUS MANUFACTURING INDUSTRIES

This major group includes establishments primarily engaged in manufacturing products not classified in any other manufacturing major group. Industries in this group fall into the following categories: jewelry, silverware and plated ware; musical instruments; toys, sporting and athletic goods; pens, pencils, and other office and artists' materials; buttons, costume novelties, miscellaneous notions; brooms and brushes; morticians' goods; and other miscellaneous manufacturing industries.

SIC 40--RAILROAD TRANSPORTATION

This major group includes companies furnishing transportation by line-haul railroad, and certain services allied to rail transportation, such as sleeping and dining car services, railway express, and switching and terminal companies. Railway companies serving a single municipality,

and its surburban areas are classified in Major Group 41.

SIC 41--LOCAL AND SUBURBAN TRANSIT AND INTERURBAN HIGHWAY PASSENGER TRANSPORTATION

This major group includes companies primarily engaged in furnishing local and suburban passenger transportation, such as companies providing passenger transportation within a single municipality, contiguous municipalities, or a municipality and its suburban areas by rail or trolley coach, either separately or in conjunction with motor bus lines, and companies engaged in furnishing transportation to local scenic features, including cable and cog railways.

SIC 42--MOTOR FREIGHT TRANSPORTATION AND WAREHOUSING

This major group includes establishments furnishing local or long-distance trucking, transfer, and draying services, or engaged in the storage of farm products, furniture and other household goods, or commercial goods of any nature. The operation of terminal facilities for handling freight, with or without maintenance facilities, is also included.

SIC 44--WATER TRANSPORTATION

This major group includes companies engaged in freight and passenger transportation on the open seas or inland waters, and companies furnishing such incidental services as lighterage, towing and canal operation.

SIC 45--TRANSPORTATION BY AIR

This major group includes companies engaged in furnishing domestic and foreign transportation by air and also those operating airports and flying fields and furnishing terminal services.

SIC 46--PIPE LINE TRANSPORTATION

This major group includes companies primarily engaged in the pipe line transportation of petroleum and other commodities, except natural gas.

SIC 47--TRANSPORTATION SERVICES

This major group includes companies furnishing services incidental to transportation, such as forwarding and packing services, arrangements of transportation, and the operation of stockyards.

SIC 48--COMMUNICATION

This major group includes companies furnishing point-to-point communication services, whether by wire or radio, and whether intended to be received aurally or visually; and radio broadcasting and television. Services for the exchange or recording of messages are also included.

SIC 49--ELECTRIC, GAS, AND SANITARY SERVICES

This major group includes companies engaged in the generation, and/or distribution of electricity or gas or steam. Such companies and systems may be combinations of any of the above three services and also include other types of service such as transportation, communication, and refrigeration. Water and irrigation systems, and sanitary systems engaged in the collection and disposal of garbage, sewage, and other wastes by means of destroying or processing materials are also included.

SIC 50--WHOLESALE TRADE

This major group includes establishments or places or business primarily engaged in selling merchandise to retailers; to industrial, commercial, institutional, or professional users; or to other wholesalers; or acting as agents in buying merchandise for or selling merchandise to such persons or companies. The chief functions of establishments included in wholesale trade are selling goods to trading establishments, or to industrial, commercial, institutional, and professional users; and bringing buyer and seller together.

SIC 52-59--RETAIL TRADE

Retail trade includes establishments engaged in selling merchandise for personal, household, or farm consumption and rendering services incidental to the sale of the goods.

SIC 60-69--FINANCE, INSURANCE, AND REAL ESTATE

This division comprises establishments operating primarily in the fields of finance, insurance, and real estate.

SIC 70--HOTELS, ROOMING HOUSES, CAMPS, AND OTHER LODGING PLACES

This major group includes commercial and institutional establishments engaged in furnishing lodging or lodging and meals, and camping space and camping facilities, on a fee basis.

SIC72--PERSONAL SERVICES

This major group includes establishments primarily engaged in providing services generally involving the care of the person or his apparel.

SIC 73--MISCELLANEOUS BUSINESS SERVICES

This major group includes establishments rendering services not elsewhere classified to business enterprises on a fee or contract basis.

SIC 75--AUTOMOBILE REPAIR, AUTOMOBILE SERVICES, AND GARAGES

This major group includes establishments primarily engaged in furnishing automobile repair, rental, and storage services to the general public.

SIC 76--MISCELLANEOUS REPAIR SERVICES

This major group includes establishments engaged in miscellaneous repair services.

SIC 78--MOTION PICTURES

This major group includes establishments producing and distributing motion picture films, exhibiting motion pictures in commercially operated theaters, and furnishing services to the motion picture industry.

SIC 79--AMUSEMENT AND RECREATION SERVICES, EXCEPT MOTION PICTURES

This major group includes establishments whose primary function is to provide amusement or entertainment on payment of a fee or admission charge, except motion pictures (Major Group 78).

SIC 80--MEDICAL AND OTHER HEALTH SERVICES

This major group includes establishments primarily engaged in furnishing medical, surgical, and other health services to persons.

SIC 81--LEGAL SERVICES

This major group includes establishments engaged in offering legal advice or legal services on a contract of fee basis, the head or heads of which are members of the bar.

SIC 82--EDUCATIONAL SERVICES

This major group includes establishments furnishing formal academic or technical courses, correspondence schools, commercial and trade schools and libraries.

SIC 84--MUSEUMS, ART GALLERIES, BOTANICAL AND ZOOLOGICAL GARDENS

This major group includes museums, art galleries, and botanical and zoological gardens.

SIC 86--NONPROFIT MEMBERSHIP ORGANIZATIONS

This major group includes organizations operating on a nonprofit membership basis for the promotion of the interests of the members. Included are such as trade associations; professional membership organizations; labor unions and similar labor organizations; and political, charitable, and religious organizations.

SIC 89--MISCELLANEOUS SERVICES

This major group includes establishments engaged in performing services, not elsewhere classified, such as those rendered by engineers, architects, accountants, artists, lecturers, and writers.

SIC 91-93--GOVERNMENT

This division includes all Federal, State, local, and international government activities, such as the legislative, judicial, and administrative functions, as well as government owned and operated business enterprises.

CHAPTER VIII

ARKANSAS LAND AND WATER RESOURCES

ARKANSAS LAND AND WATER RESOURCES

Arkansas is fortunate to have an abundance of fertile soil and clean water, but the inbalance in the distribution of these invaluable resources often hinders economic growth. We often take our natural resources for granted by unconsciously squandering or misusing them. Our land and water resources are closely related--too much rainfall causes the land to flood and erode; without adequate rainfall the land is unproductive.

LAND RESOURCE

Arkansas has a total land area of approximately 33,246,484 acres, based on the June 1969, Arkansas Conservation Needs Inventory. Figure 7-1 shows the land use breakdown for the state.

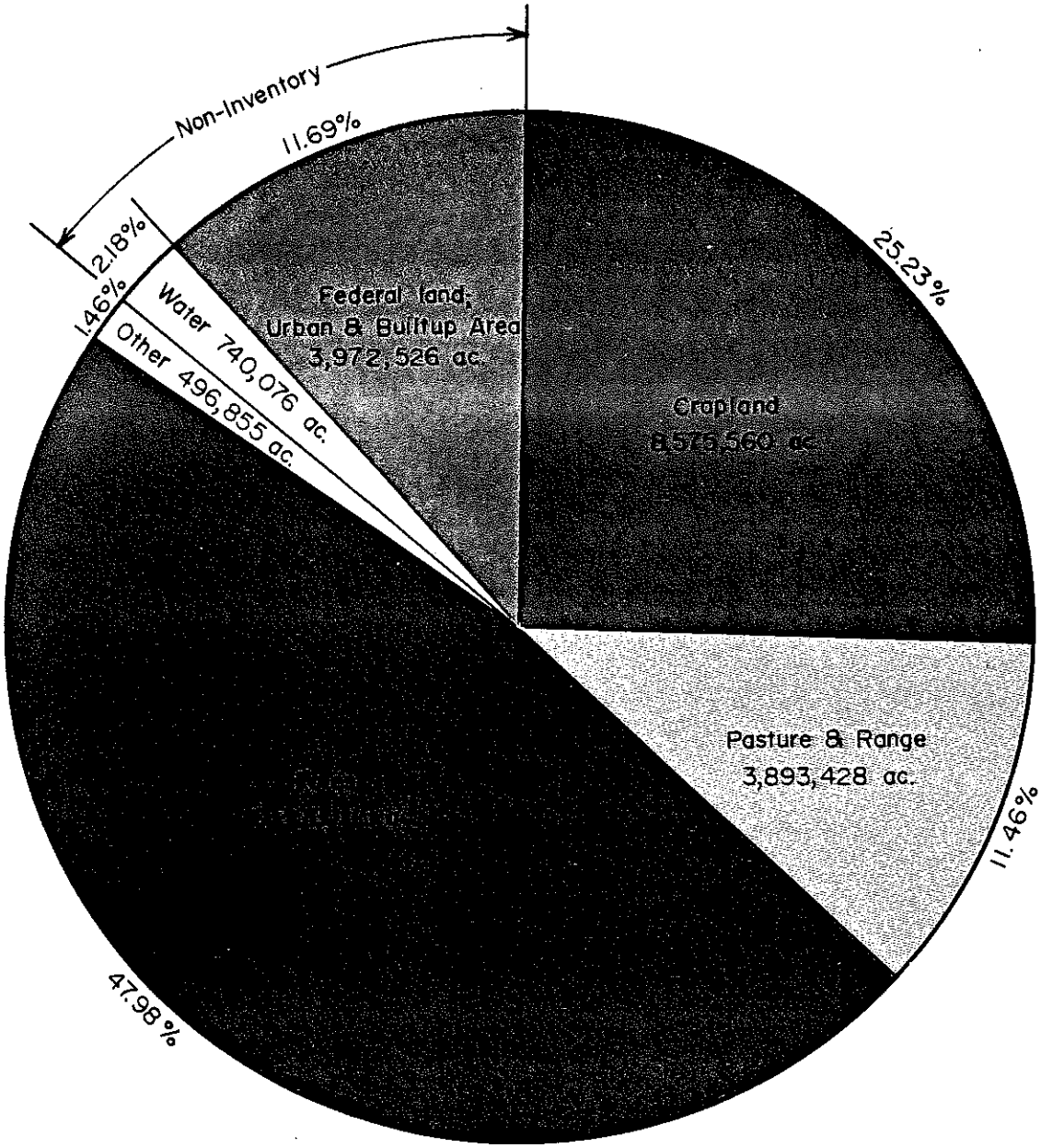
Major Land Resource Areas

Arkansas is covered by three major land resource areas. The following land resource area map (Page 115) and descriptions resulted from efforts of the Soil Conservation Service to assemble and organize currently available information about the land as a resource for farming, ranching, forestry, engineering, recreation, and other uses. The map is an updating, revision, and redesigning of the 1950 map "Problem Areas in Soil Conservation." The information provided is current as of the end of 1964. Further revision of both map and descriptions will be required as new information becomes available and as improved methods for organizing and presenting information are devised.

Land resource maps are interpreted primarily from general soil maps (until recently termed soil association maps); at equivalent scales, delineations on land resource maps are the same as delineations on general soil maps except that some delineations on a general soil map are divided into two or more land resource delineations because of significant and mappable differences in climate, water resources, land use, and type of farming. For example, some soil map delineations are divided into two land resource delineations on the basis of marked differences in kind of farming or climatic differences critical to one or more important crops. The principal difference between the two kinds of maps, however, is in the orientation and organization of the information and the nomenclature used to express it.

In the preparation of land resource maps at State and National levels, three land resource categories have evolved.

1. Land resource units are geographic areas of land, usually several thousand acres in extent, that are characterized by particular patterns of soil (including slope and erosion), climate, water resources, land use, and type of farming. A unit may occur as one continuous area or as several



LAND USE OF THE AREA OF ARKANSAS, 1967

Source: Arkansas Conservation NEEDS Inventory June 1969

Figure 8-1

separate but nearby areas. Land resource units are the basic map units on State land resource maps, which are usually at the scale of 1:1,000,000. They are coextensive with map units of State general soil maps except that some map units of general soil maps are subdivided into two or more land resource units because of significant differences in climate, water resources, land use, and type of farming. They are not described in this handbook or shown on the national map, but they are the basic units from which the major land resource areas have been determined.

2. Major land resource areas consist of geographically associated land resource units. Identification of these large areas is most important in State-wide agricultural planning and has value in inter-State, regional, and national planning. At the scale of 1:1,000,000 a map of a State or ordinary size and complexity shows between 6 and 12 land resource areas.

3. Land resource regions consist of geographically associated major land resource areas; their identification is most significant for national planning.

In grouping land resource units into major land resource areas and these, in turn, into land resource regions, the objective is to preserve as much uniformity as possible in relationships significant to agriculture. Uniformity is greatest in land resource units, considerably less in major land resource areas, and very much less in land resource regions. Such losses in uniformity cannot be avoided.

On the map on page 115 land resource areas are designated by numbers. No. 1 is on the west coast and No. 156 on the east coast. The legend identifies each area by number and by a descriptive geographic name. A few major land resource areas consist of two or more parts separated for short distances by other land resource areas. Land resource regions are designated by capital letters, which are identified in the legend by a descriptive name.

Descriptions of the land resource regions and the 156 major land resource areas follow. The descriptions are based on information from many sources, mostly within the Soil Conservation Service. The principal other sources are given in the list of selected references. Most statements about land use are based on recent State soil and water conservation needs reports. The States in which each area occurs are listed, and the approximate area and proportionate extent of each in the United States is listed in table 8-1.

The dominant physical characteristics of each land resource region and area are described briefly under five headings: Land Use, Elevation and Topography, Climate, Water, and Soil. Definitions of the kinds of information included under each heading in this chapter follow.

Land Use also includes statements of principal crops and type of farming. Figures given for the proportion of cropland, pasture, range,

forest, and land in industrial and urban uses are for the entire area unless specifically stated otherwise.

For Elevation a range in height above sea level for the area as a whole is given, followed by a brief statement of significant exceptions to the general range, which is not absolute but one that best characterizes the area. Topography is described in very broad terms and includes features characteristic of most of the area. Significant exceptions are mentioned.

Climate includes only three features. Average annual precipitation gives a range of annual averages--from whose in the driest parts of the area to those in the wettest parts. A statement of seasonal distribution of precipitation is included. For both average annual temperature and average freeze-free period, a range--again characteristic and not absolute--of annual averages in different parts of the area is given.

Water includes statements of surface streamflow and ground water. Special mention is made of sources of irrigation water and, in some areas, of municipal water. Some land resource areas depend on other areas for their water supply; some furnish water to other areas.

Soil information is given by naming the principal great soil groups[1] and soil series[2] because they connote more information then could be given in very brief soil descriptions. Names of representative soil series are given in parentheses after each great soil group. Usually enough descriptive information is given to provide a general notion of the soils to those unfamiliar with the great soil groups and soil series. Reports of modern soil surveys of counties within a major land resource area contain descriptions of soil series. Other publications, such as bulletins of some State agricultural experiment stations, also contain descriptions of soil series.

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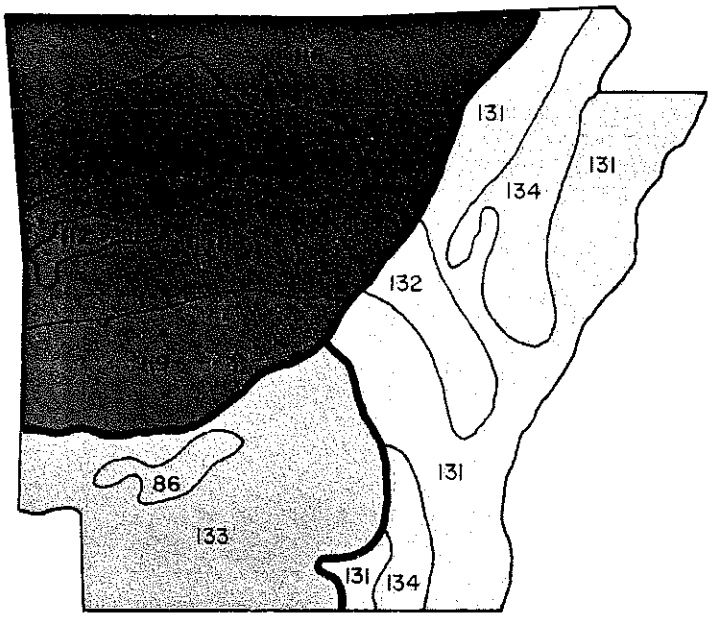
[1] Great soil groups consist of many soil series whose profiles have many features in common. All soil series in any one great soil group have the same number and kind of major horizons, but the horizons may not be expressed to the same degree in every profile.

[2] A soil series is a group of soils that have profiles almost alike. The soils have horizons similar in order and in differentiating characteristics in the soil profile except for texture of the surface soil, and they formed in a particular kind of parent material.



EAST AND CENTRAL GENERAL FARMING AND FOREST REGION

112 Cherokee Prairies
116 Ozark Highland
117 Boston Mountains
118 Arkansas Valley and Ridges
119 Ouachita Mountains

MISSISSIPPI DELTA COTTON AND FEED GRAINS REGION

131 Southern Mississippi Valley Alluvium
132 Eastern Arkansas Prairies
134 Southern Mississippi Valley Silty Uplands

SOUTH ATLANTIC AND GULF SLOPE CASH CROP, FOREST, AND LIVESTOCK REGION

86 Texas Blackland Prairie
133 Southern Coastal Plain

Major Resource Regions and Major Land Resource Areas of Arkansas

Figure 8-2

Source: Agricultural Handbook 296

The three major land resource areas which cover the state of Arkansas are described in the following narrative. These areas include: (N) - East and Central General Farming and Forest Region; (O) - Mississippi Delta Cotton and Grains Region; and (P) - South Atlantic and Gulf Slope Cash Crop, Forest, and Livestock Region.

N--EAST AND CENTRAL GENERAL FARMING AND FOREST REGION (236,500 square miles)

This borderland region between the North and the South includes the Appalachian mountains, valleys, and dissected plateaus and the Ozarks. The annual precipitation is 40 to 50 inches over much of the region but ranges from 35 inches along the western edge to 60 inches or more on some of the higher mountains in the east. The freeze-free season is 180 to 200 days over a large part of the region but ranges from about 150 days in the northeast to as long as 240 days in some of the valleys in the south.

Sols Bruns Acides from sandstones and acid shales are the more extensive soils on the mountain slopes and dissected plateaus. Red-Yellow Podzolic soils are on limestones and more deeply weathered shales. Reddish-Brown Lateritic soils are conspicuous in some limestone valleys and basins, but their total area is small. Alluvial soils along the many streams are of small total extent, but they are cropped intensively throughout the region.

Small general farms are characteristic of much of the region, but there are large dairy and livestock farms in areas of more favorable soils. Corn, small grains, and hay are the most extensive crops. Tobacco is an important cash crop, especially in the eastern two-thirds of the region. The steeply sloping areas, amounting to nearly one-half of the region, are mainly in forests, which are used for both recreation and timber production. A large part of the Nation's coal is mined in this region.

116--Ozark Highland (Missouri, Arkansas, and Oklahoma--34,400 square miles)

Land Use: About three-fifths of the area is in forest or woodland, most of it in farm woodlots but some in large holdings. About one-fifth of the area is cropland. Corn, feed grains, and hay for dairy cattle and other livestock are the principal crops, and orchards, vineyards, and truck crops are important on some of the more friable deep soils. Pastures, mainly of tame grasses and legumes, occupy most of the remaining one-fifth of the area.

Elevation and Topography: 500 to 1,500 feet. These sharply dissected limestone plateaus have narrow rolling ridgetops that break sharply to steep side slopes. Valleys are narrow and have steep gradients, especially in the upper reaches. There are some gently sloping plateau remnants in the west. Local relief is in several tens of feet to a few hundred feet.

Climate: Average annual precipitation--40 to 48 inches; highest in spring and early summer and low in midsummer. Average annual temperature--55 degrees to 60 degrees F. Average freeze-free period--180 to 200 days.

Water: Crops and pasture depend upon the moderate rainfall. Shallow wells or springs supply domestic needs and water for livestock on most farms, but deep wells are required to obtain large supplies. Water from deep wells is of good quality but hard. Small ponds on many individual

farms provide some water for livestock, and a few large reservoirs are used for flood control and recreation.

Soil: Red-Yellow Podzolic soils (Baxter, Clarksville, Nixa and Dickson, the latter two with fragipans) from deeply weathered cherty limestone occupy much of the area. Other members of this group are Talbott and Colbert soils from slayey limestones. Reddish-Brown Lateritic soils (Decatur) from relatively pure limestones and Rendzinas (Gasconade) from shaly limestones or calcareous clays are soils that are locally conspicuous but of small total extent. Small areas of soils like Brunizems are in small prairie outliers in the west.

117--Boston Mountains (Arkansas and Oklahoma--6,200 square miles)

Land Use: About three-fourths of the area is in forest, mainly in farm woodlots but some in Arkansas in national forests. The remaining one-fourth of the area is about evenly divided between cropland and pasture. Corn, other grains, and hay for livestock feed are the main crops, and peach and apple orchards are important locally. Pastures are mostly of tame grasses and legumes but of native grasses on the prairie outliers in the west.

Elevation and Topography: 500 feet on the lowest valley floors to 2,500 feet on the highest ridge crests. Ridgetops of these deeply dissected sandstone and shale plateaus are narrow and rolling; valleys are narrow and steep sided and have steep gradients. Local relief is in a few hundreds of feet.

Climate: Average annual precipitation--45 to 52 inches; highest in spring and fall and lowest in mid-summer. Average annual temperature--55 degrees to 60 degrees F. Average freeze-free period--180 to 205 days.

Water: The moderately high rainfall is adequate for crops and pastures. Shallow wells are the principal source of water for domestic use and livestock in the uplands. Small ponds on individual farms provide some water for livestock, and springs are numerous in the valleys. Deep wells are needed to obtain large supplies of ground water. Large reservoirs on several of the major streams are a source of municipal water and also provide flood control and recreation.

Soil: Lithosols (Montevallo, Ramsey, and Hector) and rough stony land on hilly to steep slopes are dominant in much of the area. Red-Yellow Podzolic soils (Hartsells, Linker, Allen, and Jefferson) are on the less sloping ridgetops, benches, and foot slopes; Planosols (Johnsburg and Tyler) on some flats with restricted drainage; and Reddish Prairie soils on prairie outliers in the west.

118--Arkansas Valley and Ridges (Arkansas and Oklahoma--7,000 square miles)

Land Use: About one-half of the area is in forest; about one-third of the wooded area is Federally owned and most of the remainder is in farm

woodlots. The other half of the area is one-third cropland and two-thirds pasture. Most of the cropland is on the less sloping land in the valleys but some is on flat mountain tops. Corn, cotton, soybeans, other feed grains, and hay are the major crops. Fruits and vegetables are important locally on the deeper soils throughout the area. Pastures are on the bottom land of small streams and throughout cleared parts of the uplands; they consist of mixtures of tame and native grasses and legumes.

Elevation and Topography: 300 feet on the lowest valley floors to 2,800 feet on some mountain tops. These ridges and valleys are underlain by slightly folded to level beds of sandstones and shales. Ridge slopes are steep; most crests are narrow and rolling but some are broad and flat. The intervening valleys are broad and smooth. Local relief is in several tens of feet in valleys and on the flat ridgetops. The ridges and mountains rise sharply hundreds of feet above adjacent valleys.

Climate: Average annual precipitation--44 to 50 inches; highest in spring and autumn. Average annual temperature--60 degrees to 63 degrees F. Average freeze-free period--200 to 240 days.

Water: The moderate rainfall is generally adequate for crops and pasture. In the uplands, water for domestic use is obtained mainly from shallow wells and water for livestock from small ponds on individual farms. In the valleys, springs, shallow wells, small ponds, and perennial streams provide water for most uses. Deep wells yield large amounts of hard water except in areas of shale bedrock where ground water is scarce.

Soil: Lithosols (Hector, Ramsey, and Montevallo) are dominant on hilly to steep ridges. Red-Yellow Podzolic soils (Linker, Hartsells, Enders, Monongahela, and Waynesboro) are extensive on level to rolling uplands and terraces. Planosols (Johnsburg and Wrightsville) are on level to gently rolling uplands and in clayey old alluvial deposits. Alluvial soils (Pope, Philo, and Stendal) on flood plains occupy about 10 percent of the area and are among the more important soils for crops.

119--Ouachita Mountains (Arkansas and Oklahoma--11,700 square miles)

Land Use: Slightly more than four-fifths of the area is forested. Of this about one-fourth, mainly in Arkansas, is Federally owned. Some of the remainder is in large holdings, but much of it is in farm woodlots. Lumbering, wood-using industries, and recreational uses are important throughout the area. About 15 percent of the area is cropped or in pasture; the pasture acreage is a little larger than cropland acreage. Corn, oats, other feed grains, and hay for livestock feed are the main crops. Pastures are largely mixtures of tame grasses and legumes except on some small prairie outliers in the west where pastures are in native grasses.

Elevation and Topography: 300 feet on the lowest valley floors to 2,700 feet on the highest mountain peaks. These steep mountains are

underlain by folded and faulted shales, slates, quartzites, sandstones, and novaculite. Most of the stream valleys are narrow and have steep gradients, but wide terraces and flood plains border the Ouachita River in western Arkansas. Local relief is a few hundred feet to more than 1,000 feet.

Climate: Average annual precipitation--Mainly 48 to 56 inches, decreasing to 35 inches along the western edge; fairly evenly distributed through the year but higher in spring and early autumn. Average annual temperature--60 degrees to 62 degrees F. Average freeze-free period--200 to 240 days.

Water: The high rainfall and many perennial streams provide abundant water. Several large reservoirs for water storage and flood control are used also for recreation. In the valleys spring and shallow wells are the main sources of water for domestic use and for livestock.

Soil: Lithosols (Goldston, Hector, Ramsey, and Montevallo) and rough stony land occupy most of the steep slopes throughout the area. Red-Yellow Podzolic soils (Georgeville, Herndon, Enders, and Wickham) are on the gentle slopes of ridgetops, benches, foot flopes, and old stream terraces and Planosols (Conway) on the gentle slopes of valleys underlain by shale. Alluvial soils (Congaree, Chewacla, and Pope) are on flood plains in some of the broader valleys and are among the most important agricultural soils.

O--MISSISSIPPI DELTA COTTON AND FEED GRAINS REGION (45,600 square miles)

This region consists of the flood plains and terraces of the Mississippi River south of its confluence with the Ohio River. The average annual precipitation ranges from 45 to 65 inches. Average annual temperatures are 58 degrees to 70 degrees F., and the freeze-free season is 200 to 280 days.

Low-Humic Gley soils, Humic Gley soils, Alluvial soils, and Grumusols are the extensive soils on flood plains and low terraces. Red-Yellow Podzolic soils are important on the higher silt-mantled terraces.

The soils throughout much of the region are naturally poorly drained and poorly suited to crops, but if they are artificially drained, they are highly productive of many crops. Cotton, soybeans, corn, and hay are grown throughout the region. Rice in Arkansas and Louisiana and sugarcane in Louisiana are important crops locally. The wettest areas that are not artificially drained remain in forests, which are important for hardwood-timber production.

131--Southern Mississippi Valley Alluvium (Arkansas, Mississippi, Louisiana, Missouri, and Tennessee--36,600 square miles)

Land Use: Nearly all the area is in farms. For the area as a whole, about 10 percent is in woodland and the remainder is evenly divided between

cropland and pasture. But the proportion of cropland is nearly three-fourths in the north and less than one-fourth in the south. The amount of land in forest varies inversely with that in crops; the amount in pasture is a little higher in the south. This is an important cash-crop area. Cotton, corn, and soybeans grown by highly mechanized methods are major crops throughout the area. Rice is an important crop in Arkansas and Louisiana and sugarcane in southern Louisiana.

Elevation and Topography: Sea level in the south, increasing gradually to about 500 feet in the north. The area consists of nearly level to gently sloping broad flood plains and low terraces. Most of the area is flat. The only noticeable slopes are sharp terrace scarps and natural levees that rise sharply a few feet to several tens of feet above adjacent bottom lands or stream channels.

Climate: Average annual precipitation--45 to 65 inches, increasing from north to south; over most of the area highest in winter and early spring, decreasing gradually to a minimum in autumn; along the Gulf Coast highest in midsummer and early autumn. Average annual temperature--58 degrees to 70 degrees F., increasing from north to south. Average freeze-free period--200 to 280 days, increasing from north to south.

Water: Rainfall, streamflow, and ground water supply an abundance of water. Surplus water is a serious problem on many of the soils, and artificial drainage is required before they can be used successfully for crops. The Mississippi River crosses the area from north to south and many of its tributaries also cross the area. Oxbow lakes and bayous are extensive throughout.

Soil: Grumusols (Sharkey, Alligator, Tunica, and Perry) formed in clayey alluvium are the most extensive. Alluvial soils (Commerce, Mhoon, and Robinsonville) are also important, and Adler soils from local alluvium lie at the foot of the adjoining bluffs in many places. Low-Humic Gley soils (Forestdate and Waverly) and Humic Gley soils (Jeanerette) are conspicuous on low terraces. On some of the older terraces Gray-Brown Podzolic soils (Dundee, Dubbs, and Bosket) are the major soils.

132--Eastern Arkansas Prairies (Arkansas--7,000 square miles)

Land Use: Most of the area is in farms, but about 10 percent is urban or in other uses. About one-half is cropland and only a small amount is in pasture. Rice is the major crop in this cash-crop area. Cotton, corn, and soybeans are other important crops. About one-third of the area is in forest.

Elevation and Topography: 150 to 300 feet. Nearly level broad terraces are crossed by meandering streams having shallow valleys. The terraces terminate in short steep escarpments, and natural levees one to several tens of feet high border the stream channels. Elsewhere local relief is in only a few feet.

Climate: Average annual precipitation--About 50 inches; highest in winter and spring, decreasing through summer to a minimum in autumn. Average annual temperature--About 63 degrees F. Average freeze-free period--About 220 days.

Water: Rainfall, groundwater and streamflow provide an abundance of water. Water for rice irrigation is stored in many artificial ponds and reservoirs, and water from wells is also used for this purpose. Except for rice, artificial drainage is required for the successful production of most crops. The many lakes and ponds, both natural and artificial, provide excellent hunting and fishing.

Soil: Planosols (Crowley) from fine-textured sediments on level terraces are the dominant soils. On better drained and less clayey materials Gray-Grown Podzolic soils having a fragipan (Grenada) are the major soils.

P--SOUTH ATLANTIC AND GULF SLOPE CASH CROP, FOREST, AND LIVESTOCK REGION
250,200 square miles

This cotton-growing region consists of the gently sloping to rolling southern Piedmont and upper Coastal Plain. The average annual precipitation ranges from 40 to 60 inches; rainfall is considerably higher in mid-summer than in the rest of the year. Average annual temperatures are 60 degrees to 68 degrees F. over most of the area but are as low as 57 degrees F. in some of the higher parts and as high as 71 degrees F. in the extreme southeast. The freeze-free season is 200 days or more in most of the region and as long as 300 days in the southernmost part.

Red-Yellow Podzolic soils are dominant throughout the region. Reddish-Brown Lateritic soils from basic rocks are conspicuous locally as are Grumusols from marls or soft limestones. Alluvial soils on flood plains of the major streams are among the better soils for crops.

Cotton is the main cash crop throughout the region, but cotton acreage has been declining for many years. Peanuts and tobacco are also important, especially in the northeast. The acreage in improved pasture has been increasing, and much of the more sloping land is being returned to forest.

133--Southern Coastal Plain (Georgia, Alabama, Mississippi, Louisiana, Texas, Arkansas, Tennessee, North Carolina, South Carolina, Virginia, and Florida--145,300 square miles)

Land Use: Nearly all the area is in farms. A small acreage is owned by the Federal Government, and additional small areas are urban or in other uses. Between one-half and three-fourths is woodland, nearly all in small holdings but some in large tracts. The proportion of woodland is greatest in the west. Lumber, pumpwood, and naval stores are the major forest

products. Between one-tenth and one-third is cropland; the largest acreage is in the east. Less than one-tenth is in pasture. This is a cash-crop area, and cotton is a major crop. Peanuts, tobacco, melons, various vegetable crops, and corn are important also. The trend recently is to more pasture and woodland and less cropland.

Elevation and Topography: 100 to 600 feet, increasing gradually from the lower Coastal Plain to the Piedmont. The gently to strongly sloping dissected coastal plain is underlain by unconsolidated sands, silts, and clays. In their upper reaches stream valleys are narrow, but the lower parts of the valleys are broad and have widely meandering stream channels. Local relief is mainly in a few tens of feet, but some of the more deeply dissected parts have relief of 100 to 200 feet.

Climate: Average annual precipitation--40 to 60 inches; lowest in autumn throughout the area and highest in midsummer in the east and in winter and spring in the west. Average annual temperature--60 degrees to 68 degrees F., increasing from north to south. Average freeze-free period--200 to 280 days, increasing from north to south.

Water: Rainfall, many perennial streams, and groundwater provide an abundance of water. Even though summer rainfall is fairly high, droughts are common and then good returns are obtained from irrigation on all but the wettest soils. Drainage is necessary before the wet lowlands can be used for crops. Domestic water supplies are obtained mainly from shallow wells and water for livestock from perennial streams and small farm ponds. The many perennial streams are potential water sources that have been little used in most of the area.

Soil: Red-Yellow Podzolic soils are dominant throughout (Ruston, Norfolk, Orangeburg, Saffell, and Lexington from sandy or gravelly materials; Malboro, Bowie, Savannah, Shubuta, Kirvin, and Silerton from medium to moderately fine textured materials; and Boswell, Susquehanna, Sawyer, and Cuthbert in fine-textured materials). Associated with them on wet lowlands are Low-Humic Gley soils (Plummer, Bladen, Bibb, Falaya, and Coxville) and Humic Gley soils (Portsmouth, Bayboro, Weeksville, and Johnston). Reddish-Brown Lateritic soils (Greenville, Red Bay and Nacogdoches) are important locally, mainly in the south, but are of small total extent. Regosols (Eustis, Lakeland, and Kershaw) are on gently rolling to steeply sloping areas underlain by sands. Alluvial soils (Mantachie and Iuka) on narrow bottom lands are important to agriculture locally; in Texas and Louisiana, where the alluvium contains a large amount of material from red rocks, Miller and Yahola are important soils.

134--Southern Mississippi Valley Silty Uplands (Mississippi, Tennessee, Kentucky--24,000 square miles; Louisiana and Arkansas--2,000 square miles)

Land Use: Most of the land is in farms, a small amount is Federally owned, and other small areas are urban or in other uses. About a third of

the whole area is cropland but the amount of cropland varies greatly from county to county, depending on soils and topography. This is largely a cash-crop area. Cotton, corn, and soybeans are major crops, but rice is important locally in Arkansas and strawberries in Louisiana. Feed grains and forage are grown on dairy farms, mainly near the larger towns and cities. Only about a tenth of the area is in pasture, but the present trend is to a moderate increase in land in pasture. About one-fourth is in forest. Lumber is the major forest product and some pulpwood is harvested.

Elevation and Topography: 100 to 600 feet. The sharply dissected plains have a thick loess mantle, which is underlain by unconsolidated sands, silts, and clays, mainly of marine origin. Valley sides are hilly to steep, especially in the west. The intervening ridges are mostly narrow and rolling, but some of the interfluves between the upper reaches of the valleys are broad and flat. Stream valleys are narrow in their upper reaches but broaden rapidly downstream and have wide flat flood plains and meandering stream channels. Local relief is mainly in several tens of feet of 100 or 200 feet.

Climate: Average annual precipitation--46 to 60 inches, increasing from north to south; highest in winter and spring, decreasing gradually through summer to autumn except for a moderate increase in midsummer. Average annual temperature--60 degrees to 68 degress F., increasing from north to south. Average freeze-free period--200 to 280 days, increasing from north to south.

Water: Rainfall and groundwater are abundant. In the uplands shallow wells, cisterns, and ponds are the main water sources for domestic use and livestock. Shallow wells provide only small amounts of water but deep wells in the underlying sands and gravels yield large amounts. Most streams in the area are small and flow intermittently. They flow most of the time in winter and spring but only during and immediately after storms in summer and autumn.

Soil: Gray-Brown Podzolic soils (Memphis, Loring, and Grenada) that formed in thick loess on gently rolling to hilly uplands and terraces are the dominant soils. On associated level areas Planosols (Calloway and Henry) are conspicuous. All these soils except Memphis have a strongly expressed fragipan. In the east, where the loess mantle thins, Red-Yellow Podzolic soils (Lexington, Brandon, Providence, Lax, and Silerton) are the major soils. Alluvial soils (Vicksburg, Collins, and Mantachie) and Low-Humic Gley soils (Waverly, Falaya, and Bibb) on the broad flood plains in the west are some of the most important agricultural soils. Small areas of Solonetz soils (Lafe, Foley, and Verdun) are conspicuous, especially in Louisiana.

Table 8-1-Approximate area and proportionate extend of land resource regions and major land resource areas covering Arkansas and surrounding area. (Area given to nearest 100 square miles and percentages to nearest tenth)

Land resource region and major land resource area	Area	Extent in region	Extent in United States
	Square miles	*Percent*	*Percent*
N. East and Central General Farming and Forest Region:	236,500		8.0
112. Cherokee Prairies	1,000	.4	—
116. Ozark Highland	34,400	14.5	1.2
117. Boston Mountains	6,200	2.6	.2
118. Arkansas Valley and Ridges	7,000	3.0	.2
119. Ouachita Mountains	11,700	4.9	.4
120. Kentucky and Indiana Sandstone and Shale Hills and Valleys	11,200	4.7	.4
121. Kentucky Bluegrass	11,000	4.7	.4
122. Highland Rim and Pennyroyal	22,700	9.6	.8
123. Nashville Basin	5,700	2.4	.2
124. Western Allegheny Plateau	8,200	3.5	.3
125. Cumberland Plateau and Mountains	25,900	10.9	.9
126. Central Allegheny Plateau	19,400	8.2	.7
127. Eastern Allegheny Plateau and Mountains	15,900	6.7	.5
128. Southern Appalachian Ridges and Valleys	28,600	12.1	1.0
129. Sand Mountain	8,700	3.7	.3
130. Blue Ridge	18,900	8.0	.6
O. Mississippi Delta Cotton and Feed Grains Region:	45,600		1.5
131. Southern Mississippi Valley Alluvium	36,600	80.3	1.2
132. Eastern Arkansas Prairies	7,000	15.3	.2
134. Southern Mississippi Valley Silty Uplands	2,000	4.4	.1
P. South Atlantic and Gulf Slope Cash Crop, Forest, and Livestock Region:	250,200		8.4
86. Texas Blackland Prairie	700	.3	—
133. Southern Coastal Plain	145,300	58.1	4.9
134. Southern Mississippi Valley Silty Uplands	24,000	9.6	.8
135. Alabama and Mississippi Blackland Prairies	9,000	3.6	.3
136. Southern Piedmont	59,000	23.6	2.0
137. Carolina and Georgia Sand Hills	8,200	3.3	.3
138. North Central Florida Ridge	4,000	1.6	.1

LAND OWNERSHIP AND USE

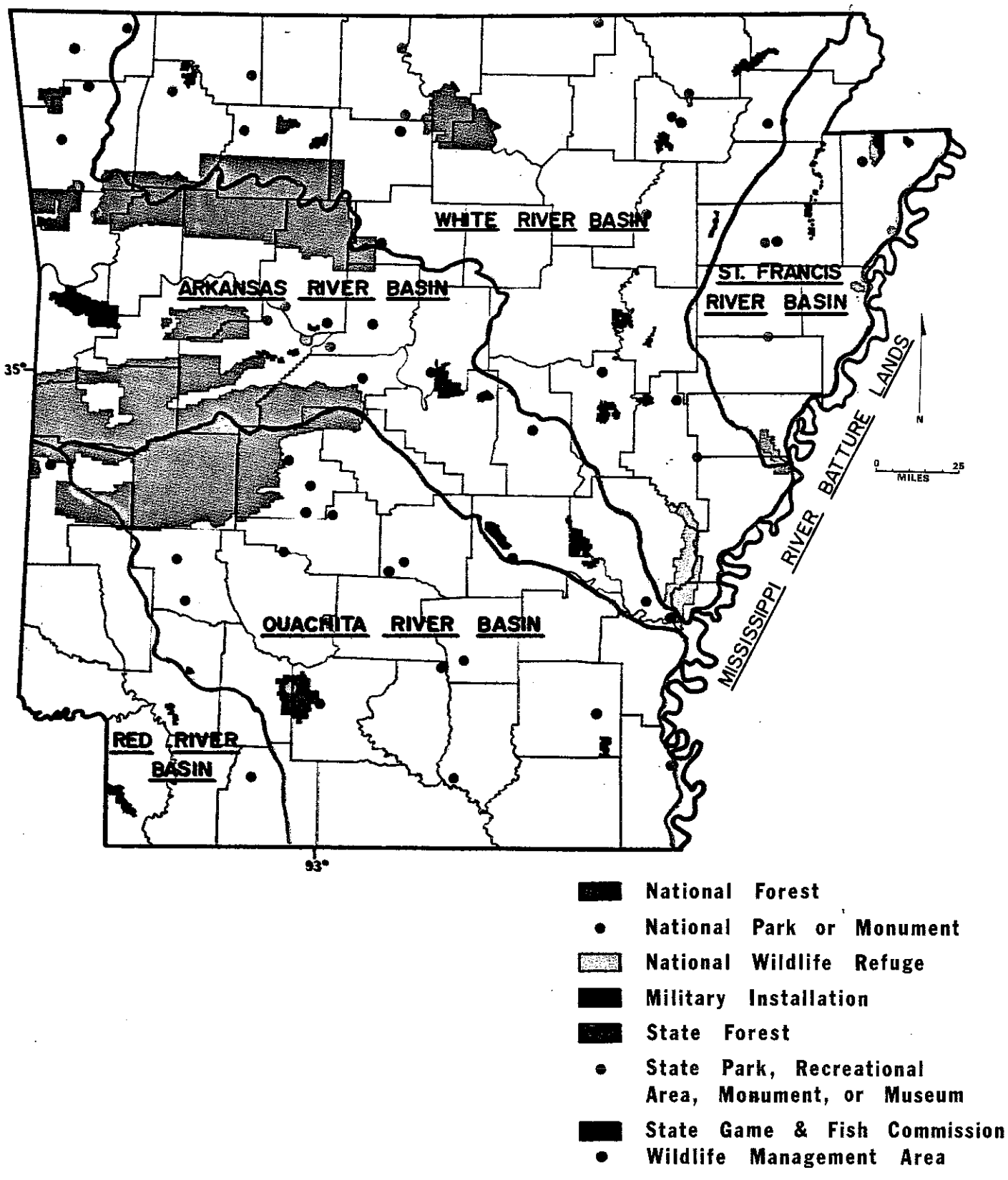
Approximately 11 percent of the total area of Arkansas is public land. Public lands are widely scattered and and used for a variety of purposes. By far, the largest percent of public land is in federally-owned national forests which are located chiefly in the western part of the state. National forests account for about 77 percent of all public land. The following table shows a breakdown of federally-owned land in Arkansas.

FEDERALLY OWNED LAND IN ARKANSAS

		Acres
Department of Agriculture (Chiefly national forests)		2,442,924
Department of Defense		578,203
Air Force	9,378	
Army	86,066	
Corps of Engineers	482,640	
Navy	119	
Department of the Interior		133,774
Fish and Wildlife	125,870	
National Park Service	5,547	
Bureau of Land Management	2,309	
Office of Saline Water	48	
Other		506
Total		3,155,407

The state government owns over 500,000 acres of land which is administered by a number of state agencies. The Arkansas Game and Fish Commission has control over approximately 268,000 acres which includes wildlife management areas and fishing waters. About 161,000 acres of land is under the control of the Highway Commission. Several other state agencies have control over the remaining state land including the Department of Higher Education, Parks and Tourism and Corrections.

The map on page 126 shows the location of state and federally owned lands in Arkansas.



STATE AND FEDERAL LANDS, 1972

Source: Atlas of Arkansas, Arkansas Department of Planning Figure 8-3

WATER RESOURCES

Arkansas' water resource consists of large quantities of both surface and ground water. The state receives over 30 million acre-feet of water annually from other states through the Arkansas, White, Red and St. Francis Rivers and tributaries to each. On the other hand, over 80 million acre-feet of water flows out of Arkansas each year. An estimated average of nearly 6 million acre-feet of ground water is available from transient storage in aquifers, with an addition estimated 600 million acre-feet of ground water occurring as permanent storage beneath the land surface. Figure 1 shows a simplified picture of the state's water resources. It does not attempt to detail the complex relationships between precipitation, evapotranspiration, ground water storage and streamflow.

As one can notice, Arkansas does have an abundance of water but it should be noted that not all of this vast resource can be utilized in its present condition and location. In some cases, it is either physically or economically impossible to make the water available, or it may be of undesirable quality. In general, we have taken both ground water and surface water for granted. Even though we do have a large quantity of this very important and vital resource, one must realize that Arkansas' agricultural, industrial and municipal use of water has increased greatly in the past few years, and will continue to do so due to the ever growing demand for agricultural products, forest products and manufactured goods. The type (ground or surface) water used is dependent largely on the geography and geology of the area of the State being considered.

Arkansas lies within two major physiographic provinces--the Gulf Coastal Plain and the Interior Highlands. The Gulf Coastal Plain, occupying eastern and southern Arkansas, constitutes 52 per cent of the area of the state. It has two major division, the Mississippi Alluvial Plain and the West Gulf Coastal Plain, hereafter referred to as the Delta and the Coastal Plain, respectively. Figure 8-6 shows the topographic divisions.

The Delta, located in the eastern part of the state, is relatively flat to gently rolling. Elevations vary from about 100 to 300 feet above sea level. Crowley's Ridge, an erosional remnant, is its most prominent topographic feature.

The Coastal Plain, extending across most of southern Arkansas, is rolling to slightly hilly with elevations varying from about 200 to 700 feet above sea level. The majority of the water used in these two regions is from the ground.

The Interior Highlands, occupying northern and western Arkansas, constitute 48 per cent of the area. This highland region has three major divisions: Ouachita Mountains, Arkansas Valley, and Ozark Plateaus. The elevation ranges up to 2,823 feet above sea level. This region lends

itself better to the impoundment of surface water. For this reason, most of the states' larger reservoirs are located in the Interior Highlands.

Surface Water Resource

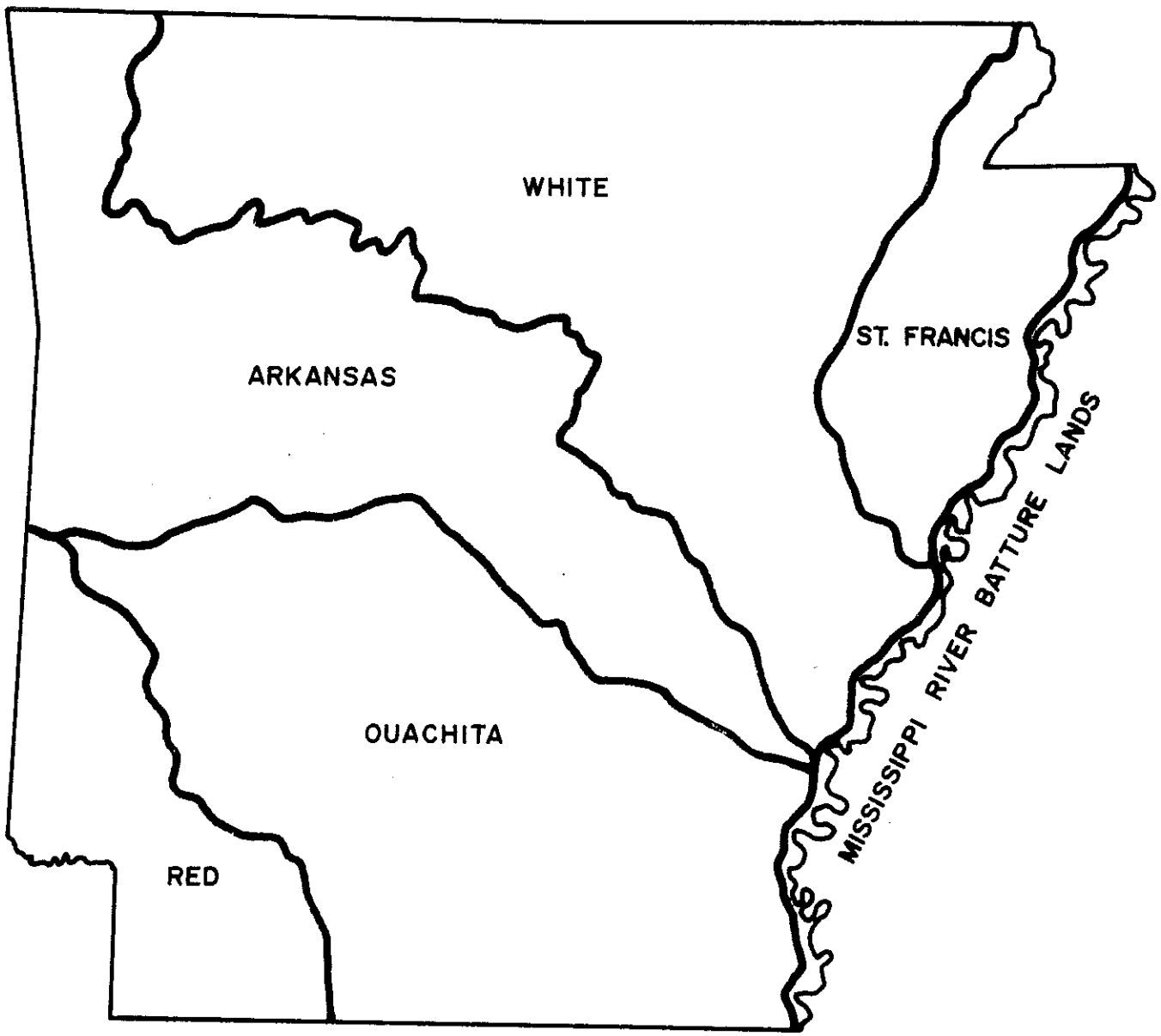
Most of the major streams in Arkansas' surface drainage system flow generally toward the southeast. (See Figure 8-5). In the northeastern quarter of the state this general rule is broken where the White, Cache, and St. Francis rivers flow southward. Also, in the northwest corner the White River flows north before turning toward the east and south. The largest streams, in descending order according to volume-flow, are the Mississippi, Arkansas, White, Red, Ouachita, and St. Francis rivers. All surface drainage in Arkansas eventually flows into the Mississippi River. For the purpose of this report, the State was divided into five (5) major river basins and the Mississippi River Batture lands shown in Figure 8-4.

Arkansas is also divided by two Water Resource Council (WRC) Planning Areas: Lower Mississippi Region and Arkansas-White-Red (Figure 8-8). The numbering system for the river basins and sub-basins was derived from the "Atlas of River Basins of the United States" U.S.D.A., Soil Conservation Service.

To obtain areas of manageable size for planning purpose the State was divided into 36 sub-basins and then into 482 watersheds. These smaller divisions allow more precise hydrologic study of an area and also affords a very useful tool for the handling of any specific problems which might arise.

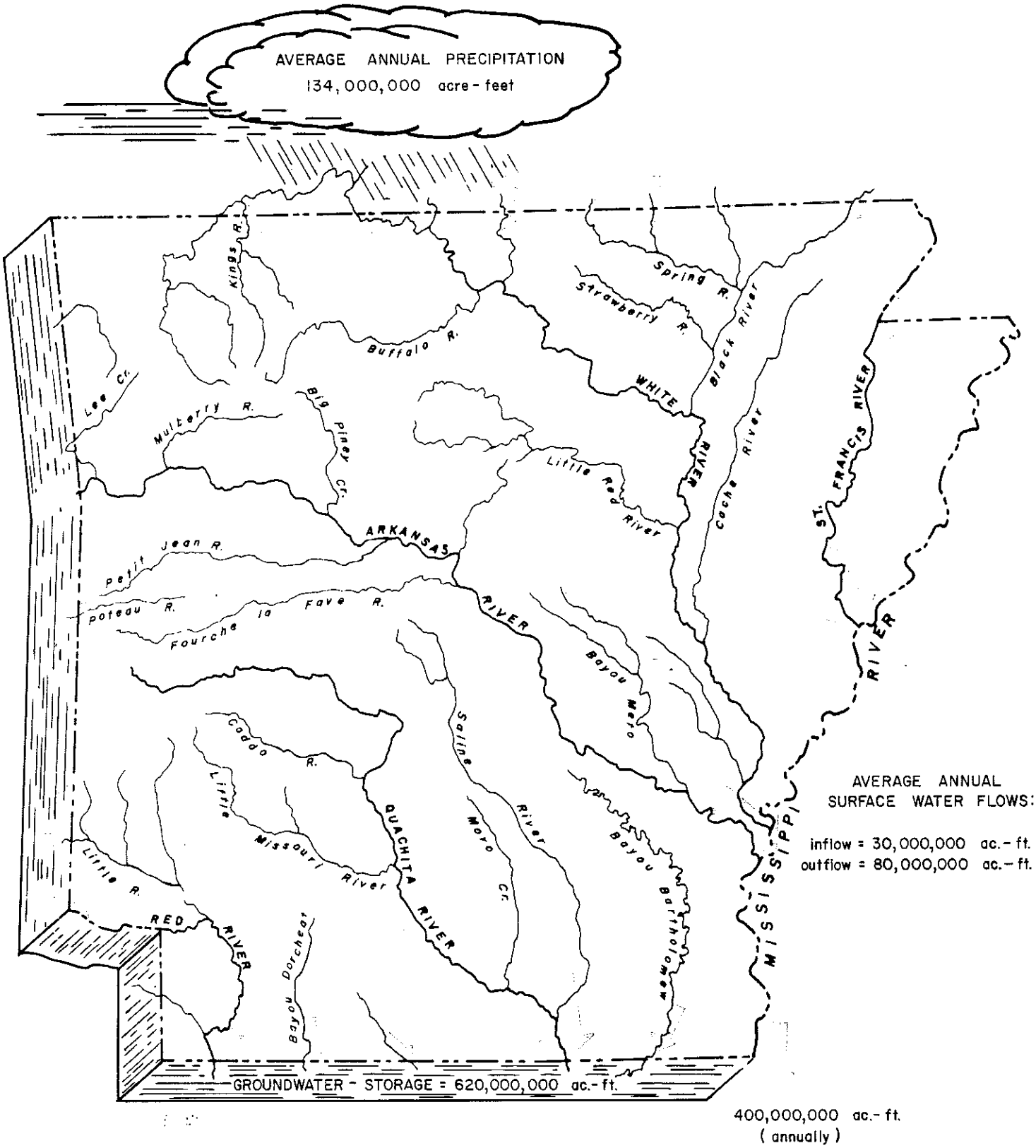
The five major river basins yield an average annual runoff amounting to approximately 80 million acre-feet (See Figure 1). The average annual flow for the period of record, of the Arkansas River at Little Rock is about 29 million acre-feet; the White River at Clarendon 21 million acre-feet; the Red River at Fulton, 13 million acre-feet; the Ouachita River at Camden, 5 million acre-feet; and the St. Francis River near Marked Tree, 1 million acre-feet. This does not include the entire amount since tributaries enter the main stem of the rivers downstream from the last gaging station. The Arkansas River Basin includes about 25 percent of the land area of the State and accounts for 38 percent of the stream runoff; the White River Basin, 34 percent of the land area and 28 percent of the stream runoff; the Red River Basin, 11 percent of the land area and 18 percent of the stream runoff; the Ouachita River Basin, 21 percent of the land area and 11 percent of the stream runoff; the St. Francis River Basin, 9 percent of the land area and 5 percent of the stream runoff. Figure 8-9 shows the average discharge of the major streams in Arkansas.

Records of gage heights for some streams in Arkansas date back to 1871 while the first streamflow records were collected from 1903 to 1905 on the



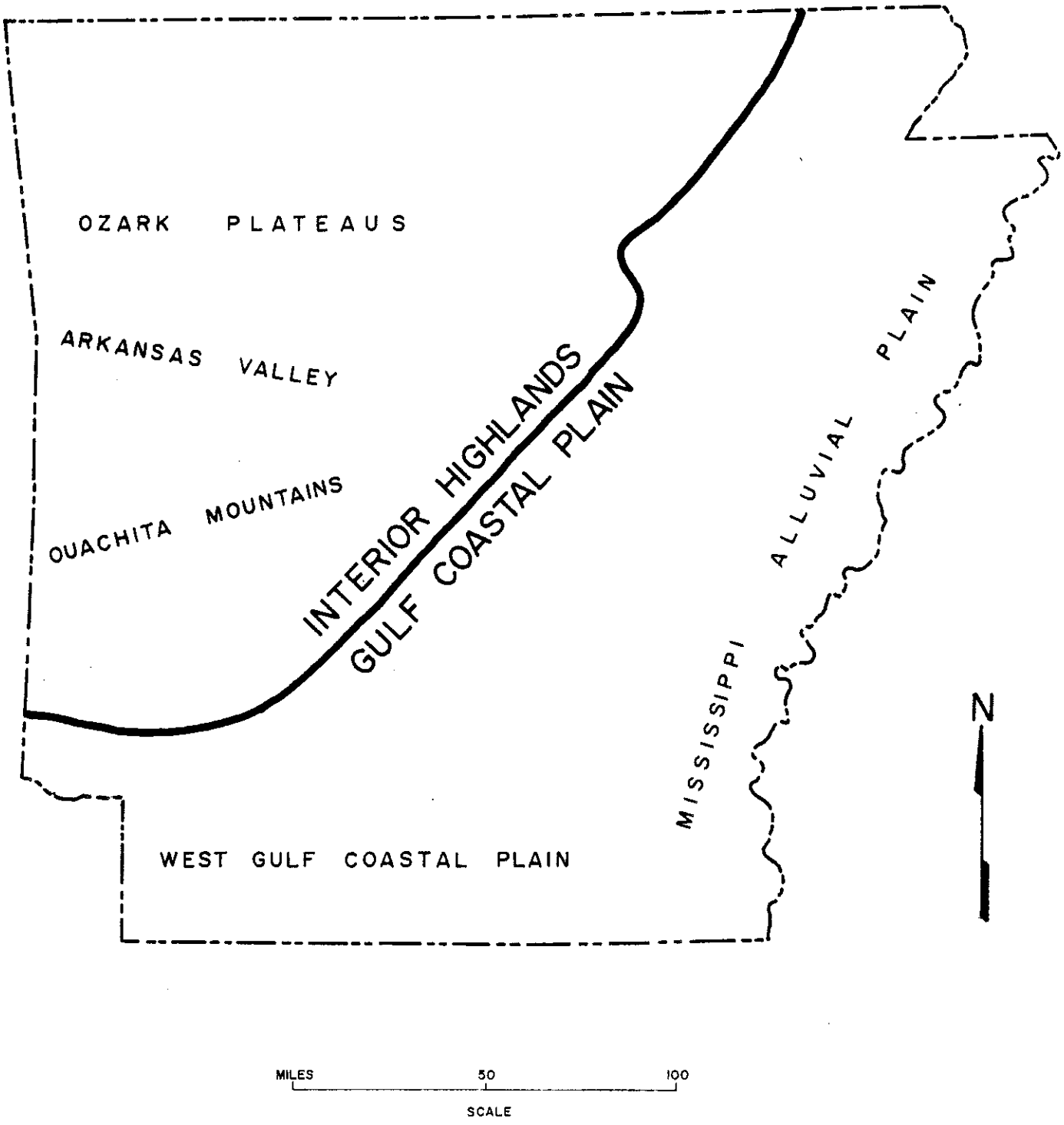
Major River Basins & Mississippi River Batture Lands

Figure 8-4



ARKANSAS' WATER RESOURCES

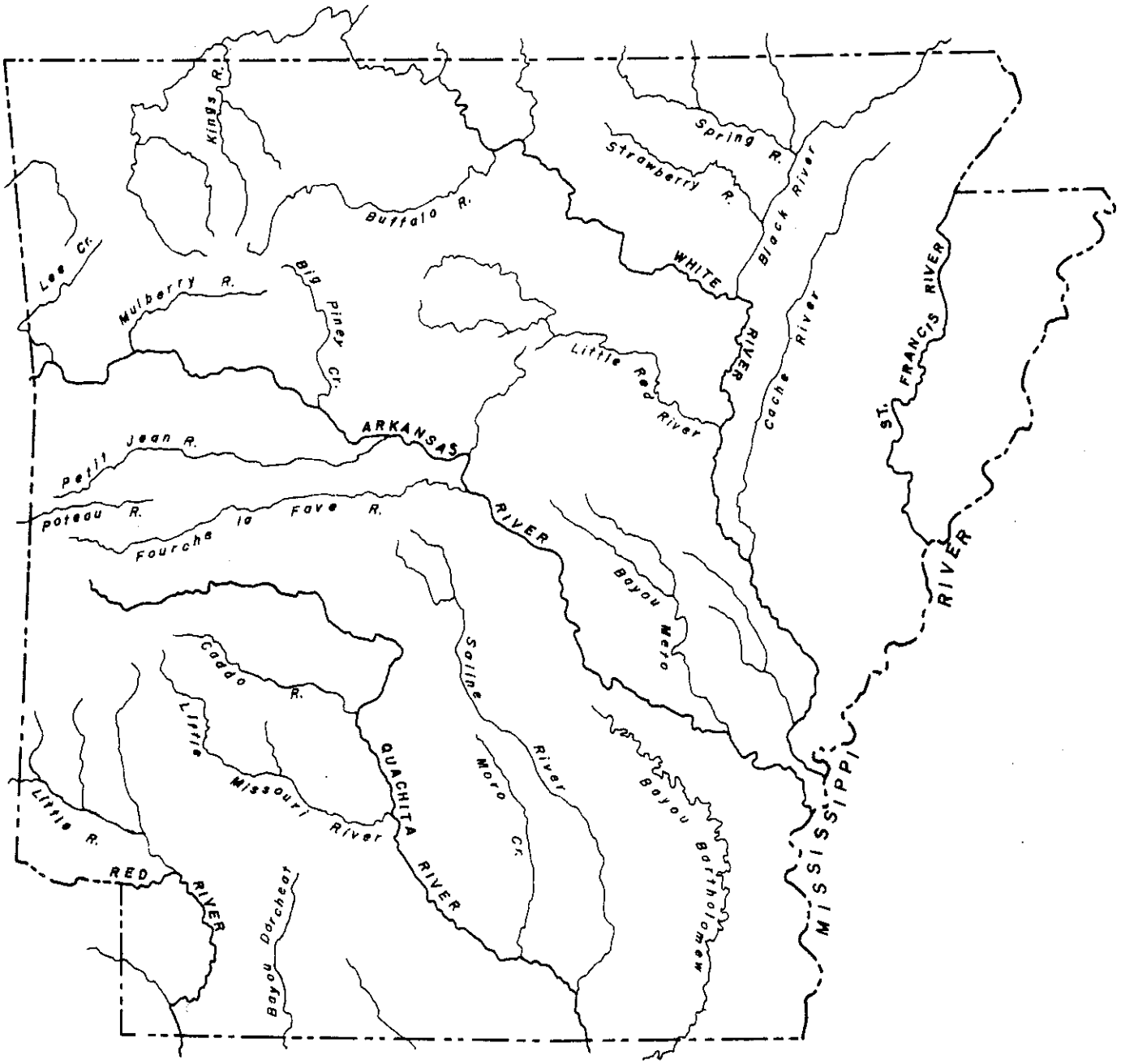
Figure 8-5



MAJOR PHYSIOGRAPHIC PROVINCES AND DIVISIONS OF ARKANSAS

Figure 8-6

Reference: Arkansas Water Resources, 1959



Major Rivers and Streams in Arkansas

Reference: Water For Arkansas, U.S.G.S., 1969 Figure 8-7

Fig. 4 Water Resource Planning Areas (WRPAs) in Arkansas

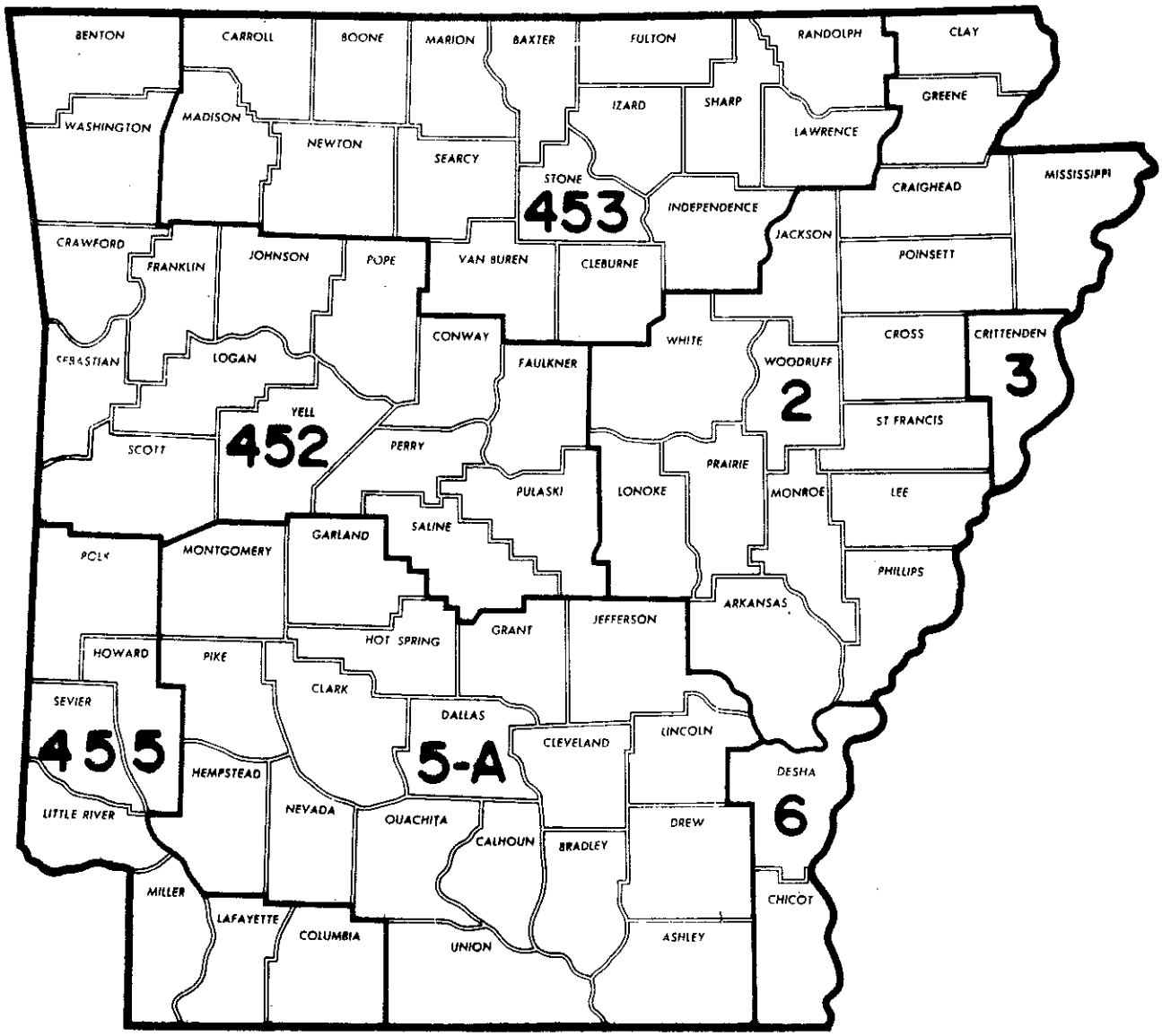
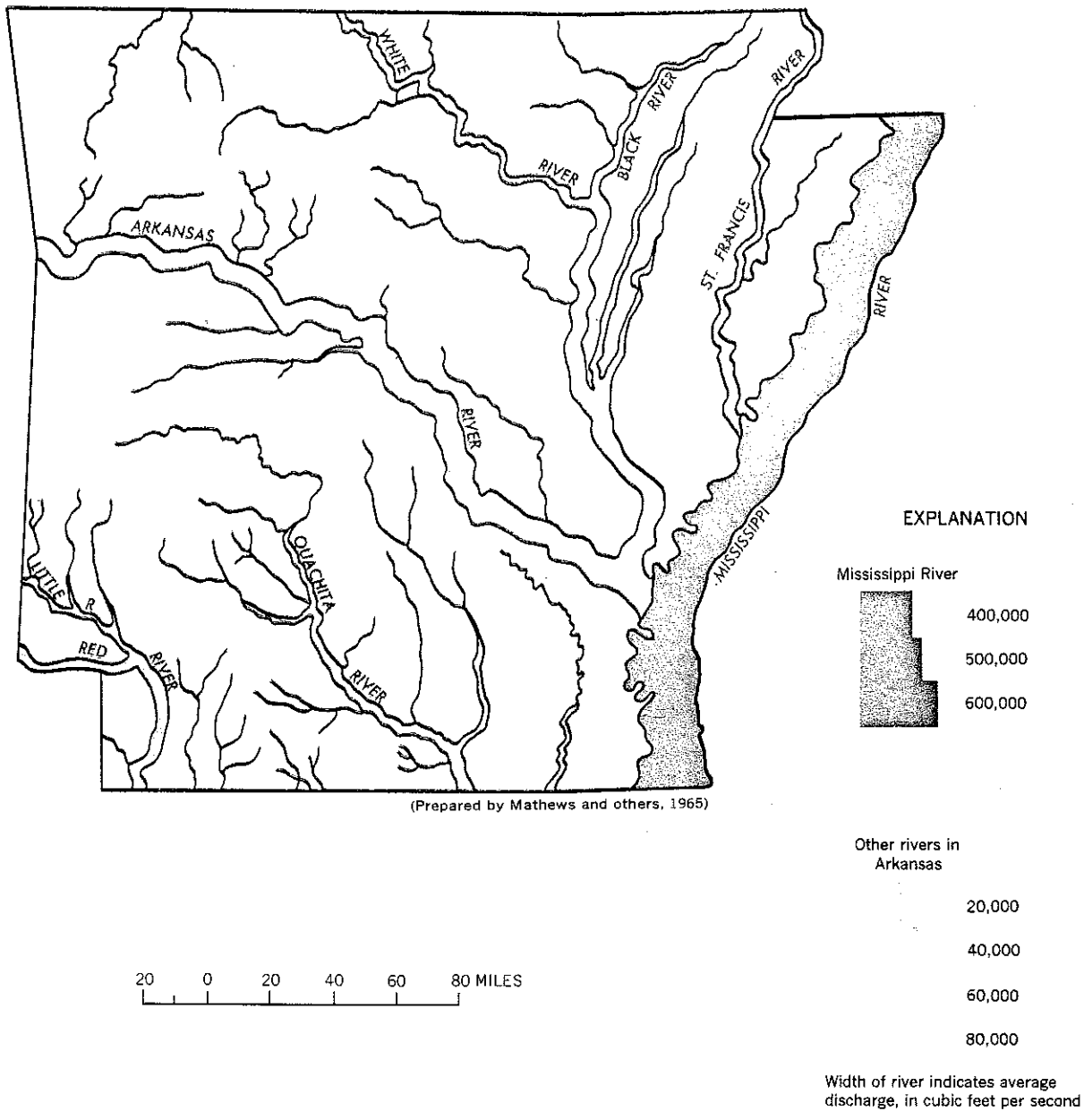


Figure 8-8



Approximate Average River Discharge

Figure 8-9

Reference: Water For Arkansas, U.S.G.S., 1969

Ouachita River near Malvern, Arkansas. A few miscellaneous streamflow records were collected during the year 1909 to 1926. The first statewide cooperative water-resources investigations in Arkansas began in 1927 and were maintained from 1927 to 1933. The statewide cooperative program was reestablished in 1937 between the U. S. Geological Survey and other state agencies. Parts 1 and 2 of the U.S.G.S. publication "Water Resources Data for Arkansas" contain surface water data.

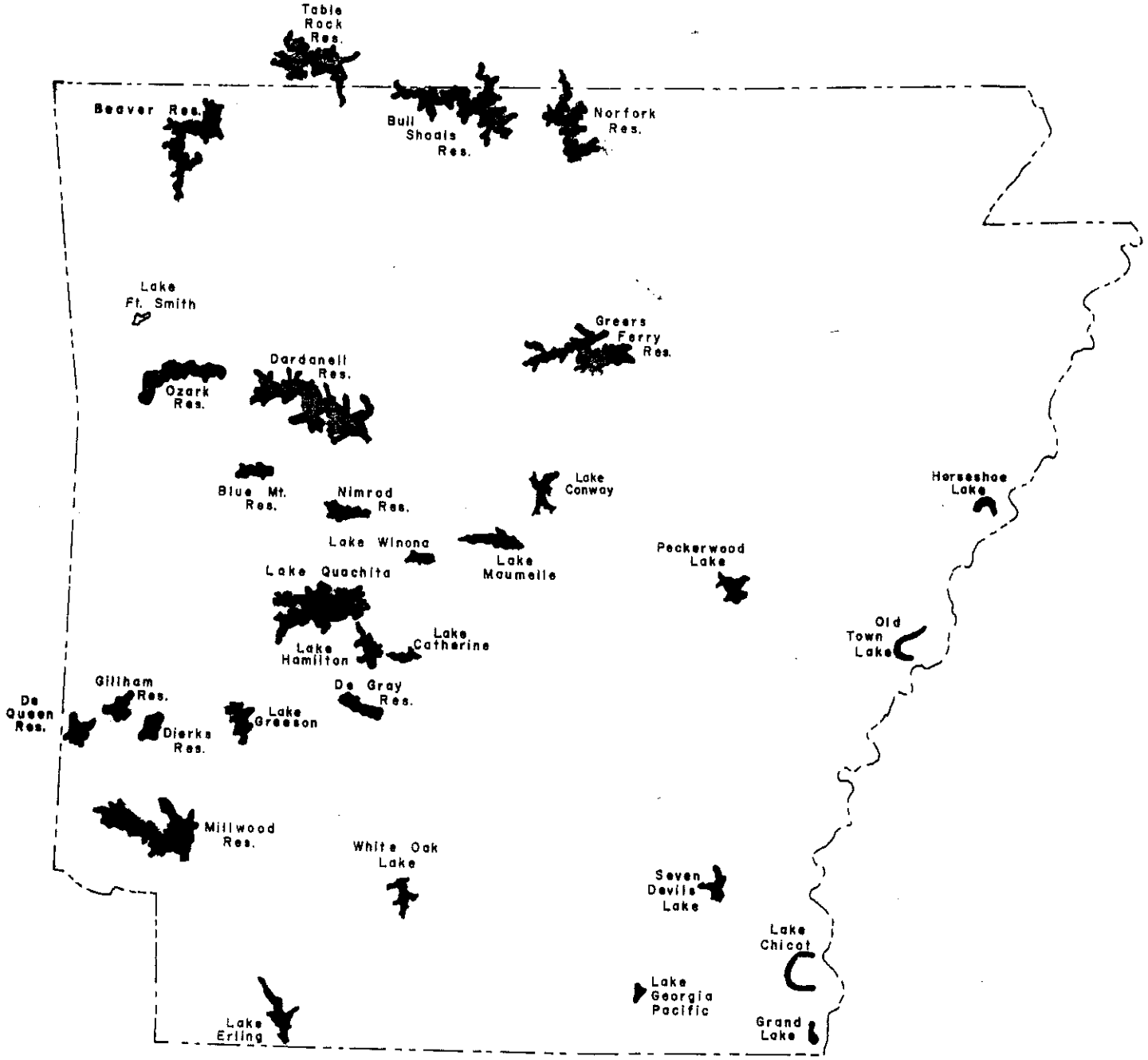
Normally, the major flood flows on Arkansas streams occur during the winter and spring months. Conditions vary from intense "flash" floods in the hill and mountainous areas, to long duration floods in the Delta and plains areas.

The "flash" floods are caused by very rapid runoff due to intense rains and steep terrain. These type floods are very hazardous to buildings, livestock, and human lives. In many cases the high velocity of the flood waters cause severe erosion problems, dependent upon the type soils and vegetative cover in the area. This type flood usually occurs in the Interior Highlands of the State, but also can be observed along Crowley's Ridge in the Delta Region. Such floods are capable of extensive damage, but are normally short in duration.

The long duration floods, observed in the Gulf Coastal Plain region in Arkansas, normally result from overbank flow of the streams in that area. Due to the comparatively low and flat topography of this region, flood waters spread out over very large tracts of land. The most detrimental effect of this type flood is to the vital cropland of Arkansas. Floods have prevented the planting and harvesting of cotton, soybean, wheat, and rice due to the relatively slow runoff and the vast quantity of water present. In an effort to reduce the amount of damage resulting from such natural disasters, a number of reservoirs have been constructed in the State.

Arkansas has a large number of surface water impoundments which range in size from a farm pond of less than an acre in surface area to Bull Shoals Lake which has a surface area of over 45,000 acres, extending into southern Missouri. Figure 8-10 shows the major lakes in Arkansas in which over 16 million acre-feet of water is presently available and being used for a wide variety of purposes.

The majority of the larger lakes in Arkansas have been built by or in cooperation with the Corps of Engineers and the Soil Conservation Service (SCS). From Table 8-2, one can observe that the Corps of Engineers has constructed the most of its lakes on major streams and that flood control is a purpose included in all but two of the reservoirs.



MAJOR LAKES

Figure 8-10

TABLE 8-2

U. S. CORPS OF ENGINEERS RESERVOIRS IN ARKANSAS

NAME OF RESERVOIR	STREAM	MAXIMUM FLOOD POOL SURFACE AREA	MAXIMUM FLOOD POOL AC/FEET STORAGE	CONSERVATION POOL 1/ SURFACE AREA	CONSERVATION POOL 1/ AC/FEET STORAGE	DAM HEIGHT	PURPOSE 2/
Bull Shoals	White	71,240 3/	5,408,000	45,440 3/	3,048,000	258'	F.C., P., R
Norfork	North Fork	30,700 3/	1,983,000	22,000 3/	1,251,000	222'	F.C., P, W, R
Table Rock	White	52,300 3/	3,462,000	43,100 3/	2,702,000	252'	F.C., P, R
Greers Ferry	Little Red	40,500	2,844,000	31,500	1,910,000	243'	F.C., P, R
Lake Ouachita	Ouachita	48,300	2,768,000	40,100	2,151,000	231'	F.C., P, R
Millwood	Little	95,200	1,858,000	29,200	206,600	88'	F.C., W, R
Blue Mountain	Petit Jean	11,000	258,000	2,900	25,000	115'	F.C., R
Nimrod	Fourche La Fave	18,300	336,000	3,600	29,000	97'	F.C., R
Lake Greeson	Little Missouri	9,800	407,900	7,260	279,700	190'	F.C., P, R
Dardanelle	Arkansas	--	--	36,600	486,000	68'	P, N, R
Gillham	Cossatot	4,680	221,800	1,370	33,100	160'	F.C., W, R
DeQueen	Rolling Fork	4,050	136,100	1,680	34,900	160'	F.C., W, R
Beaver	White	31,700	1,952,000	28,220	1,652,000	228'	F.C., P, W, R
Ozark	Arkansas	--	--	10,600	148,400	58'	P, N, R
DeGray	Caddo	17,000	881,900	13,400	654,700	243'	F.C., P, W, R
Dierks	Saline	2,970	96,800	1,360	29,700	134'	F.C., W, R
TOTAL		437,740	22,613,500	318,330	14,641,100		

1/ Bottom of Flood Control Pool

2/ F.C. - Flood Control, P - Power, W - Water Supply, N - Navigation, R - Recreation

3/ Some of area in the State of Missouri

All structures built by or in cooperation with the SCS, under P.L. 566, contain flood control storage. These lakes are normally smaller than those built by the Corps due to a limitation in the size of the watersheds and impoundments on which they may participate. Therefore, most P.L. 566 structures are built in the area of a watershed which is more hilly or mountainous. These type structures provide flood control to agricultural land downstream on many of the smaller tributaries to the larger rivers. The SCS, as well as the Corps, has cooperated with the Arkansas Game and Fish Commission on some projects, which provide the public with surface water impoundments used primarily for recreational purposes.

The Arkansas Game and Fish Commission own and manage 31 lakes in the State, dedicated to the enjoyment and recreation of the general public and the preservation and management of fish and wildlife. Over 20,000 surface acres of water are contained in these reservoirs. Fishing, camping and swimming in designated areas are the principal forms of recreation on these impoundments.

Water based recreation can also be enjoyed on the larger Corps of Engineers' lakes, some lakes owned by municipalities, or the many natural lakes throughout the State. Many of the lakes used for the storage of municipal and industrial water cannot be used for such water contact sports as swimming and skiing.

Municipal and industrial water supply, irrigation, power generation, and fish and wildlife preservation are other uses of the water stored in Arkansas' lakes. Larger reservoirs such as Beaver and Millwood Lakes are capable of supplying areas and groups of towns, while P.L. 566 lakes, such as the one near Alma, can only supply small towns or communities. Power generation is usually confined to the major rivers such as the Arkansas River (Dardanelle and Ozark Reservoirs), White River (Bull Shoals and Beaver Lakes) and Ouachita River (Lake Ouachita). The majority of the smaller reservoirs used for irrigation and fish farming are located in the Mississippi Alluvial Plains and are primarily off-stream reservoirs and in some cases, use groundwater to fill these reservoirs. Although an abundance of water exists on the land surface of Arkansas, we must still consider the quality of said before we can determine its best use.

The present quality of Arkansas water is generally good, both on the surface and in the ground. The quality of surface water is influenced by many factors, some of which are climate, geography of the watershed, vegetation, industrial activity, irrigation use, and cultural activity. Ground water is usually more highly mineralized and more uniform in chemical quality and temperature than surface water found in the same area. Water quality can best be discussed on the basis of physical, chemical, and biological characteristics. The two chief physical properties affecting Arkansas' water quality are sediment or other solids in suspension and temperature. Important chemical characteristics are those related to the beneficial uses of water for

domestic supply, agriculture, and industry. Biological characteristics are generally related to public health.

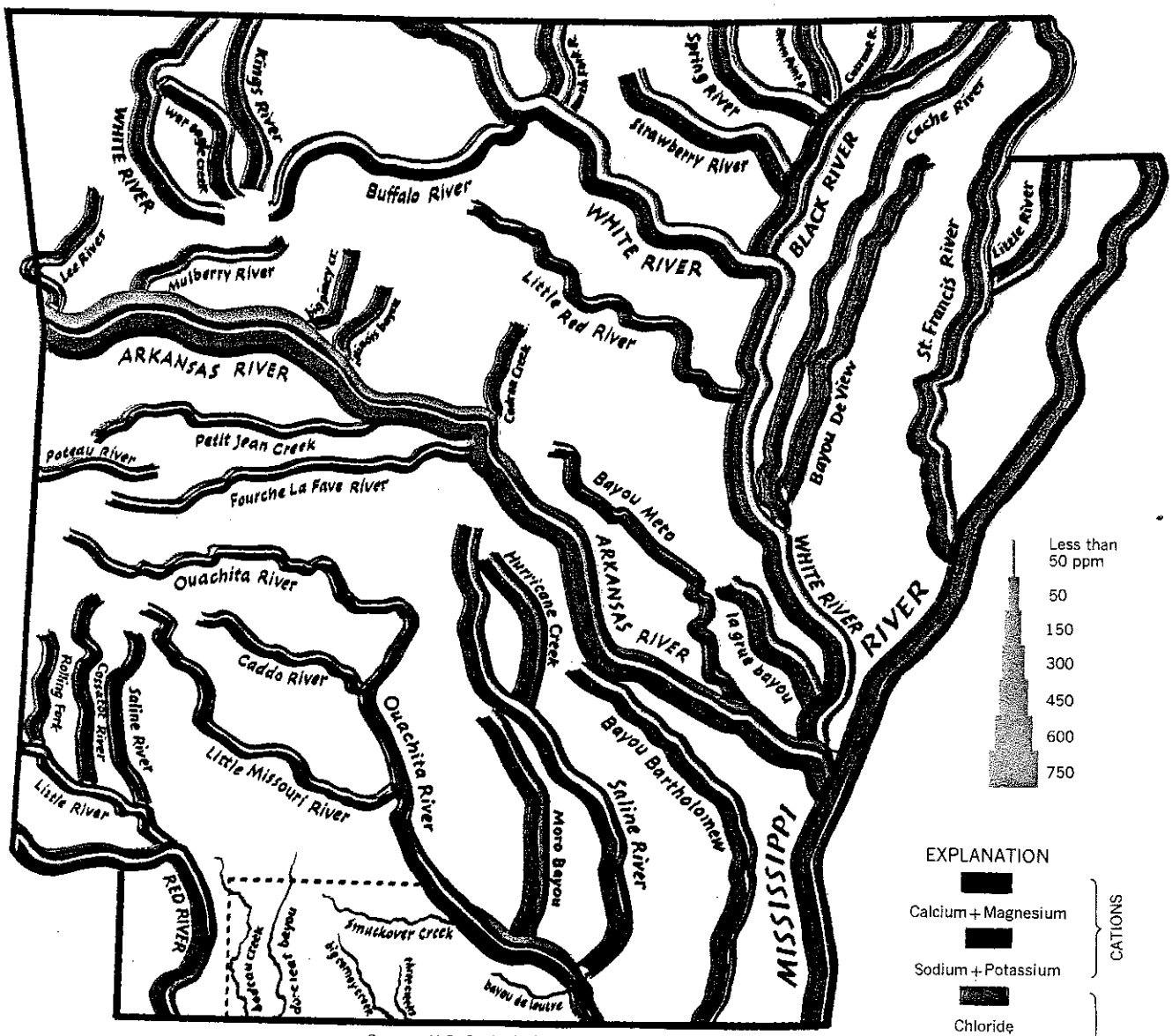
The principal pollutant of the state's surface water is sediment. Erosion is the greatest in Eastern (notably in Crowleys Ridge) and Southwest part of the State, so water quality degradation from sediment is most severe in these areas. Concentrations of suspended sediment range from over 15000 milligrams per liter (mg/l) on the Red River near Fulton, Arkansas, to 2 mg/l on North Sylamore Creek near Fifty Six, Arkansas, observed from a period of recorded data dating from 1969 through 1973. These high sediment loads usually occur during periods of peak or flood flows. The flow is regulated on the Arkansas River by a series of 18 dams extending into Oklahoma, which enable the stream to be used for navigational purposes. The White River also has a number of dams and reservoirs. These reservoirs aid in the reduction of the sediment loads in our streams, but as in the case of the Red River and the Arkansas River, most of the sediment load is due to the inflow from other states. These two rivers also carry a high concentration of dissolved solids in from neighboring states.

The principal dissolved constituents in three of Arkansas' rivers are chlorides. (Figure 8-11). The Ouachita River, unlike the two previously mentioned streams, is also of poor chemical quality in Southern Arkansas, due to brine water contamination from oil fields within the State. Water of such quality is especially detrimental when used for irrigation purposes on certain types of soils. Two studies have been initiated for the Arkansas and Red Rivers to determine the result of use of this water for irrigation. 1/ Due to the system of locks and dams and upstream reservoirs on the Arkansas River and the upstream reservoirs and diversions on the Red River, the water quality of these rivers has improved and should continue to do so.

Increased water temperature, or thermal pollution, is generally caused by use of water for cooling of thermal electric power plants and other industrial plants. It can sometimes accelerate euthrophication of surface waters and affect fish habitat in cold water streams. There is no evidence of thermal pollution in Arkansas but records are sketchy and data is not collected on a regular basis throughout the state.

Pathogenetic bacteria are usually introduced into surface water through the disposal of partially treated sewage, but the potential for pollution by livestock wastes from cattle, swine, and poultry operations has increased in recent years. The use of large quantities of poultry manure as fertilize for pastures in Northwest and Southwest Arkansas, sometimes leads to stream pollution during peak runoff periods. Total confinement operations of both swine and cattle, if not managed properly, could cause serious pollution problems. In addition to the obvious health hazard they cause, such organic wastes also have a biochemical oxygen demand(BOD) which can deplete the dissolved oxygen content of the receiving stream.

1/ Irrigation - Using Arkansas River Water, L. H. Hileman



Source: U.S. Geological Survey and the University of Arkansas.

CHEMICAL QUALITY OF SURFACE WATERS OF ARKANSAS

The most frequently occurring chemical quality of the various streams in Arkansas is shown on this map. The combined width of the five colored lines represents, for each stream, the total concentration of the principal dissolved ions, in parts per million. The widths of the individual colored line represents the relative proportions of the principal ions in solution.

Some of the creeks in the area bounded by dashed lines contain oil field brines. However, this pollution is being reduced rapidly.

FIGURE 3.—Water in the Arkansas and lower Ouachita Rivers has a relatively high chloride content.

Figure 8-11

Chemical agents enter surface water from many sources to degrade its quality. Some chemicals are dissolved naturally from soil and rock by percolating water, while others are introduced in runoff as residuals from oil well operations or agricultural chemicals applied to the land and from municipal and industrial wastes. During certain periods, the concentration of calcium sulfate is relatively high in the Red River.

The U. S. Geological Survey in cooperation with the Arkansas Department of Pollution Control and Ecology, has initiated a water sampling network throught the State, resulting in a number of publications which cover the pollution problems on several rivers. The river basins studied in their reports, correspond very closely with those designated in this report as sub-basins.

In general the surface water of Arkansas is of good quality and in abundance. Yet, the quality as well as quantity of water which can be used for various purposes is dependent upon the area of state in which its found. In the future, surface water may have to be utilized, due to the heavy use of a limited amount of ground water throughout the State.

GROUNDWATER RESOURCES

GENERAL

Some of the precipitation that reaches the earth's surface filters into the soil and eventually reaches the water table. Generally, below the surface of the water table the earth is saturated and the water contained in this area is known as groundwater. Groundwater movement is influenced by gravity and is always seeking a lower elevation. The type of earth material through which groundwater moves has a major effect on its rate of movement, which is usually very slow, only a few hundred feet a year.

Consolidated rock materials are generally rather impermeable; therefore, water movement must take place through bedding planes and tractures. Generally, the more fractured rock transmits larger amounts of groundwater.

In unconsolidated materials such as sand and gravel deposits, the pore spaces, or voids between particles, are quite large. These large pore spaces permit water to move through the deposits readily. Fine grained materials such as silt and clay have large numbers of pore spaces but they are extremely small and do not allow water to move through them readily. In some areas such as the Grand Prairie areas natural clay layers restrict water movement into the groundwater.

Although there is a large amount of groundwater in storage, the groundwater supply is by no means inexhaustible. It is estimated that there is over 200,000 billion gallons in storage beneath the land surface of Arkansas but we use in excess of 1,500,000 gallons a day. In some areas of the state natural recharge is adequate to replenish groundwater supplies while pumping rates in other areas exceed the natural recharge rate.

Arkansas can be divided into two major physiographic regions--the Gulf Coastal Plains and Interior Highlands. (See figure 8-6 page 131 .) The geologic formations of the two areas affects to a large extend the amount, availability and location of groundwater in these regions. Figure 8-20 page 160 shows the approximate well yields that can be expected in different areas of the state.

For the purpose of discussing groundwater resources, the state will be divided into four physiographic areas--the Gulf Coastal Plains (including the Mississippi Alluvial Plain), Arkansas Valley, Boston Mountain-Ozark Plateaus, and Ouachita Mountains. The following discussion will be limited to those aquifers that are most important to the specific area.

GROUNDWATER RESOURCES OF THE QUATERNARY DEPOSITS

Introduction

Most of eastern Arkansas and valleys of the Arkansas, Red, Saline and Ouachita Rivers are covered with deposits of the Quaternary Age. (See figure 8-12 page 144 . Quaternary deposits are geologically recent formations and occur as terrace and alluvium. In most cases these deposits are less than 200 feet thick with the lower part consisting of water-bearing sand and gravel. Much of the upper layers of these deposits consist of relatively impermeable silts and clays.

Quaternary aquifers are a very important source of ground water in the state. Water from these deposits is used for rural domestic, industry and irrigation supplies, with irrigation being by far the largest use. In some areas heavy pumping has caused a severe decline in the groundwater level.

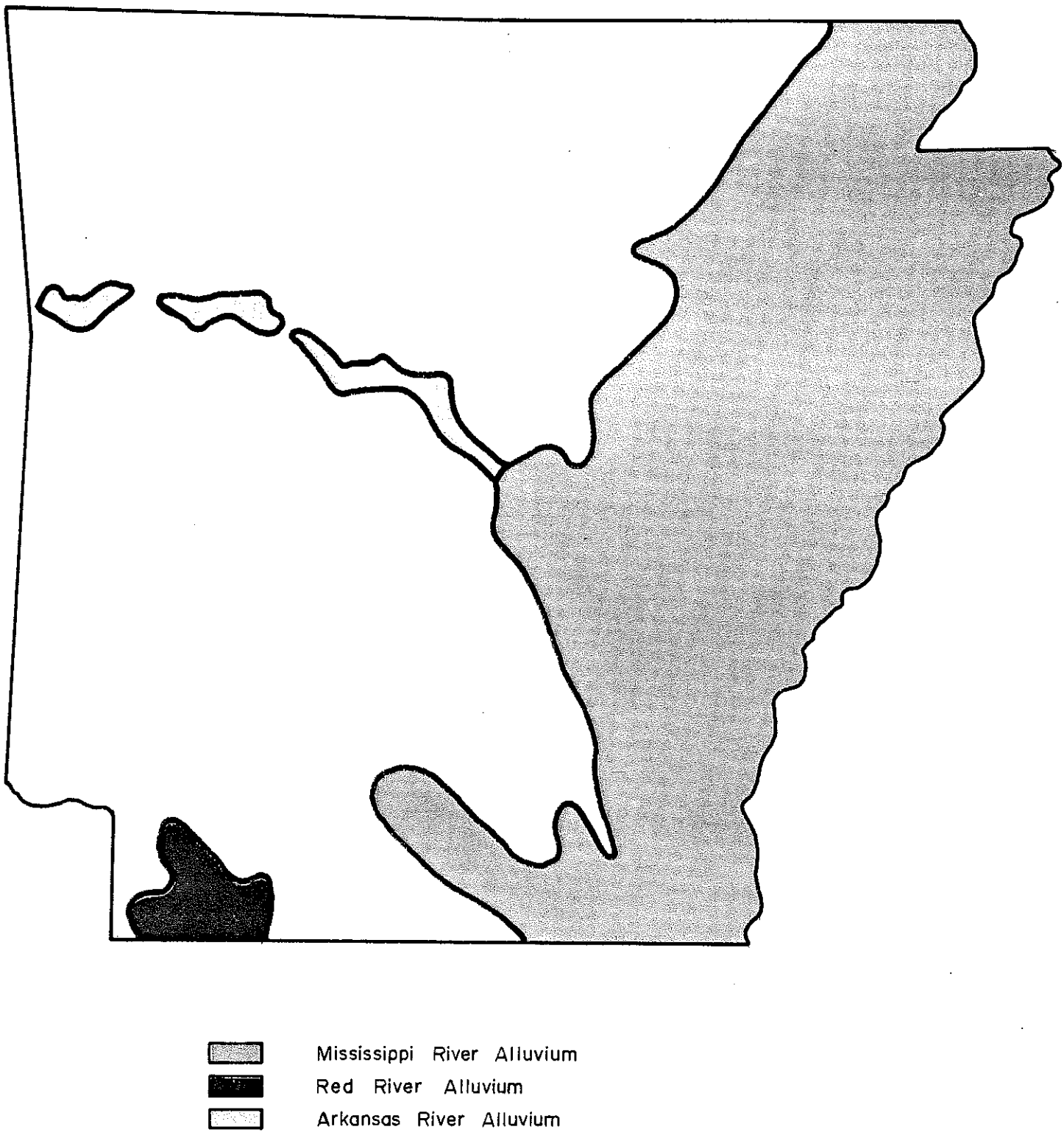
Water quality in Quaternary aquifers varies greatly from place to place and is generally hard with a high iron content. In some areas the high iron content makes the water unsuitable for industrial uses.

Mississippi River Alluvium

Figure 8-12on page 144 shows the approximate productive area of the Quaternary deposits of the Mississippi Alluvium. As was mentioned earlier, the Quaternary deposit is made up of a lower portion of water-bearing sand and gravel covered by silts and clays. The average thickness of these deposits is somewhat less than 200 feet. Wells yield from a few gallons per minute to as much as 6000 gallons per minute. Most of the large wells are used for irrigation. Irrigation well yields generally range between 500 and 2000 gallons per minute.

Water from Quaternary aquifers is used for many different purposes--municipal, industrial, fish farming, and irrigation. The Mississippi Alluvium is the major farming area of the state, hence irrigation is the major groundwater user. Over 70 percent of all groundwater use within the area is for irrigation. The counties of Arkansas, Prairie and Lonoke, within the Grand Prairie area, account for one-third of the groundwater used for irrigation. This heavy pumpage for irrigation has caused a drop in water level of the Quaternary aquifer and has reduced irrigation well yields. As a result, many farmers have developed surface water sources or resorted to more expensive wells penetrating deeper aquifers.

Water quality varies considerably within the Quaternary Aquifer depending on location. In most cases the water is hard and high in iron content which makes it unsuited for domestic supply without treatment. Some areas of the Mississippi Alluvium have rather highly mineralized water within the Quaternary aquifer, with calcium, magnesium and sodium causing some problems on rice soils that are irrigated frequently.



Approximate Productive Areas Of The Quaternary Deposits

Figure 8-12

Source: Water Resource Circular No.1, Arkansas Ground-Water Resources, U.S. Geological Survey, R. C. Baker

Arkansas River Alluvium

The Arkansas River flood plain is underlain by recent deposits of sand, silt, clay and gravel and generally grades from finer grained particles near the surface to coarse grain at its base. The thickness of this Quaternary deposit varies from approximately 40 feet at Fort Smith to 80 feet near Little Rock. See figure 8-12 page 144 for the approximate location of the Arkansas River Alluvium.

Quaternary aquifers in the Arkansas River Valley do not yield as much water as Quaternary aquifers in the Gulf Coastal Plains. Wells have been developed in the Arkansas River Valley that yield a maximum of about 500 gallons per minute. Most of the water obtained from this aquifer is used for municipal supply and irrigation.

Groundwater in the Arkansas River Alluvium is principally of the calcium magnesium bicarbonate type with a high iron content. The water requires considerable treatment which makes it unsuitable for individual domestic supplies. The high iron and nitrate content and the hardness could make the water unsuited for some industrial uses. Most of the groundwater in the alluvium is suitable for irrigation use.

Red River Alluvium

The Red River flood plain is underlain with deposits of the Quaternary Age. (See figure 8-12 page 144.) These deposits consist of clay, sand, silt and gravel varying in thickness up to a maximum of about 90 feet. In general the upper portion of the deposits are made up of silt and clay with the lower portion being sand and gravel.

Yields from irrigation wells reach a maximum of about 1200 gallons per minute in the southern part of the area. Irrigation is the largest single use for groundwater in the Red River Alluvium.

Water from the Quaternary formation is frequently hard; however, wells near Texarkana produce soft water. In isolated areas the Quaternary aquifer has been contaminated by oil field brine. Near Garland City chloride contents of 46,250 milligrams per liter have been found. In these areas the chloride content has made groundwater from Quaternary aquifers unsuitable for irrigation.

GROUNDWATER RESOURCES OF THE TERTIARY DEPOSITS FOR THE GULF COASTAL PLAINS

Introduction

Tertiary deposits of the Gulf Coastal Plain area provide the primary source of water for municipal and industrial use. Also in areas where

yields of the Quaternary aquifers have been reduced, many farmers are using Tertiary aquifers for sources of water for irrigation. The following discussion will be limited to Tertiary aquifers that are most important as groundwater sources.

Cockfield Formation

The Cockfield formation underlies a large portion of eastern Arkansas (see figure 8-13 page 147). The depth from the land surface to the formation varies from less than 100 feet to about 500 feet, and the thickness of the formation varies from about 50 feet to more than 300 feet. It contains irregular beds of fine to medium sand, generally in the lower portions of the formation. Because of the fine-grained texture of the Cockfield formation, well yields range from a few gallons per minute to over 2000 gallons per minute.

Most of the water pumped from the Cockfield formation is used for rural domestic and livestock supplies. Some industries and municipalities use this aquifer as a source of supply. Also, there are a few irrigation wells in east-central Arkansas that pump water from the Cockfield formation.

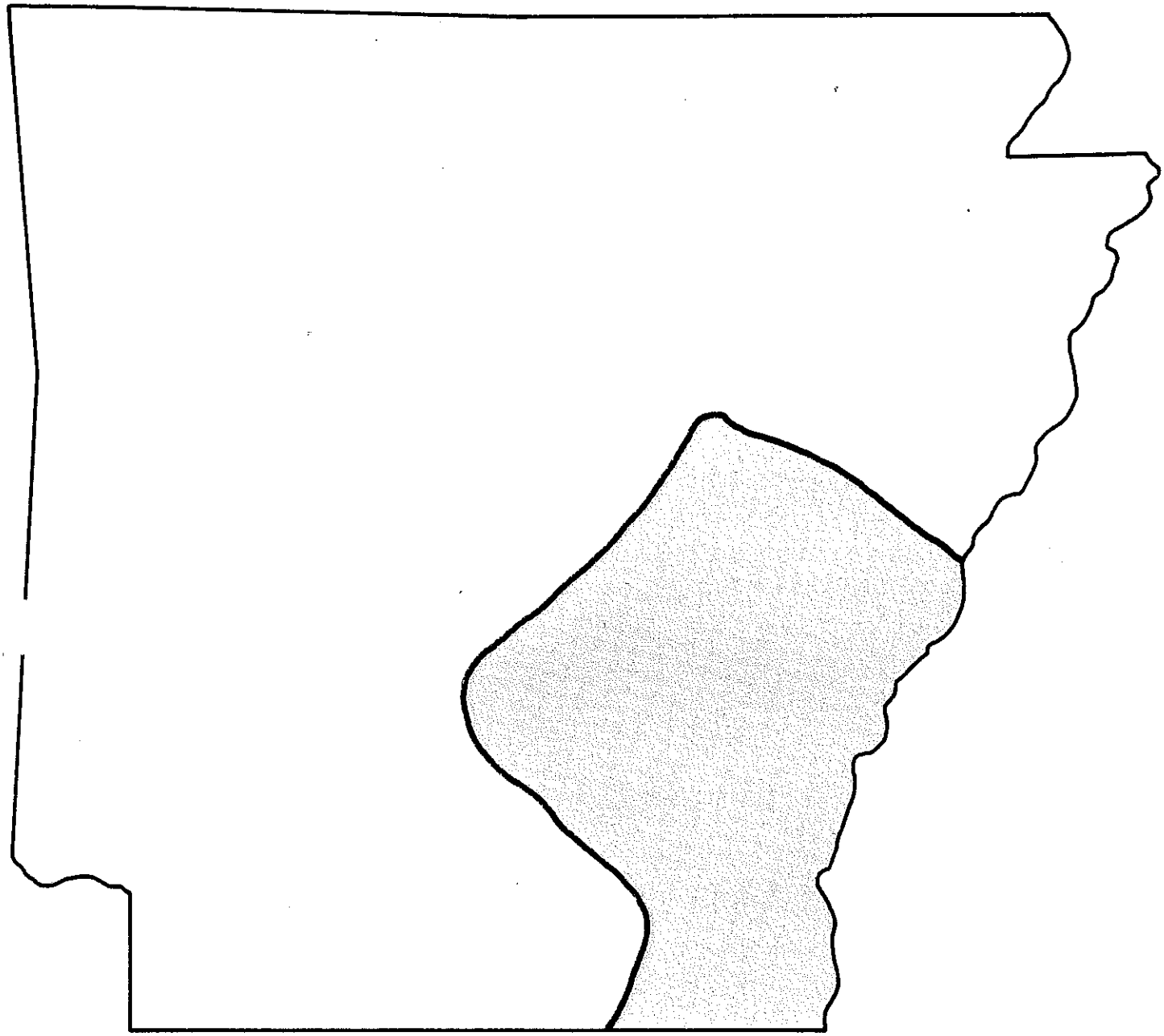
Water quality in the Cockfield formation varies considerably, from very good in parts of Drew County to poor in southern Chicot County. Practically no water is used from the formation in southern Chicot County because of its high salinity and general unsuitability.

Sparta Sand

The Sparta Sand is the most widely used Tertiary aquifer in Arkansas. Figure 8-14 page 148 shows the extent of the Sparta Sand and the most productive area. Over most of the area the Sparta contains thick extensive sands, and wells have been developed that yield 3000 gallons per minute. Some areas, especially in south Arkansas, discontinuity of sand layers cause reduced transmissibility and yields.

The largest user of water from the Sparta Sand is industry, which withdraws more than 60 million gallons per day. In Columbia, Jefferson and Union Counties, heavy withdrawal by industry and minicipalities have caused large depressions in the piezometric surface. In recent years several irrigation wells have been drilled into the Sparta Sand in Arkansas and Prairie Counties, which withdraw more than 22 million gallons per day.

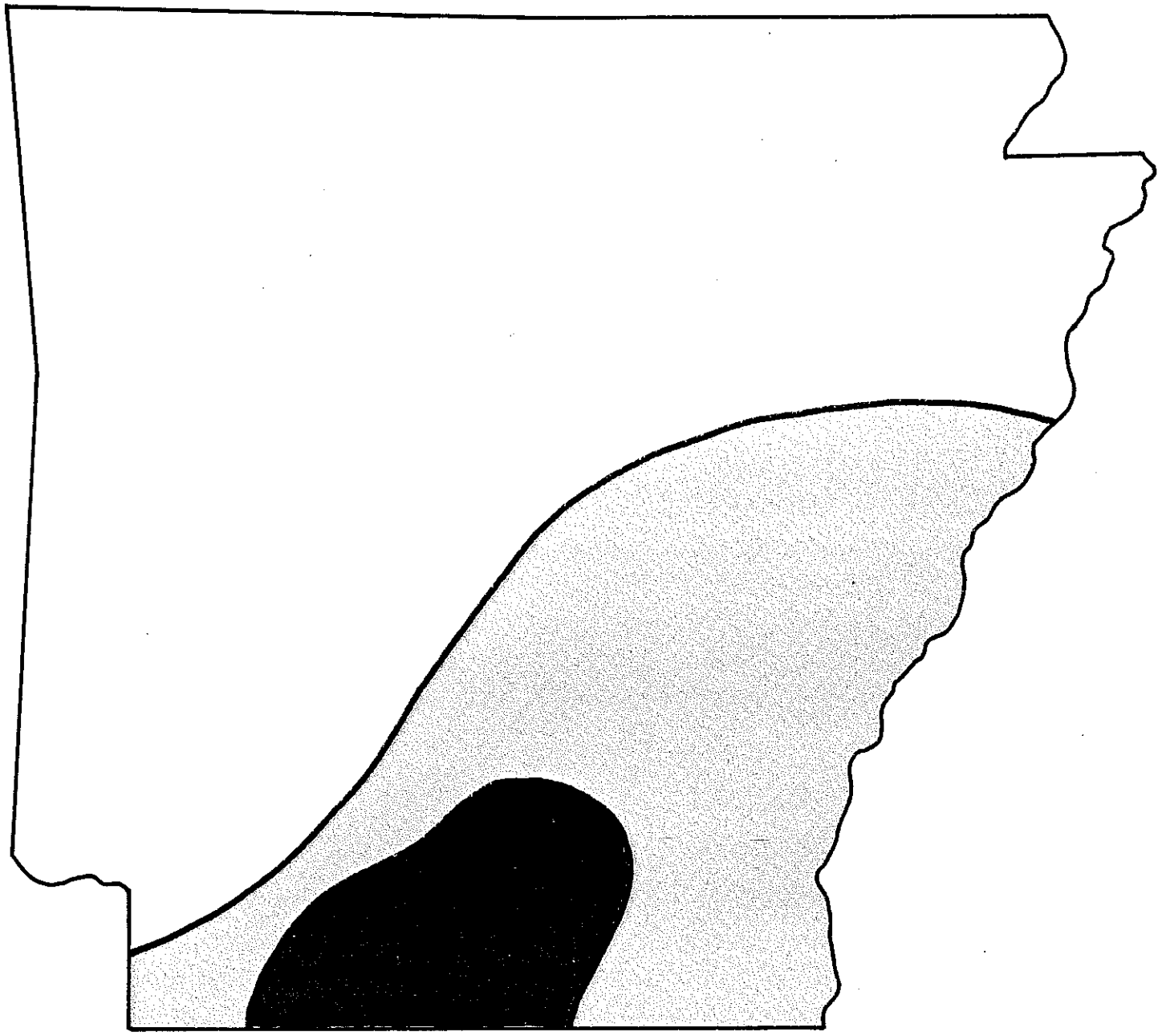
The quality of water from the Sparta Sand is generally excellent, especially for municipal and industrial uses. It is the sodium bicarbonate type with little or no iron. In extreme southeast Arkansas water from the Sparta Sand becomes too highly mineralized for use. There is some concern that the water may contain enough sodium to be damaging if used continually for irrigation.



Approximate Productive Areas Of The Cockfield Formation
(Tertiary Age)

Figure 8-13

Source: Water Resource Summary No. 4, Ground-Water Levels In Deposits Of Quaternary And Tertiary Age, 1965; U. S. Geological Survey by D. R. Albin, J. W. Stephens & J. Edds



Approximate Area of Sparta Sand

More Productive Area of the Sparta Sand Formation

Sparta Sand Deposits of the Tertiary Age

Figure 8-14

Source: Water Resource Summary No. 4, Ground-Water Levels In Deposits Of Quaternary And Tertiary Age, 1965; U.S. Geological Survey by D.R. Albin, J.W. Stephens & J. Edds

Carrizo Sand

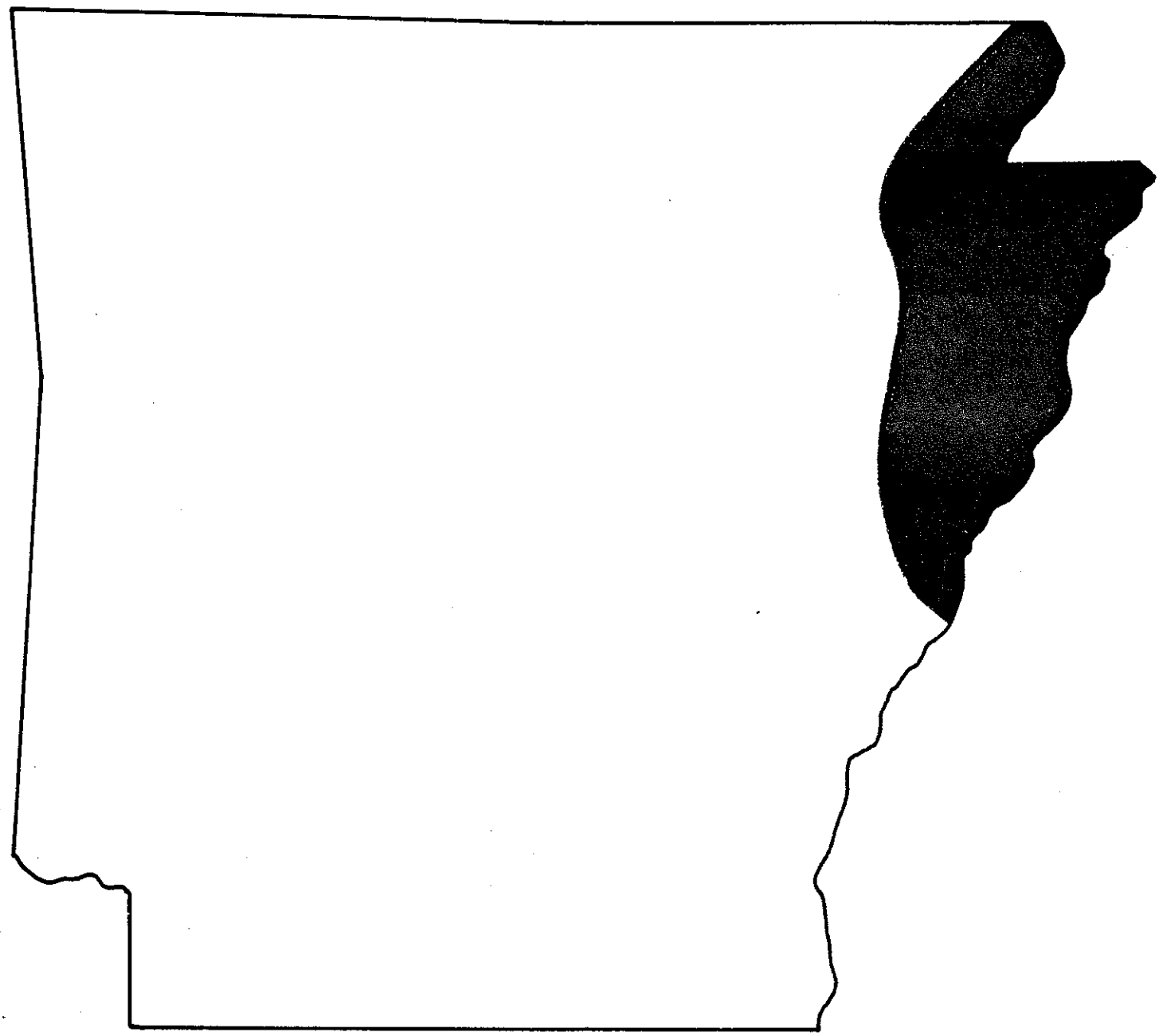
The Carrizo Sand, which is a part of what is known as the Memphis aquifer, underlies a large part of northeastern Arkansas. This is an extensive almost unused source of water. This should be a source of large capacity wells.

"1400-Foot" Sand

The "1400-Foot" Sand comprises the middle unit of the Wilcox formation and is an important source of groundwater in northeast Arkansas. See figure 8-15 page 150 for approximate productive area of the "1400-Foot" Sand. This sand occurs at a depth of about 1000 feet in Mississippi County and reaches a depth of 1900 feet in Lee County. The "1400-Foot" Sand consists predominately of fine to medium grained micaceous quartz. This formation is capable of well yields of 2000 gallons per minute.

This aquifer has not been developed as a water source to any great extent in Arkansas; however, considerable amounts of water are withdrawn near Memphis, Tennessee. In Arkansas, most of the wells in the "1400-Foot" Sand are used for municipal water supply.

Quality of the water from the "1400-Foot" Sand is generally good; however, it does contain undesirable constituents such as iron and free carbon dioxide. The water also contains enough sodium to restrict its use for irrigation.



Approximate Productive Area of the " 1400 Foot " Sand

" 1400 Foot " Sand of the Tertiary Age

Figure 8-15

Source: Water Resource Summary No. 4, Ground-Water Levels in Deposits of Quaternary and Tertiary Age, 1965; U. S. Geological Survey by D. R. Albin, J. W. Stephens & J. Edds

BOSTON MOUNTAIN-OZARK PLATEAU[1]

Introduction

Groundwater in the Ozark Plateaus is derived from shallow and deep aquifers, with the total reservoir section consisting of over 2,000 feet. Similar to physiography, the Ozark Plateaus area may also be divided into three units in terms of groundwater availability; the Salme Plateau, Springfield Plateau, and Boston Mountains. See figure 8-18 page 158 for location of Boston Mountain-Ozark Platueas area. Groundwater in the Salem Plateau is derived from aquifers of Cambrian and Ordovician age, which are at or near the surface throughout the area. Groundwater in the Springfield Plateau and Boston Mountain areas is obtained from shallow aquifers of Mississippian and Pennsylvanian age and deeper aquifers of Cambrian and Ordovician age. Water from the shallow aquifers occurs under water table conditions and generally supplies enough water for domestic use. Groundwater from the deep aquifers is generally under artesian pressure and yields are usually considerably higher than those of the shallow aquifers. The most dependable water supplies for industrial, municipal and agricultural uses are derived from the deep aquifer section.

Deep Aquifers

Groundwater from the deep aquifers of the Ozark area is derived from Cambrian and Ordovician sandstone and dolomite. The deep aquifer section encompasses the following principal fresh water formations: the Lamotte Sandstone, Potosi Dolomite, Gasconade Dolomite and Gunter Sandstone Member, and the Roubidoux Formation. The position of these units in the geologic column and their relationship to other geologic units is shown in Figure 8-16. All of the principal aquifer units crop out in concentric belts surrounding the St. Francois Mountains but are confined to the subsurface in southwestern Missouri and northern Arkansas.

Recharge to the principal aquifers is by vertical movement of water through overlying younger formations (Fuller and Knight, 1967). Recharge and water yields are dependent upon the permeability of the formations. Yields often show large variations because of low permeability associated with the carbonate lithologies of the formations. Relative yields of the principal aquifers in southern Missouri are shown in Figure 4.

General Hydrologic Character of the Principal Aquifers

Lamotte Sandstone

The Lamotte Formation is the oldest aquifer in the Ozark Area and is the basal unit of the Cambrian system. The Lamotte crops out in the St. Francois Mountain area but is confined to the subsurface throughout southern Missouri and northern Arkansas. Depths to the Lamotte range from 1,200 feet in southern Missouri to over 2,500 feet in northern Arkansas.

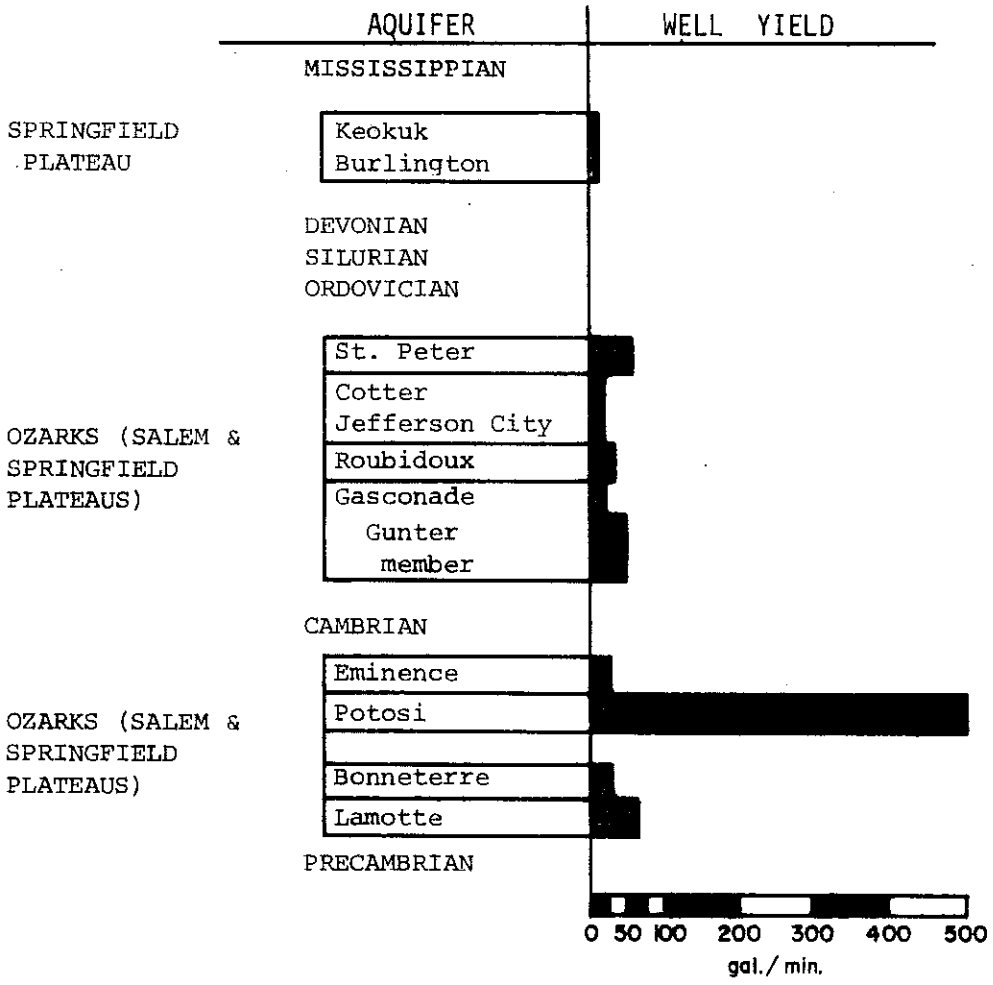
The Lamotte Sandstone in Missouri is generally a low yield aquifer (average 75 gpm) due to the void-filling cementation of the sand grains (Fuller and Knight, 1967); however, little is known about water yields from the Lamotte in northern Arkansas. No wells have been reported that produce from the Lamotte. The only penetration of the formation resulted from the drilling of oil wells which were not tested for fresh water yield.

[1]Reprinted from: Northern Arkansas Groundwater Inventory: Prepared for Arkansas Soil and Water Conservation Commission by Arkansas Water Resources Research Center, Director: R. E. Babcock; Investigators MacDonald, Zachry, Jeffus.

SYSTEM	SERIES	STAGE	FORMATION	MEMBER
PENNSYLVANIAN	UPPER	ATOKA	Atoka	Greenland Sandstone
		MORROW	BLOYD	Trace: Creek Shale Kessler Ls. Dye Shale Woolsey Sh. Brentwood Limtestone
			HALE	Prairie Grove
MISSISSIPPIAN	UPPER	CHESTER	PITKIN	
			FAYETTEVILLE	Wedington Sandston
			BATESVILLE	Hindsville Limestone
	LOWER & MIDDLE	OSAGE	BOONE	St. Joe Limestone
			CHATTANOOGA	Sylamore Sandston
DEVONIAN	UPPER	UPPER CANADIAN	EVERTON	Kings River Sandstone
ORDOVICIAN	LOWER		POWELL	
			COTTER	
			JEFFERSON CITY	
			ROUBIDOUX	
			GASCONADE	Gunter Sandstone
			EMINENCE	
CAMBRIAN	UPPER		POTOSI	
			DERBY-DOERUN	
			DAVIS	
			BONNETERRE	
			LAMOTTE	
PRECAMBRIAN BASEMENT ROCKS				

Generalized stratigraphic column of northwestern Arkansas, Southwestern Missouri, and northeastern Oklahoma.

Figure 8-16



(After Knight, 1962)

Typical yields of wells in principal aquifers of the Ozark Plateaus.

Figure 8-17

Potosi Dolomite

The Potosi Dolomite is exposed on the flanks of the St. Francois Mountains and as the Lamotte is confined to the subsurface in southern Missouri and northern Arkansas. The Potosi of Missouri is generally a coarsely crystalline dolomite, and in most of the area it is drusy and vuggy (Fuller and Knight, 1967). The cavities are interconnected and water is able to flow freely (Fuller and Knight, 1967). This characteristic makes the Potosi one of the highest yielding formations of Missouri, and it is the primary source of water for municipal and industrial use in the area. Yields average 500 gpm (Knight, 1962) from the Potosi. Depths to the Potosi in Missouri average 1,200 feet.

As is true of the Lamotte, little is known about the yield potential of the Potosi in Northern Arkansas. Only a few wells have penetrated the formation and are producing from it. A well drilled near Rogers, in Benton County, Arkansas, is reported to be producing from the Potosi. The well is located in Sec. 13, T. 20 N., R. 29 W., and has a total depth of 1,968 feet, with a surface elevation of 1,460 feet. The well has a yield of 230 gpm with a drawdown of 49 feet (Taylor Engineering Co., Springdale, Arkansas, Personal Communication, 1975). The water from this well is of good chemical quality.

A well located in Sec. 17, T. 15 N., R. 13 W., in Washington County, Arkansas, is reported by the United States Geological Survey at Little Rock to be in the Potosi at a total depth of 2,097 feet. This is an old oil test well by the Camden Oil Company. The well is reported to have yielded 50 to 60 gpm and had an unusually high total dissolved solid content of 928 ppm. The chloride content was 290 ppm.

Water from the Potosi may be considered as a future potential source in northern Arkansas. As the need for water increases in the area deeper wells may have to be drilled. Also, in areas where the Gunter Member and Roubidoux Formation are not good producers, the Potosi may be a logical alternative.

Eminence Dolomite

The Eminence Dolomite is medium to coarsely-crystalline and locally very siliceous (Fuller and Knight, 1967). In Missouri only small quantities of water are produced from the upper 100 feet of the formation. Moderate quantities are obtained from the lower portion of the formation, down dip from the outcrop area. The water is being produced from openings and fractures in the dolomite in yields sufficient for municipalities and small industries (Fuller and Knight, 1967). Yields from the Eminence average 25 gpm in Missouri (Knight, 1962).

In northern Arkansas the Eminence does not appear to be a significant aquifer. Many wells penetrate the first 50 feet of the formation, but no major increases in yield are apparent over those encountered in the penetration of overlying formations.

The Gasconade Formation and Gunter Sandstone Member

The Gasconade Formation is the earliest Ordovician unit in Missouri and northern Arkansas. The formation consists of an upper cherty dolomite unit averaging over 300 feet in thickness, and a lower basal sandstone and sandy dolomite member termed the Gunter Sandstone Member.

The Gunter Member crops out in the Lake of the Ozarks area of south central Missouri. It is generally a well developed sandstone averaging 30 feet in thickness throughout most of south central Missouri and north central Arkansas but becomes increasingly more dolomite east and west of this area. Yields from the Gunter Member throughout most of southern Missouri to the Arkansas border average 40 to 50 gpm, and locally as much as 1,000 gpm (Fuller and Knight, 1967). Yields from the Gunter in northern Arkansas average greater than 100 gpm, with local yields as high as 581 gpm.

The dolomite beds of the Gasconade Formation above the Gunter Member contain several dense zones in the upper 150 feet of the formation. These zones apparently do not yield water and may form an aquiclude to water from overlying formations. The next 100 feet to 150 feet below these dense zones contain up to 50 percent chert and yield water sufficient for farm and domestic use in Missouri. The availability of water from this zone in northern Arkansas has not been determined. Wells which penetrate only the upper Gasconade are not numerous enough at this time to permit proper evaluation of the aquifer's potential.

Roubidoux Formation

The Roubidoux Formation crops out extensively in southern Missouri, and is the most reliable shallow aquifer for farm wells in this area (Fuller and Knight, 1967). The Roubidoux is confined to the subsurface for the most part in southwestern Missouri and northern Arkansas. It consists of sandy, cherty dolomite, with distinct sandstone units appearing at the base, middle, and top of the formation in western Missouri.

Yields from the Roubidoux throughout Missouri average 15 to 20 gpm with some local production as high as 300 gpm (Fuller and Knight, 1967). Yields in northern Arkansas average 60 gpm with local variations as high as 600 gpm. The formation is the shallowest of the principal aquifers in the Ozark Region, and produces adequate yields for small industrial and municipal use.

Regional Hydrologic Character of the Roubidoux and Gasconade Formations

Domestic supplies of groundwater outside of the outcrop area of the five principal deep aquifers in the Ozark Plateaus region are generally obtained from relatively shallow wells in formations of Pennsylvanian and Mississippian age. Water for municipal and industrial utilization is generally not available in sufficient quantities from these shallow aquifers, and must be obtained from the deep aquifer units (Feder and others, 1969). The Roubidoux and Gasconade Formations are being utilized extensively throughout Missouri as reliable aquifers for industrial and municipal needs. In northern Arkansas extensive development of these

aquifers has been restricted by high drilling costs and relatively sparse population. At present, only a limited number of wells penetrate the Roubidoux and Gasconade Formations in the area; however, future development of large groundwater supplies in northern Arkansas appears to depend primarily on the water-bearing properties of the Roubidoux and Gasconade units.

Estimated Yields

Most wells drilled into the Roubidoux and Gasconade Formations are open below a certain casing depth. This casing depth is determined by the presence of surface contaminants, the degree of weathering, and economics. Estimated yields from these wells, therefore, represent the total contribution from all open aquifers in the section. Yields from wells are dependent on the diameter and total depth of the bore hole, formations penetrated, geographic location, structural attitude of the rocks, and permeability of the aquifers tapped. The probability of interformational movement of water also makes it difficult to define parameters which describe the yield capabilities of the individual aquifers. There is generally, however, a substantial increase in the collective yield of a well when either the Roubidoux or Gasconade formations are penetrated. It is therefore possible to arrive at conclusions about the water-yielding properties of the Roubidoux and Gasconade Formations by using data from wells penetrating various aquifer combinations.

Analysis of the Roubidoux Yield from the Study of Existing Wells

1. Yields range from 4 gpm to a maximum of 600 gpm, with an average yield of 50-60 gpm throughout the study area.

2. Yields are generally low (0-50 gpm) in the outcrop area of the Roubidoux Formation, but generally increase to the south and west of this area.

3. Yields appear to decrease significantly from the northern Arkansas structural platform toward the Arkhoma basin.

4. High yield areas (greater than 150 gpm) are not uniform throughout any portion of the study area. This observation would suggest that either the rock characteristics which dictate water production are not constant in their sub-surface distribution, or that yields are affected by structure, faulting, or solutioning more than by lithic character.

5. Yields of 50 to 150 gpm are available from a belt beginning in the southwestern corner of Missouri and extending southeast across northern Arkansas.

Analysis of the Gasconade yield data can be summarized as follows:

1. Yields are generally higher than for wells penetrating the Roubidoux Formation. Yields range from 4 gpm to a maximum of 732 gpm, with the average being approximately 170 gpm.

2. Yields are low (0-50 gpm) in the outcrop area of the Gasconade Formation, and increase to the south and west of this area.

3. Yields appear to decrease toward the Arkhoma basin.

4. High yield zones (greater than 250 gpm) are more uniform and continuous than those of wells penetrating the Roubidoux Formation. These yield zones appear as elongate belts localized in southwest Missouri and extreme northwest Arkansas.

5. Yields of from 50 to 250 gpm are available over a large portion of the study area extending from southwest Missouri, south and east into northern Arkansas to the border of the structural platform.

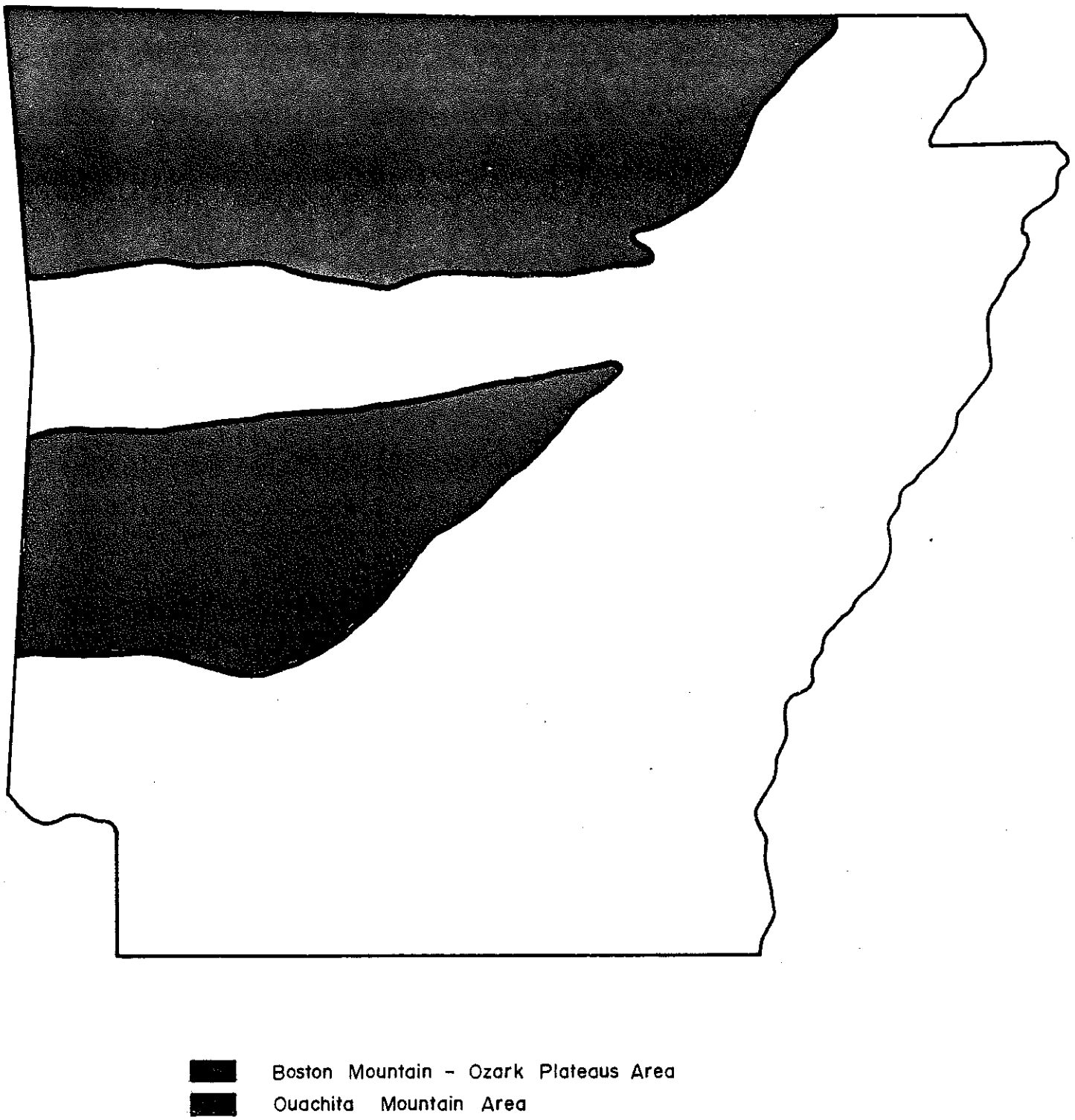
Arkansas Valley

The groundwater in the Arkansas Valley physiographic area (exclusive of the Arkansas River Alluvium) is very scarce. The Atoka sandstone formation exists in this area and is comparable to that described for the Boston Mountains. The Hartshorne sandstone is basicly continuous throughout the area but is extremely dense and cemented and is not considered as a source of water.

Ouachita Mountains

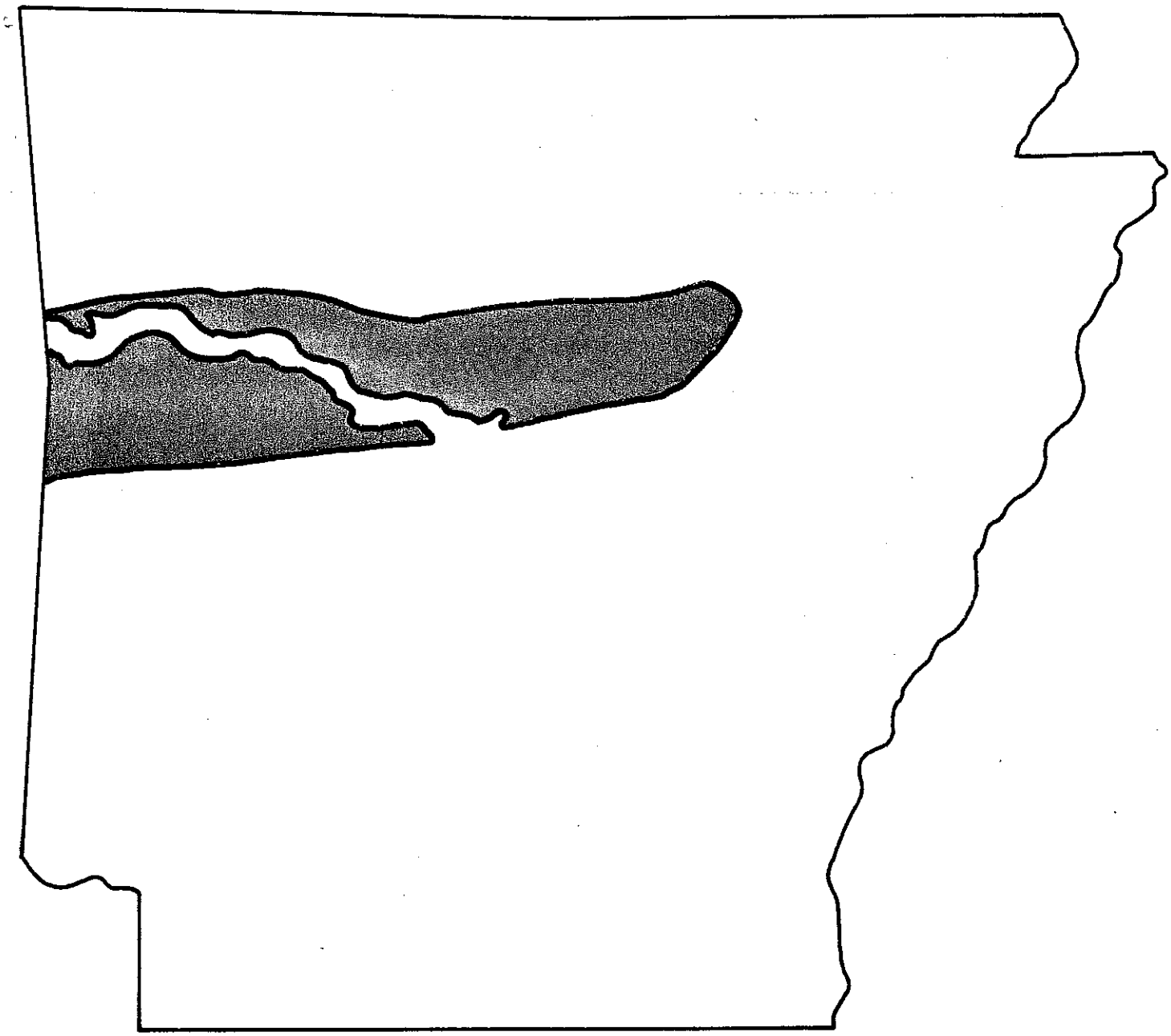
The porosity of the older rocks of the Ouachita Mountains has been destroyed by compaction. See figure 8-18 page 158 for location of the Ouachita Mountain area. Groundwater in this area occurs in mostly fractures or along bedding planes. The yield from these formations generally depends upon the degree of fracture. Only one geological unit is generally considered an aquifer throughout its area of occurrence; this is the Bigfork Chert. Bigfork Cherk is very brittle and has been highly fractured.

Most wells in the mountain area yield less than 50 gallons per minute; however, one well penetrating the Bigfork Chert yields as much as 350 gallons per minute. The aquifers in the mountain should not be considered as sources for municipal water supplies.



Interior Highland Area of Arkansas

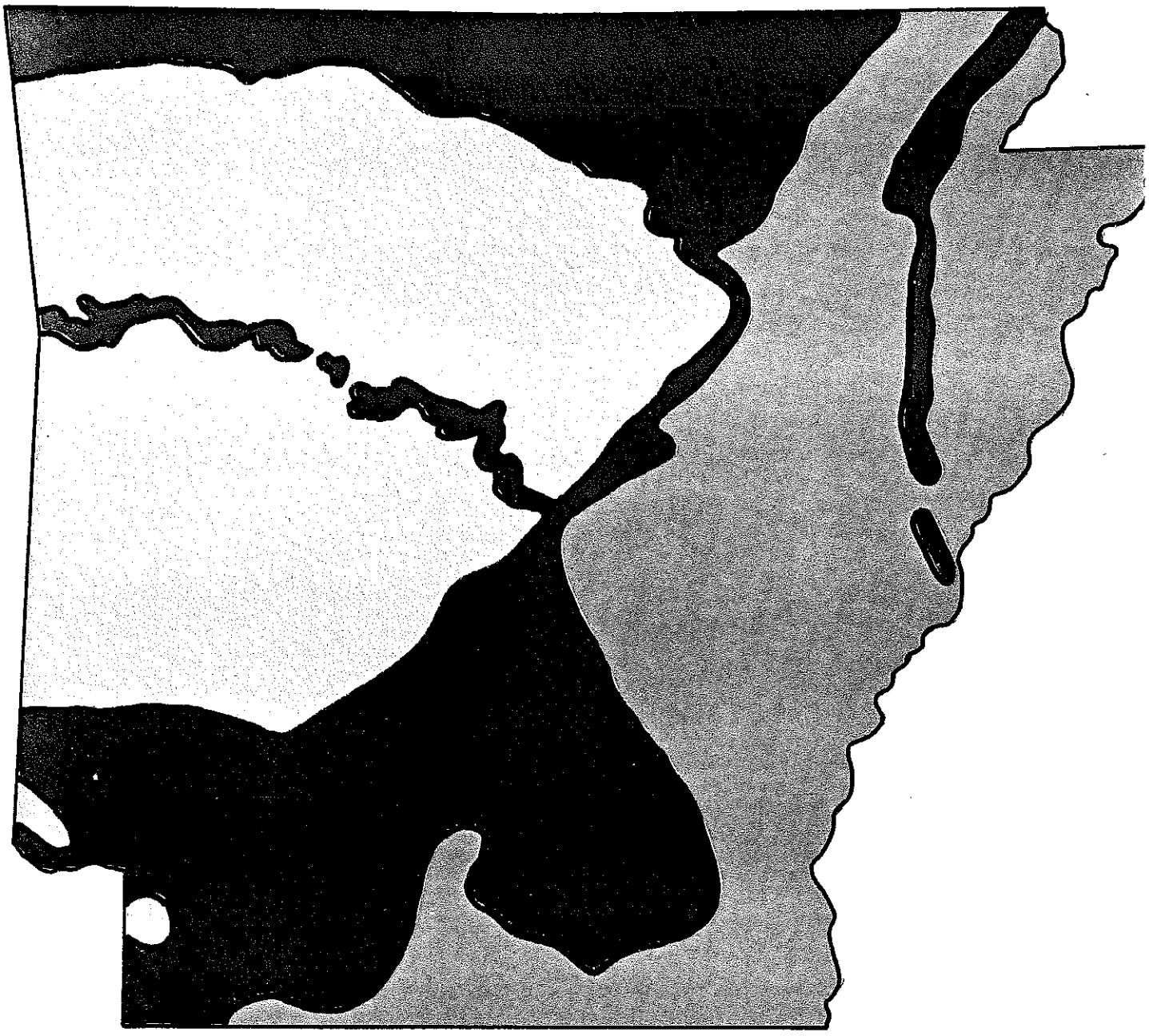
Figure 8-18



Arkansas Valley Area - (Excluding Arkansas River Alluvium)

Arkansas Valley Area

Figure 8-19



Approximate Expected Well Yield For Areas In Arkansas

Figure 8-20

Source: Water Resource Circular No. 1, Arkansas Ground-Water Resources
U.S. Geological Survey, R. C. Baker

CHAPTER IX

ENVIRONMENTAL CONSIDERATIONS

STREAM PRESERVATION

It would be remiss to present a plan for future water management without first taking into consideration the effects the projected use patterns would have upon the preservation of streams and rivers in Arkansas. It is an easily recognizable fact that the pressure and pace of our highly urbanized society has resulted in a gradual shift to a more diverse recreational pattern--pertinently speaking, from a highly electric and excitement oriented "mass recreation" to what is sometimes referred to as "escape recreation." It has also long been recognized that the streams and rivers of Arkansas are extremely important in respect to their historic, scenic and mere aesthetic value. The mountain streams have long been noted for their clear white waters, ideal for fishing, canoeing, swimming, and recreation in general. The lowland streams in the alluvial plains nourish the land and, due to their seasonal overflow, provide habitat for an endless number of waterfowl and other wildlife.

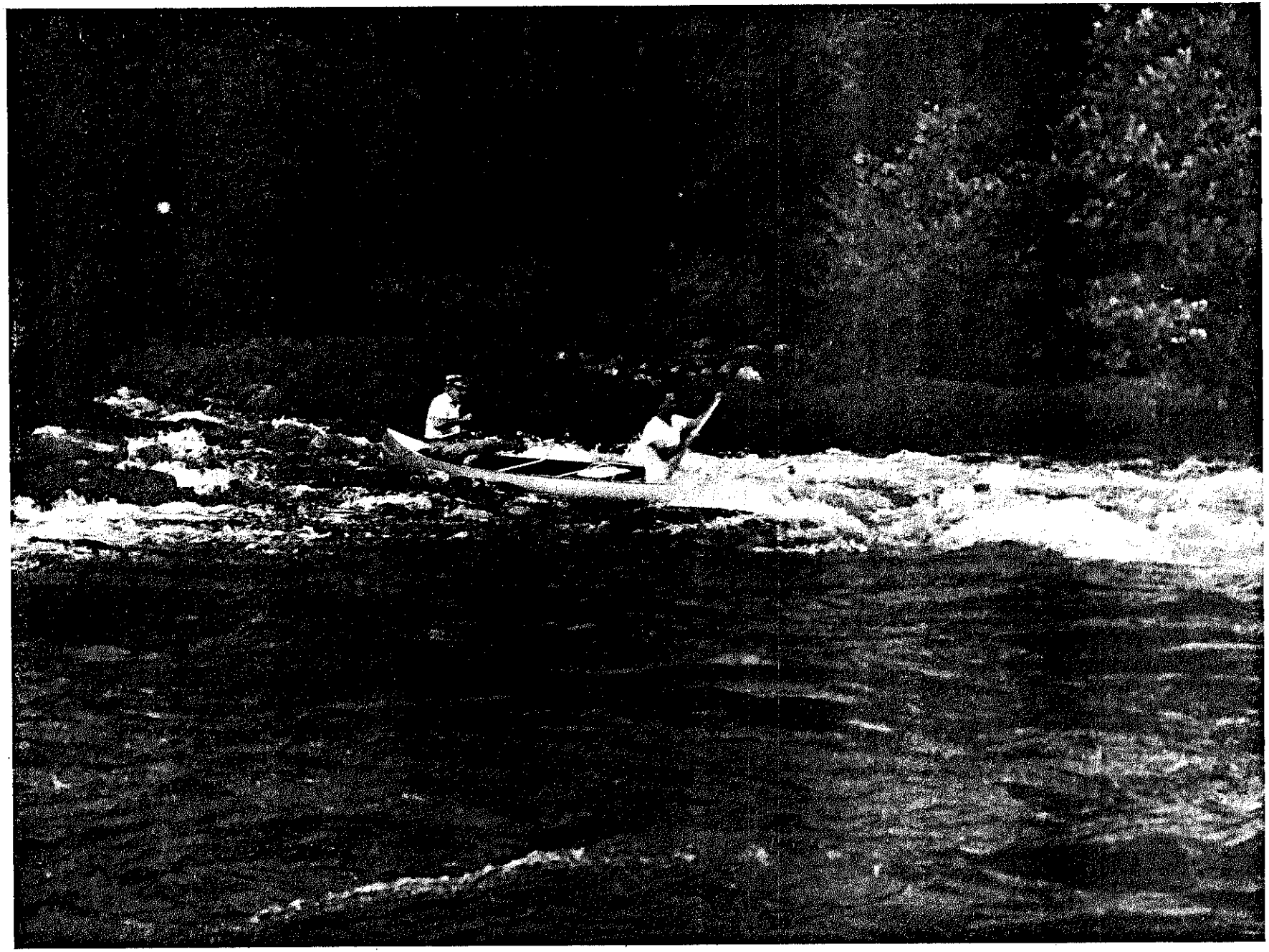
It would be equally as negligent to consider future water use plans without also taking into consideration the enormously increased demands that industry, agriculture and population density have on our water supply.

Herein lies the dilemma. Where is the line drawn? Naturally, it would not be so difficult if growth and technology were to suddenly cease. But where are our needs going to lie in the future? True, as mentioned previously, our urban masses are faced with both a greater need and more time for the recreational uses of these waterways, and this recreational pressure will unquestionably increase. It also cannot be denied that future economic growth and development will place an ever-increasing demand on our present water resources.

Basic economic principles and mass survival instincts assure that the developmental aspects of future water resource use will take care of themselves. In other words, economics and survival instincts have naturally directed our objectives towards such ends as production of electric power, river navigation, industrial and municipal water supplies, and the allocation of ever-increasing amounts of land to agriculture. But on the other side of the spectrum, no intrinsic characteristic has provided for the preservation of streams and rivers for the multitude of purposes mentioned earlier. Taking this fact into consideration, in 1967 the Arkansas State Legislature passed a bill to establish a state Committee on Stream Preservation. As pointed out in the bill, the purposes of this committee were as follows:

(1) Study, locate and designate selected high quality streams in Arkansas which are as yet relatively unaltered.

(2) Make preliminary surveys to define the character, quality, recreational potential, scenic, historical, esthetic, and other values to be retained in preserving such streams in their natural state; such selected streams to include both swift-water and lowland streams and rivers.



PLANS FOR STREAM PRESERVATION MUST BE INCORPORATED INTO WATER MANAGEMENT PLANS AS AN IMPORTANT ASPECT OF WATER USE.

(3) Evaluate and describe the potentials of such designated streams in accordance with recognized classification systems.

(4) Prepare a preliminary report on streams which are selected and classified, for presentation to the Governor, the General Assembly and other interested agencies and parties.

(5) Prepare recommendations for preservation of designated streams and other watersheds, and to recommend courses of action to implement the preservation of such streams in their natural state.

These purposes are in keeping with a growing national and state concern for the preservation of the quality and diversity of our natural environment essential to this and future generations. It is also in keeping with the establishment of a national wild and scenic rivers system, and actions by other states to do likewise. Intially, the functions of the Stream Preservation Committee were headquartered in the offices of the now defunct Arkansas Planning Commission. It is now housed in the newly-created Department of Natural and Cultural Heritage.

In full recognition of the importance of stream preservation in Arkansas, and recognizing the Stream Preservation Committee as the state authority, it will be the intention of this organization to closely communicate with the Committee on any projects that will alter the environmental quality of any river or stream in Arkansas.

NATURAL AREA PRESERVATION

Here again we have the same issue at hand as in the preceding paragraphs--and that is striking a proper balance between economic development on the one side and preservation on the other.

In 1973, the Arkansas General Assembly passed Act 112 which, among other things, created the state authority on natural area preservation, the Environmental Preservation Commission. Section 2 of this act states that, "It is the policy of the State of Arkansas to preserve, manage and enhance the lands, waters, and air of the state with full recognition that this generation is a trustee of the environment for succeeding generations; to preserve to the fullest extent possible, areas of historical, geological, archeological, paleantological, ecological, biological and recreational importance; to promote as wide a range of choice as possible among beneficial uses of the environment; and to strike a proper balance among population growth, economic development, environmental preservation, and ecological diversity; all to the end that the environment and resources of the State of Arkansas shall be used and preserved for the welfare of man."

TO BE EFFECTIVE, WATER DEVELOPMENT PLANNING IN ARKANSAS MUST STRIKE A PROPER BALANCE AMONG POPULATION GROWTH, ECONOMIC DEVELOPMENT, ENVIRONMENTAL PRESERVATION AND ECOLOGICAL AND RECREATIONAL DIVERSITY.

Section 9 of this Act granted the following rights, powers, and duties of the commission:

(a) To choose lands, waters, and interests therein to be acquired in the manner set forth elsewhere in this Act for inclusion in the natural-areas system, in accordance with criteria specified in Section 10 of this Act;

(b) to acquire, by purchase, gift, devise, grant, dedication (as hereinafter defined), or otherwise, the fee or other interest in real property, for inclusion in the system; provided, however, that the Commission shall not have the power of eminent domain; and provided further, that the Commission shall not itself permanently hold fee title to any real property, but shall either cause said title to be conveyed directly to such agency or department of the State as it may select, or shall, promptly after acquisition of said property, forthwith convey the same to such agency or department of the State as it may select;

(c) to acquire and hold by dedication (as hereinafter defined) any interest in real property less than the fee, including environmental or scenic easements;

(d) to establish and, from time to time, to amend, such policies, rules, and regulations for the selection, acquisition, management, protection, and use of the "system" (meaning a state system of natural areas as set forth in a previous section of this Act), as it may find necessary or appropriate to preserve the lands or interests therein acquired hereunder and carry out the policies of this Act, such policies, rules, and regulations to prevail, in the event of conflict, over any policies, rules, regulations, and practices of any agency or department that may receive title to any portion of the system;

(e) to cooperate and contract with any Federal, State, or local governmental agency, private organization, or individual;

(f) to maintain a registry or inventory of lands and waters in the State, whether publicly or privately owned, that retain their primeval character to a substantial degree, or that have flora, fauna, ecological, geological, or archaeological features of significant scientific, educational or recreational interest, said registry to be known as the registry of natural areas; and to maintain an inventory of habitats of rare, vanishing, or endangered species, subspecies, or populations of plants and animals, and other records of natural areas; provided, however, that the Commission shall have no regulatory jurisdiction over lands or interests therein not actually acquired for the natural-areas system;

(g) to conduct research and investigation and to publish and disseminate information and recommendations pertaining to natural areas and to the system;

(h) to supervise the protection, management, and use of the system and to administer and enforce its policies, rules and regulations;

(i) to investigate, promote, advise, and assist in the preservation, protection, and management of natural areas;

(j) to advise the Departments of Agriculture and Interior and other agencies of the federal government concerning areas or streams eligible for treatment under federal criteria as wildlife refuges, wilderness areas, or wild, scenic, or recreational rivers; and

(k) to submit to the Governor and the General Assembly, and to publish, on or before the first day of December of each year, a report which shall describe and account for the status and condition of each portion of the system and of each natural area listed in the registry of natural areas.

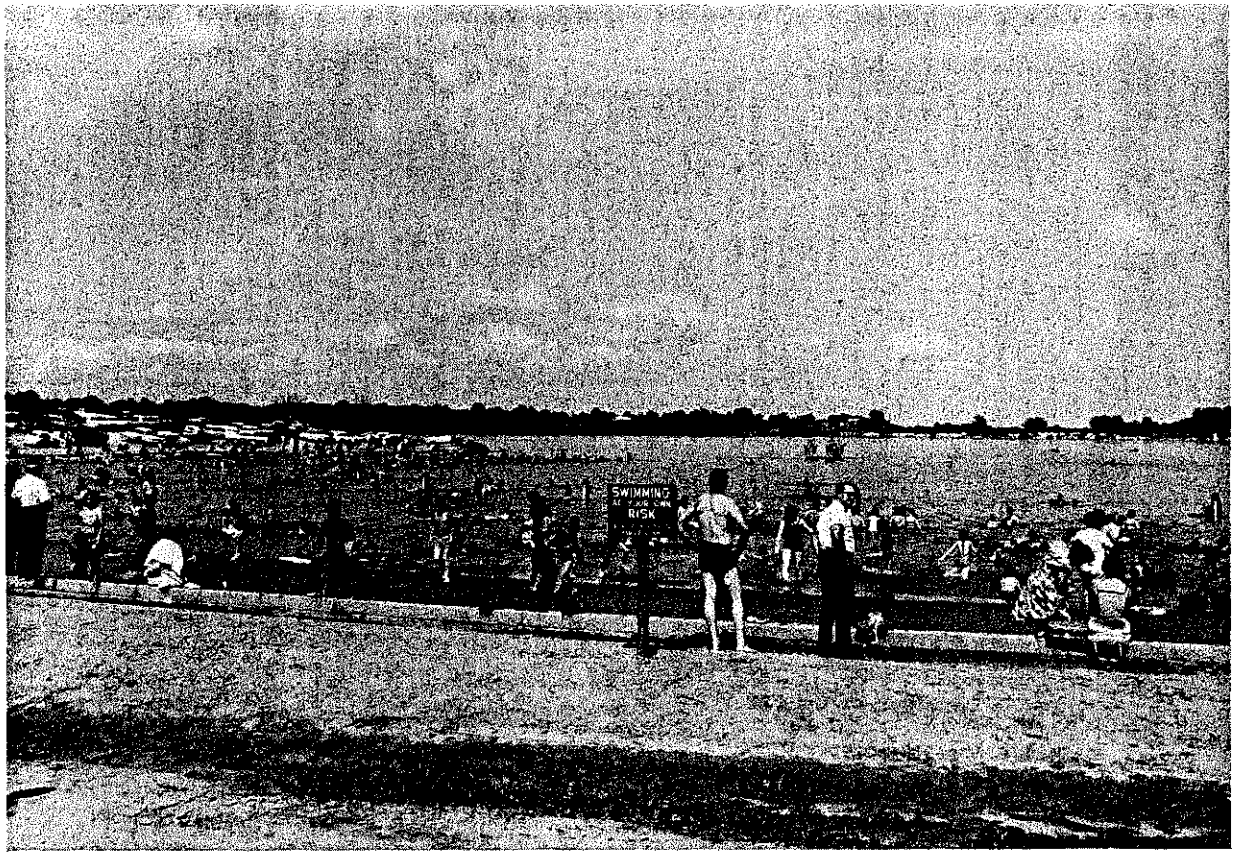
In 1975, the Arkansas General Assembly passed Act 227 which changed the name of the Environmental Preservation Commission to the "Arkansas Natural Heritage Commission," and appropriated funds to staff and operate the commission.

It will be the intention of this organization to operate within the purpose and spirit of these two acts and to closely communicate and cooperate with the Arkansas Natural Heritage Commission regarding any water development projects that would affect Arkansas' natural areas system.

OUTDOOR RECREATION

The tremendous increase in leisure time, affluence, mobility and pressures or urban living has noticeably driven the masses to the outdoors in unprecedented numbers--and the numbers are steadily increasing with time. The supply of outdoor recreation areas, both natural and developed, will probably never again keep pace with this overwhelming demand. It is for this reason that we must remain adroit of the future outdoor recreation needs and the socio-economic conditions that will dictate recreational values, and plan accordingly.

A very large percentage of outdoor recreational activity is water-based in some way, either directly or indirectly. Hunting, fishing, boating, skiing, swimming, canoeing, camping--these are but a few of the recreational activities that revolve around the lakes and streams



LAKE CHARLES IN LAWRENCE COUNTY IS AN IDEAL EXAMPLE OF A MULTI-PURPOSE P. L. 566 RESERVOIR. HERE HUNDREDS OF PEOPLE TAKE ADVANTAGE OF THIS FLOOD CONTROL STRUCTURE FOR ITS WATER-RELATED RECREATIONAL OPPORTUNITIES.

of Arkansas. It is for this reason that future water resource planning in Arkansas should emphasize the multi-purpose aspect when possible, such as taking advantage of flood control and water supply impoundments for their water-related recreation opportunities. An ideal example of such a multi-purpose reservoir is Lake Charles in Lawrence County. This SCS P. O. 566 project provides water-based recreational opportunities to thousands of people in northeast Arkansas, incidental to the flood protection that it was designed for.

The official state plan for outdoor recreation is the Arkansas Statewide Comprehensive Outdoor Recreation Plan (SCORP) published in 1974 by the Arkansas Department of Planning (now the Department of Local Services). The 1974 SCORP is a completely updated analysis of outdoor recreation in Arkansas and was designed to comply with the requirements of the federal Land and Water Conservation Fund Act and the directives set forth by the USDI Bureau of Outdoor Recreation. The major intent was a complete restudy of the 1969 SCORP; to update it and review, reanalyze, and re-evaluate the current outdoor recreation situation in Arkansas. The data from this study forms the foundation for continued planning efforts in the field of outdoor recreation in Arkansas. Basically, the statistical data in SCORP consists of updated demand and supply surveys that were administered to a statistical sample of Arkansas residents, and a comparison of the demand and supply surveys to calculate need. In order to provide a framework for a continuing planning process, the results of these studies were projected into future years on the basis of population growth, structural changes in demand, availability of leisure time, mobility, and other related factors.

It will be the policy of this plan to work within the framework of SCORP for the express purpose of maximizing the use potential of all water development projects.

MITIGATION

The primary points brought forth in the previous sections of this chapter are twofold--first, that we need recreation, and, second, that it is in our best interest to strike a proper balance between development and preservation. How, though, when a drainage project is deemed as absolutely necessary for the protection, growth, and development of an area, are we going to strike a proper balance, relative to the aforementioned, in such an isolated example? It is only logical that both preservation and development, as total concepts, must be managed at the micro, as opposed to the macro level--point being that we certainly can't say let's preserve the eastern half of the country and develop the western. The obvious solution here is mitigation (a word that has become quire popular in recent years, especially since the "Fish and Wildlife Coordination Act" of 1958), meaning in this instance to mollify, soften, or offset the impact of a particular project.

Basically there are three types of mitigation procedures: a) To use extraordinary construction methods and techniques in a development

project that would either provide for wildlife habitat, recreational use, or any other use not incidental to the project in its primary purpose. A good example would be the use of ports in risers of P. L. 566 projects to augment stream flow during low flow periods for the express purpose of improving fish and wildlife habitats. b) To take advantage of environmental changes caused by a project by introducing wildlife or recreation not indigenous to the area previously. A first-rate example would be the federal trout hatcheries installed below the dams on Corps of Engineers reservoirs where the cold water release has made the streams unfit for native fishes. These hatcheries have provided thousands of Arkansas anglers with a type of fishing never before available in the state. c) The purchase of land by the government for preservation purposes. An example here would be the thousands of acres of wetlands the government proposes to purchase to offset the impact of the controversial Cache River-Bayou DeView drainage project. The irony here is that, irregardless of the drainage project, the agricultural economy is forcing this privately-owned land into production at a tremendous rate, which could mean that these mitigation lands will be the bulk of the remaining wetlands in the Arkansas Delta at some point in time.

It is the intent of this plan that for every water development project that adversely affects the environment, there should and will be an extreme effort to reduce and counteract the impact as much as possible. Without a doubt the total mitigation concept will continue to play a very important role in the future development of water resources in Arkansas.

CHAPTER X

ARKANSAS WATER LAW

WATER RIGHTS

We are always in the act of either consuming water or defending against water. We cannot live without it, but uncontrolled, water can destroy us. One man's use or manipulation of water resources can often affect another man's water supply or damage his property, thus giving rise to various conflicts between people or groups of people in our society under the management and use of water resources. Planning, development, conservation, management and use of our water resources must necessarily require due regard and acknowledgment of the legal principles applicable to water resources.

Classification

In order to understand the content of this section of the water plan, it is important to become familiar with the legal classifications of water resources and definitions.

Surface waters are those waters appearing upon the surface of the earth and may appear in various forms:

(1) Lakes, ponds and reservoirs.

(2) Rivers and streams.
   a. Navigable
   b. Non-navigable

(3) Diffused surface waters.

(4) Flood waters.

Groundwaters are subterranean and are recognized in the law as either percolating or waters of underground streams.

Lakes, ponds and other surface reservoirs of water may be located either on or off a stream and may be either man-made or natural.

Rivers and streams are known in the law as watercourses, and in Arkansas, if they are non-navigable, the beds thereof belong to the riparian landowners, whereas the beds of navigable streams belong to the State of Arkansas. Streams which are navigable in fact are determined to be navigable in law. Also, there are several streams in the State of Arkansas which have been declared navigable by act of legislature. In determining whether or not a stream is navigable in fact, the courts look to the types of travel upon the stream, and if it is found to be utilized for commercial traffic, whether it be floating logs or barging goods, it is declared navigable and ownership and control of the bed and surface of the waters between the ordinary high water marks on each side of the stream belongs to the State of Arkansas.

The Arkansas Supreme Court defines a watercourse as follows: "... a running stream of water;....There must be a stream, usually flowing in a particular direction, thought it need not flow continuous. It may sometimes be dry. It must flow in a definite channel, having a bed and banks, and usually discharges itself into some other stream or body of water. It must be something more than mere surface drainage over the entire face of the tract of land occasioned by unusual freshets or other extraordinary causes." Boone vs. Wilson, 125 Ark. 364, 188 S.W. 1160 (1916).

The fact that a slough may intermittently flatten out and the water therein may flow without well defined banks does not destroy its character as a watercourse. Solomon vs. Congleton, 245 Ark. 482, 432 S.W. 2nd, 65 (1965).

The Arkansas Legislature has defined a stream as follows: "'stream' means a stream of water and its channel, including springs, lakes, or marshes in which the stream originates or through which it flows, where the stream flows in a reasonably definite channel; excluding depression, swail, or gulley through which diffused water flows." Act 81 of 1957, Section 2 (b).

The bed of a stream is distinguished by its banks by what is known as the "ordinary high water mark." Act 81 of 1957, as amended by Act 180 of 1969, Section 1.

Diffused surface waters are those waters occurring naturally on the surface of the ground other than in natural channels, lakes or ponds. Act 81 of 1957, as amended by Act 180 of 1969, Section 1.

Flood waters are those waters which escape from or extend outside the beds of lakes, ponds, reservoirs, or watercourses.

USE AND CONSUMPTION

State Constitution

There are no provisions of the state constitution either setting forth the state's policy with respect to its water resources or establishing a doctrine to be followed in the allocation of its water resources among the water users and inhabitants of the state.

Surface Waters

The state's judiciary has adopted and laid down what is recognized as the doctrine of riparian rights governing the use of surface waters and streams. A riparian landowner is one who owns lands bordering a watercourse and as such owns riparian rights to the use of the water

flowing in that watercourse. The nature and extent of his right is clearly defined by such notable cases as Thomas vs. LaCotts, 222 Ark. 171, 257 S.W. 2nd 936 (1953), Harris vs. Brooks, 225 Ark. 436, 283 S.W. 2nd 129, 54 ALR 2nd 1440 (1955), Harrell vs. City of Conway, 224 Ark. 100, 271 S.W. 2nd 924 (1954), and Scott vs. Slaughter, 237 Ark. 394, 373 S.W. 2nd 577 (1963).

According to Harrell vs. City of Conway, Supra., the common law doctrine of riparian rights prevails in Arkansas. Arkansas has no appropriative doctrine, which is a statutory doctrine of water rights prevailing in the western states.

The riparian water right is a vested right. It inheres in the soil and is acquired by the acquisition of riparian land. It is forever diminishing and never increasing, for it attaches only to the riparian land and every time a tract of land is divided by conveyance into two or more pieces, only those pieces of land remaining riparian, continue to carry a riparian water right.

The riparian doctrine contains two theories: (1) the natural flow theory, and (2) the reasonable use theory, and Arkansas recognizes both of these theories. Harrell vs. City of Conway, Supra.

The natural flow theory is subject to the reasonable use theory. The reasonable use theory is stated thusly: every riparian owner "... is entitled to the usual flow of a stream in its natural channel over his land, undiminished in quantity and unimpaired in quality, ..." This right is "... subject to the reasonable use by upper proprietors, and with the right to make any reasonable use of the water necessary for his convenience or pleasure." Meriweather Sand and Gravel Co. vs. State, 181 Ark. 216, 26 S.W. 2nd 57. Thus upper riparian owners may exercise reasonable use of their riparian rights, and lower riparian owners are entitled to the usual flow of a stream subject to the upper riparian's right to reasonable use.

Under the riparian doctrine, the use of the water from a stream is limited to the use to which it can be put on the riparian land. It is incident to ownership of the riparian land, to be used on the riparian land in the watershed of the stream. The watershed of a stream is that area of land which drains into the stream. Therefore, the riparian doctrine is designed to permit only those uses of water which will result in maximum return of water to the stream for which it was taken, thereby maintaining its natural characteristics. This leads us to the conclusion of the Harrell case which held that when a city purchases land abuting on a stream, acquiring the right of a riparian owner, "... it does not thereby acquire the right to divert or take water from the stream for the purpose of selling it to the inhabitants of the city without making compensation to those who are thereby deprived of water rights." Therefore, under Arkansas case law there can be no interbasin transfer of water without payment of damages nor without complying with the law of eminent domain where applicable.

Resolution of Conflicting Lawful Uses of Water

Both the case law in Arkansas and the statutory law provide guides in selecting priorities among conflicting lawful uses of water. As stated in Harris vs. Brooks, Supra and Scott vs. Slaughter, Supra,

"The Right to use water for strictly domestic purposes--such as for household use--is superior to many other uses of water--such as for fishing, recreation, and irrigation."

"All other lawful uses of water are equal."

"Some of the lawful uses of water recognized by this state are: fishing, swimming, recreation, and irrigation."

"When one lawful use of water is destroyed by another lawful use the latter must yield, or it may be enjoined."

"When one lawful use of water interferes with or detracts from another lawful use, then a question arises as to whether under all the facts and circumstances of that particular case, the interfering use shall be declared unreasonable and as such enjoined, or whether a reasonable and equitable adjustment should be made, having due regard to the reasonable rights of each."

In making allocations of water among lawful users thereof the Arkansas Soil and Water Conservation Commission "may consider the use which each person involved is to make of water allocated to that person. In making such allocations of water, reasonable preferences shall be given to different uses in the following order of preference: (i) sustaining life, (ii) maintaining health, and (iii) increasing wealth." Ark. Stats. Anno. Sec. 21-1308. Under the statute a water use for swimming, fishing and recreation is not mentioned. It is suggested, however, that commercial ventures utilizing water for such purposes might fall within category (iii) of the above-quoted statute.

Groundwater

All groundwaters are presumed by the courts to be percolating groundwaters. The term "percolating waters" includes all groundwaters without a definite channel and not shown to be supplied by a definite flowing stream; they seep, ooze, filter, and otherwise find their way through the subsurface strata in a course not discoverable from surface indications without excavations for that purpose.

There are two rules followed by the courts in states which do not appropriate groundwaters: (1) English rule and (2) Reasonable use.

A landowner's right to use percolating waters is governed in Arkansas by what is known as the reasonable use or correlative rights doctrine. Under this test the owner of the surface estate (unless specifically reserved by conveyance) may pump from the groundwaters which are in a reservoir common to other landowners to the full extent of his needs, but if the supply is scant and one well interferes with production from another, the pumping is limited to a reasonable share of available groundwater. Each of the surrounding landowners has a correlative right to the use of the water under his land. There is authority from other jurisdictions, which follow the same doctrine with respect to percolating waters that under the reasonable use test the landowner may make any use of the water he desires on his own surface land (short of malice or waste), even to the point of exhausting the supply.

It would make no difference in Arkansas whether the groundwater could be shown to be flowing in a well defined underground channel, the only requirement being that the water claimant show that the diversion complained of causes his water shortage. He would have to show that the diversion is from his water supply also, whether it be percolating or flowing in an underground stream. The doctrine with respect to groundwaters is similar to the doctrines of riparian and littoral rights.

Although never expressed by the legislature, Arkansas is beginning to take a serious look at its depleting groundwaters. As a whole, the state's policy with regard thereto is one of conservancy. To implement this we need some legislation.

DRAINAGE

In General

Arkansas law affords us many various vehicles whereby groups of people and landowners may organize themselves into a political subdivision of the state--whether it be a drainage district, watershed improvement district, levee district, or any other such district or combination thereof--for the purpose of protecting themselves against unusual flows of water. Individuals also have certain legal rights in protecting themselves against surface waters.

In Arkansas diffused surface waters belong to the landowner upon whose surface they flow or come to rest. His use of these waters is unrestrictive so long as an adjoining landowner is not flooded thereby. This is because these waters are usually unwanted.

The Arkansas Rule with respect to defending against diffused surface waters (Common Enemy Doctrine - modified) is expounded in Duckworth vs. Williams, 238 Ark. 1001 (1965). Landowners are entitled to protect themselves against surface waters unless in doing so they unnecessarily harm the upper landowner. The question of fact remains: What constitutes

"unnecessary harm?" The court apparently looks at the necessity of obstruction, a matter of reasonableness, "not an absolute right."

When by reasonable care and expense the injury could be avoided, such a flooding of neighboring land would be considered unnecessary. It could be argued that an obstruction to capture surface waters on your own land for use which causes flooding of a neighbor's adjoining land would be unnecessary and reasonable harm.

In an urban district the right to defend against surface waters is more absolute. Here the Arkansas Supreme Court has abided by the strict common enemy doctrine. They said in Levy vs. Nash, 87 Ark. 41 (1908), that unless there is an easement across urban, populous property for the purpose of disposing of surplus waters, as a necessary incident to the ownership of such property, and ... "to make it useful for building purposes, the owner has the right to fill it up, elevate it, to ditch it, to construct buildings on it in such a manner as to protect it against the surface water of an adjoining lot...A contrary rule would operate against the advancement and progress of cities and towns and to their injury, and would be against public policy."

The grant of right of way to R. R. Co. does not authorize the company to obstruct the natural drainage of, and to overflow, the adjoining land of the grantor by the unskillful and unnecessary manner of the construction of the road bed. Kelly vs. Kansas City Southern R. Co. 92 Ark. 465 (1909) (Reflects public policy).

Surface Water Principles:

(1) Man has no right to have his surface waters flow onto adjoining land.

(2) Man has right to defend his land against surface water from adjoining land.

  (a) agricultural land - not absolute
  (b) urban land - absolute

(3) For every right there exists a duty with respect thereto.

Drainage Districts

Lee-Phillips Drainage District vs. Beaver Bayou Drainage District. 226 Ark. 105 (1956), concerns surface waters in watercourses rather than strictly diffused surface waters. The upper drainage district had right to allow natural flow of waters from its lands to follow the natural drain into the lower district without obstruction, and lower district had the burden of protecting its landowners from such natural flow of water

from its lands to follow the natural drain into the lower district without obstruction, and lower district had the burden of protecting its landowners from such natural flow of water without damage to landowners in the upper district, but the upper district would be required to furnish additional facilities to dispose of the extra flow of water into lower district as result of proposed improvement in drainage system of upper district. Again reflects public policy.

Upper districts have the right to improve ditches in lower districts to handle increase in flow caused by improvements in the upper district. Since the improvement of a natural drain does not change it to an artificial drain, whatever it costs to dispose of natural drainage from upper district is borne by lower district. Whatever it costs to provide for increased flow over natural flow is borne by upper district.

There are four doctrines followed by the courts in the United States on protection against surface water:

(1) Civil law doctrine (law of natural drainage)

(2) Modified civil law doctrine (reasonable use)

(3) Common enemy doctrine

(4) Modified common enemy doctrine (Ark. Rule)

Floodwaters are either - (1) diffused surface waters which have escaped from a watercourse, or are (2) waters of a watercourse which are outside its well defined banks.

CHAPTER XI

RECOMMENDATIONS

RECOMMENDATIONS

As noted in the preface to this publication, we consider the state water plan to be a viable instrument of management. In view of this concept, we have not attempted to prepare a recommended project type listing. There are two overriding reasons for this decision. Perhaps the most important is the vacilation in rate of progress of implementation of specific projects. Another constraining factor is the lack of information concerning the most desirable solutions to many problem areas of the state. As a guide to planners and sponsors of water resource projects, the Arkansas Soil and Water Conservation Commission has established an order or priority of the type of project that will be given approval under the authority of Act 217 of the General Assembly of 1969. Special circumstances may dictate deviations, but the following listed priorities will be the basis of the Commission's decisions:

1. Municipal and Industrial Water Supply.

2. Flood Control and Drainage.

3. Irrigation.

4. Erosion and Sediment Control.

5. Streambank Stabilization.

6. Recreation and/or Fish and Wildlife.

7. Hydro-electric Power.

8. Navigation.

There are, however, certain categories of interests for which recommendations are made.

1. Municipal and Industrial Requirements.

Projects to provide potable and industrial water should be completed within the time frame projected to preclude the occurrence of personal and economic hardship to the area effected. To accomplish this recommendation will require increased funding by local sponsors, and the state and federal governments.

2. Data Collection and Use.

There is a significant quantity of information concerning the economic and environmental aspects of the state that is not available. This information is vital to the development of a comprehensive delineation of the existing and future water resource plans. Although several federal

agencies have accumulated parts of the total information package, there remain additional items to be obtained, among which are a valid inventory of actual water use by category of use, an inventory of land use, an exact prediction of subsurface water yield, etc. The only means, within the staff available for water research, to catalog and manage this data would be the use of computerized data processing equipment. We have developed such a program; however, the 1975 legislature failed to fund a continuation of the program. Therefore, in order to enable this agency to provide the type of service directed by the controlling statutes, we recommend funding of this phase of our water plan at the earliest possible date.

3. Regional Water Distribution Districts

The regional concept should be utilized to organize water supply services for rural communities and those incorporated towns where the cost of installation would be greater than could be amortized by customers. There is also another factor to be considered--that of availability of good quality water. Many areas in the state do not have a desirable quality of water available at any cost. This statement is especially appropriate in the south central and north western areas of the state.

Another advantage of the regional district is the inability to levy taxes on persons living within the area; yet at the same time, it is a legal entity that can participate in various types of financial arrangements to support its requirements. Activities such as issuance of revenue bonds, cosponsorship by federal, state and local municipal and county subdivisions of state government is authorized.

4. Water Users Associations

Although these organizations may be a useful vehicle in certain instances, such as serving small centers of population by purchasing and distributing water from a nearby regional water district, the lack of versitility of its legal arrangements limit the association's capability to provide services. The recommendation is made to use this specific entity only within parameter cited above.

5. Stream Preservation

Some of the streams in Arkansas possess unique characteristics which can be enjoyed by many of the citizens of the state as a form of recreation. A study has been proposed by the State Department of Local Services to catalogue these streams in relation to the desirable qualities and then attempt to obtain easements or purchases to preserve the selected streams for future retention in existing state.

6. Natural Areas Protection

As part of our responsibility to assist in development of plans for water and related land resources, we recommend that all state agencies

concerned in the matter make a concerted effort to coordinate any planning to develop a master plan for preservation of natural areas. A delineation of potential areas is being made as one item in our Type IV study being accomplished by the USDA (Soil Conservation Service).

7. SCS and Corps of Engineer Flood Prevention Programs

We recommend that a continuing re-evaluation be made of the entire program's requirements. The state-wide needs are constantly changing as urbanization increases and food and fiber production goals are revised. As a result of these revised requirements in land use, water supply, flood control and drainage plans must change.

8. Navigation

In view of the statutory responsibility given this agency to provide water supply sources, any projects envisioning the development of navigation projects should be made a part of this plan.

9. Interstate Compacts

Increased efforts are recommended to develop the administration of the Arkansas/Oklahoma Compact on Arkansas River. This compact will become increasingly important instrument in the protection of the state's water rights as Oklahoma implements their water plan.

The proposed compact with Texas, Oklahoma, and Louisiana on waters of the Red River should be either consummated or negotiations discontinued. Arkansas interests would be served by a compact with Oklahoma and Texas concerning guaranteed releases upstream of our state. We recommend that the U. S. Congress be asked to revise the compact authorization to enable the several states to negotiate sub-compacts between the individual states as required.

The states of Missouri and Mississippi have interstate streams with Arkansas. There is a need to develop compacts with these states concerning water development projects and water use rights. We recommend that action be taken to obtain U. S. Congressional authorization for such compacts.

10. Water Export

Proposals have been discussed to export surplus water from Arkansas to other states. Our evaluation of this proposal is that the removal of excess water from the state during the critical periods of high-flow in the streams would prevent losses due to flooding in many areas of the state. Therefore, we recommend that a study be made to determine feasibility of this proposal.

11. Interbasin Transfer

Under the precepts of the existing water law in the State of Arkansas, the riparian landowners within a river basin also own the water rights. Therefore, transfer of water from the basin of origin is illegal. There

are several instances within the state wherein interbasin transfers are required and are being made. Only water surplus to the needs of the basin of origin is being transferred. As a result, no protests of existing practices have been made. However, we recommend that legislation be enacted to allow interbasin transfer and define the conditions of transfer.

12. Groundwater Withdrawals

In view of the trend to withdraw water from the underground water aquifers at a rate greater than recharge, we recommend the establishment of groundwater conservation districts to regulate the use of, and to protect, the good quality water. These districts would be established as a result of the desires of the people within the district as expressed in a referendum.

13. Land Treatment

As a means to implementing state wide control of sediment pollution, we recommend that persons involved in this work, ask the conservation districts to participate in the program.

14. Recreation and Fish and Wildlife Management

Any water-based recreational project and/or fish/wildlife area to be considered for development should be coordinated with this plan. The primary purpose of this coordination is to ensure that adequate quantities of water can be made available for the desired purpose.

15. Multipurpose Projects

We recommend that all future water resource development projects be multipurpose insofar as possible. The utilization of facilities can be much improved; and unit cost to provide the service can be reduced to the taxpayer.

16. Pollution Prevention

The era of pollution control on all levels of state and federal water resource projects has arrived. We recommend judicious use of potential controls. All aspects of benefits of any activity must be considered before the specific requirements are placed on any pollution deterrents.

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