WATER FOR ILLINOIS

a plan for action

illinois technical advisory committee on water resources

MARCH 1967

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PREPARED FOR THE STATE OF ILLINOIS
OTTO KERNER, GOVERNOR

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March 10, 1967

Honorable Samuel H. Shapiro
President of the Senate

Honorable Ralph T. Smith
Speaker of the House of Representatives

I am pleased to transmit to the 75th General Assembly the report **Water for Illinois, A Plan for Action.**

This report has been prepared during the past year by the State agencies working together through the Technical Advisory Committee on Water Resources. It is the first statewide water plan prepared for Illinois.

This report has my endorsement. I expect shortly to propose specific legislation consistent with the plan and aimed at implementing its recommendations. These proposals for legislation will recommend:

1. The establishment of an Illinois Resource Development Fund in the amount of $1 billion through a public bond issue referendum to be placed before the people of Illinois in 1968. The Resource Development Fund would be established to finance land acquisition and capital improvements to carry out the programs outlined in this report for water resources development, primarily for recreation, pollution control, and water management.

2. The strengthening of the administrative organization of State agencies which deal with water resources planning, development, management, and research by transforming the present Technical Advisory Committee on Water Resources into a State Water Resources Board. The Board should have broad powers for guiding and controlling the development and use of the State's water resources.

3. The appropriation of operating funds by the 75th General Assembly to implement the first stages of this plan.

I recommend that the General Assembly adopt this report as a flexible plan for the long-range development and management of the water resources of Illinois. This report is the foundation for water resources planning to the year 2020, and at the same time is the basis for action in the immediate future—1968 to 1980.

This comprehensive plan establishes the framework for wise management, but its translation into reality will require continued and increased cooperation by government at all levels. Most important, it will require support from the public and the General Assembly.

Sincerely,

Otto Kerner, Governor

To The People of Illinois:

I have asked the General Assembly to adopt this report and to authorize a referendum for a bond issue of **$1** billion for developing and managing the water resources of Illinois. I am confident that the Legislature will take such action and that you, the people of Illinois, will be asked to support the proposed bond issue in 1968. The matter is one for public decision—first by the Legislature, then by the people of Illinois.

I propose this major program in full confidence that the issues involved are of such universal concern that they transcend partisan differences. Management of the water resources in the manner recommended in this plan will benefit all the people of Illinois.

This report, **Water for Illinois, A Plan for Action,** contains a wealth of information from which you can make an objective decision. It recommends an action program—1968 through 1980—but the recommendations are of little value unless the words are translated into the reality of clean streams, water and open space for recreation, safe water supplies, and freedom from destructive floods. This is a comprehensive plan for developing the total resource. For too long we have relied on piecemeal measures to solve our water problems.

A bond issue is the only possible way to establish a capital fund large enough to finance such a comprehensive action program. Part of that program will be for a revolving fund for loans and grants to Illinois communities to finance construction of local facilities.

During the coming months, the broad proposals made here will be further refined and detailed. I ask nonpartisan discussion and consideration of these recommendations. The proposal on the ballot in 1968 must reflect the needs and desires of the entire State.

It is appropriate that the decision on this bold program will be made in 1968—Illinois' sesquicentennial year—as we review the past 150 years with pride and look to the future with confidence.

Otto Kerner
Governor

FOREWORD

Illinois must plan the long-range development of its water resource, if the State is to meet the needs of the future. Illinois must act now to implement the first stages of the plan, if it is to control the resource and manage it wisely. This report is intended as the foundation for an action program to manage and develop the resource—1968 through 2020.

Illinois is participating in a national movement to accelerate water resources development. The recent report of the U. S. Senate Select Committee on National Water Resources and many other authoritative statements establish a clear basis of need for such action. The Water Resources Planning Act of 1965 established a National Water Resources Council, authorized the establishment of Federal-State river basin commissions throughout the nation, and provided financial assistance to the states to strengthen water resources planning. The Federal Water Resources Research Act of 1964 and the Water Quality Act of 1965 make it clear that great attention will continue to be directed nationally to this vital resource.

These Federal acts require that the states assume a larger and more active role in future water resources development in the United States. The State Government must accept its responsibility to guide the development of the resource to its full potential, if Illinois is to retain autonomy in the field.

The need for strong State involvement in water resources planning is also widely recognized by local governments. Water uses, which could once be considered as isolated demands upon the resource, are now impinging upon one another. Treated or untreated waste effluents, which once could be discharged into watercourses with little effect on the quality of the receiving streams, now overtax their dilution or self-purification capabilities. Furthermore, we are adding more wastes at the same time we are demanding that the quality of water in our streams be greatly improved. Our flood problems worsen, despite increasing investments in flood control, which makes it clear that the whole strategy for these programs needs to be re-examined. There is great need to use our water resources for recreation and to enhance and develop them to serve a rapidly-growing population.

Illinois occupies a strategic position in the great inland waterway system of the country. It is important that the State's interests and responsibilities be recognized and navigation facilities be made capable of handling the increasing loads which will be placed upon them by recreational and commercial use.

Our programs of soil and water conservation and of small watershed development are well established, but the task ahead remains large. There is need to examine them to determine whether we are moving fast enough.

For all these reasons, and for others, the State of Illinois must become increasingly involved in water resources planning and must coordinate its existing efforts in this area.

Illinois' water resources are large, but this is no license for indifference toward them. Because the resource is large, our opportunities are great and our responsibilities are heavy to manage it wisely. Planning is surely the first step toward such wise management. The goals of water resources management are to:

1. Insure adequate water supplies for all cities, industries, and rural areas of the State—available in quantity, quality, and when and where needed.

2. Control pollution to make the streams safe, useful, and attractive.

3. Meet the growing needs for water-related recreation.

4. Alleviate the dangers and economic hardships of floods.

5. Complete the task of managing soil and water resources according to sound conservation practices.

6. Improve the waterway system for commercial and recreational navigation.

This is the first statewide report on water resources planning. It was preceded by the report, **Illinois Resources,** published in 1944 as a part of the effort by the Illinois Post War Planning Commission. In 1957 the Commission on Water and Drought Study issued a report to the 70th General Assembly. During the period from 1958 through 1963, the Department of Registration and Education and the University of Illinois published the **Atlas of Illinois Resources,** which included a volume, **Water Resources and Climate.**

In 1966, the Northeastern Illinois Metropolitan Area Planning Commission published **The Water Resource in Northeastern Illinois, Planning Its Use,** which deals with a six-county area in the Chicago Metropolitan Area. Numerous reports have dealt with a particular or related facet of water resources. One is the recent publication, **Outdoor Recreation in Illinois,** prepared by the Departments of Conservation and Business and Economic Development. Many regional river basin and local studies on water resources have been made available by the Waterways Division of the Department of Public Works and Buildings. Numerous reports dealing with the water resource and the means to develop and conserve it are available from the State Water Survey of the Department of Registration and Education.

Water resources planning may be defined as the consideration of alternative uses of the resource to meet future problems and opportunities and to establish priorities for action. Such consideration must begin with a reasonable knowledge of the quality and quantity of our water resources. In this regard Illinois is well equipped because of a long record of study and analysis of the resource. This report contains a concise but complete summary of the available resource, measures of its quality, and an assessment of the means by which it can be developed and conserved for multiple uses.

The problems of water resources development are measured in terms of people—their numbers, location, economic activity, and desires. Water is considered here as a resource that is basic to human life; its development should be for human use.

This report addresses itself particularly to the future dates 1980 and 2020. The year 1980 is so close that necessary action must be identified and implemented immediately. The year 2020 has been used frequently by other agencies as about the most distant one for which meaningful estimates can be made. Estimates of the needs in 2020 also provide important guidance for intermediate action. This study is addressed to and written for those people of Illinois who are involved and concerned with the future of our water resources. It is not intended as a highly technical report.

As the title implies, **Water for Illinois, A Plan for Action** is more a guide than it is a blueprint of specific steps. It is much more nearly the first word on the subject of Illinois water planning than the last. It does provide answers to a number of our most important questions, but it raises many additional questions which will require further study by the people of the State and their agencies of government at all levels.

The report points the way by a series of case studies that illustrate how problems can be solved and our objectives met in each of the areas of concern. The case studies describe, for a city or a region, a successful solution to a problem common to other areas. For example, the case studies of small watershed projects illustrate a means to solve problems of flooding, erosion, and water supply which might be applied in many places in Illinois.

Upon the groundwork laid in this report must be built a more refined analysis—in fact continuous analysis and revision of plans. But such is the nature of planning—to recommend the actions and choices which can now be clearly identified, and to remain flexible and subject to adjustment to changes in technology and public desires which are in the more distant future.

This report has been supported by a grant, Number Ill. P-62(G), under Section 701 of the Federal Housing Act of 1954, as amended, which is now administered by the Department of Housing and Urban Development. The Department of Business and Economic Development, as the official planning agency of the State, contracted and administered this project on behalf of Illinois. Mr. Allan Johnston of that department was project director. The grant provides for planning work in Illinois, including population and economic analysis of a water resources development plan leading to the development of a Comprehensive State Plan, but excluding specific public works. The period of the grant from June 28, 1963, to June 28, 1965, was extended twice by mutual agreement to February 28, 1967. The State agencies participating in the preparation of this report have furnished the matching State effort provided for in the grant. As a part of the total program, the Department of Business and Economic Development also contracted with the University of Illinois for economic studies of income, production, and shipments and for other tasks involving econometric models and analyses. Southern Illinois University was similarly engaged to develop population studies.

This report has been prepared and coordinated by the Technical Advisory Committee on Water Resources, which was established by the 73rd General Assembly. Major contributions were made by the Department of Business and Economic Development, the Department of Conservation, the Department of Mines and Minerals, the Waterways Division of the Department of Public Works and Buildings, the Sanitary Engineering Division of the Department of Public Health, the Division of Soil and Water Conservation of the Department of Agriculture, and the Water Survey and Geological Survey of the Department of Registration and Education. Many Federal, State, and local agencies contributed material and reviewed portions of the report.

Following this Foreword is a summary of the principal findings and recommendations of this study—the plan for action to develop the water resources of Illinois. Each chapter begins with a summary of its contents and closes with a more detailed statement of conclusions and recommendations relating to the subject of the chapter.

This water resources plan is not uniform in terms of its recommendations for programs, legislation, and funding. But in each area, the responsible agencies have gone as far and have been as specific in their conclusions and recommendations as present knowledge and judgment permit.

The report calls for action, but at different levels in different areas. In each chapter, an action program is recommended, be it for study or for development. In certain areas, for example in water resources research, the continuation of strong programs is recommended.

In other areas, acceleration of present studies leading to specific programs is recommended. For example, studies of water supply and use for this plan make it clear that much more detailed research is required in the form of a systems analysis which would produce a flexible design indicating how the natural movement of water should be adjusted by storage and diversion.

In other areas, for example recreation, needs identified over a long period of years and well defined in previous reports make it possible to recommend specific legislation, to give priorities to certain projects for early development, to recommend methods of financing, and to request funds to carry out the program.

The continuing planning and development program needed in Illinois cannot succeed without support from a well-informed public. Hopefully, this report meets the need for facts and considered judgments on which public decisions can be made.

PRINCIPAL FINDINGS AND RECOMMENDATIONS

This water resources plan proposes a major program for management and development of the water resources of Illinois—an immediate action program to meet the most critical needs, 1968 through 1980, and a long-range program which extends to 2020.

The proposed program outlined here in the principal findings and recommendations is a distillation of the detailed assessment of the present resource and the needs and potential for future development contained in the report.

Preparation of this report has brought into sharp focus the need for major effort in recreation, pollution control, and water management. The primary thrust of the action program to 1980 should be in these areas.

ILLINOIS RESOURCE DEVELOPMENT FUND

The needs cannot be met without a new source of funding.

Water-related recreation requires major attention. Illinois is far behind and losing ground in providing public open space and recreational facilities. The State has outstanding opportunities for recreational development if these opportunities are not allowed to be lost. A minimum of $200 million is required for land acquisition and capital expenditures from 1968 through 1980.

Pollution control is both an Illinois and a national goal. To assist local communities and to fully utilize available Federal assistance in constructing sewage treatment works will require State financial participation to the extent of $350 million by 1980.

While flood damages mount annually, a backlog of more than $100 million in needed projects has accumulated. This amount is the minimum needed for flood control projects through 1980.

The need for water supply and low-flow augmentation is or will become critical in certain areas of the State. To finance water management projects, including acquisition of sites and development of multi-purpose reservoirs, construction of local water supply facilities, sewer extensions, and related projects, $350 million will be needed by 1980.

1. It is recommended that the people of the State be asked to approve in a public referendum in 1968 a bond issue in the amount of $1 billion to create an Illinois Resource Development Fund for water resources development and pollution control as outlined in this report. The fund should be used for land acquisition and capital development of basic facilities, as indicated in the following table:

ILLINOIS RESOURCE DEVELOPMENT FUND ACTION PROGRAM—1968 THROUGH 1980

For Water-Related Recreation	$ 200,000,000
For Pollution Control (To Match Federal Grants for Sewage Treatment Works)	350,000,000
For Flood Control	100,000,000
For Water Management (Land Acquisition and Development of Multi-Purpose Reservoirs and Revolving Fund to Finance Local Water Supply Works and Sewer Extensions)	350,000,000
TOTAL	$1,000,000,000

Specific proposals for some of the programs to be financed from the Fund are contained in subsequent recommendations. Assignment of funds to other specific programs should be based upon further detailed analysis of priorities before the public referendum.

The Illinois Resource Development Fund would finance two major programs. The first, a State Projects Program, would be used for major State water resources projects, including land acquisition and development for recreation and construction of water resources facilities. This fund would also be used to finance State participation in Federal projects.

The second, a Local Government Assistance Program, would provide financial assistance to local governmental units for recreation, sewerage, and water supply facilities. This program would administer both grants and loans. Grants would be used chiefly where matching State funds are necessary to obtain the maximum benefit from Federal programs and for comprehensive planning for regional development. Loans would be offered to assist local governments which are unable to finance projects.

WATER RESOURCES BOARD

Illinois has numerous departments and agencies with major responsibilities for planning, development, management, and research on water resources. These agencies have excellent staffs and are well equipped to carry out their responsibilities.

Until recently, there has been no adequate means for communication and coordination among the several agencies. The 73rd General Assembly created the Technical Advisory Committee on Water Resources, the mechanism through which this water resources plan has been accomplished. This experience of working together has identified ways in which further and more effective coordination can be achieved to implement the plans for Illinois water resources.

1. It is recommended that the present Technical Advisory Committee on Water Resources be transformed into a State Water Resources Board to strengthen the governmental structure for water resources development. The Board should have broad statutory powers to guide and coordinate all water resources programs of the State agencies. It should have a small professional staff capable of carrying out the Board's policy decisions. The existing technical functions of the various State departments would be retained, while a significant increase would be realized in the integration of all State water resources management programs through the proposed Board. The Board would be administratively attached to the Department of Business and Economic Development. The Board would administer the Illinois Resource Development Fund.

2. To insure that the best interests of the State are served in the design and construction of Federal projects, including flood control and multi-purpose reservoir projects, it is recommended that the Water Resources Board be designated by statute as the sponsor for non-Federal participation in all Federal projects in water resources and related areas. The Water Resources Board would be the official State liaison agency with the Federal Government on such projects, but the State departments would continue to carry out appropriate technical functions.

COMPREHENSIVE PLANNING AND DEVELOPMENT

Although this water resources plan is divided by subjects into separate chapters, there is no intention that the proposed program of water resources development be so fragmented. To the contrary, coordinated and comprehensive planning and development of the water resources of Illinois is the fundamental tenet of the plan. Preparation of this plan by all the agencies of the State Government concerned with water resources is a demonstration in itself of the cooperative effort that is needed to plan and develop the total resource for many uses.

The programs and activities of the agencies must be mutually supporting in accordance with a comprehensive plan. Insofar as practical, the projects recommended to implement this plan must be multi-purpose in order to develop the resource economically and efficiently. The proposed Water Resources Board can serve as the focus for coordination of comprehensive planning and management and the proposed Illinois Resource Development Fund can supply funds to greatly expand facilities, but this will be insufficient without continued and intensified cooperative effort among all the State agencies and among all levels of government.

1. It is recommended that this plan for action be extended through preparation of more detailed comprehensive plans for resource development which establish priorities for specific projects. These studies should extend and expand the recommendations of this plan as the basis for action—1968 through 1980. The sum of these comprehensive plans would comprise the next step in this water resources plan. The proposed

Water Resources Board would be responsible for coordinating these planning efforts. Further, it is recommended that each State agency involved in water resources development prepare technical studies to implement the findings of this water resources plan as coordinated by the Water Resources Board. Such studies should include detailed cost estimates and, when appropriate, engineering studies preliminary to project design. Because of the magnitude of the task, it may be desirable to engage professional consultants from outside the agencies to prepare some of these studies.

The control of water involves control of its quality and quantity, as well as measures to prevent damage from flooding, erosion, and siltation. The management program for Illinois must build the resource for many uses, as well as prevent its depletion or destruction.

The multi-purpose reservoir that impounds a stream to form a lake which can be used for recreation, water supply, low-flow augmentation, and flood control helps to solve these problems on a regional basis.

1. It is recommended that sites for at least 21 multi-purpose reservoirs be acquired and developed at a cost of approximately $51,650,000. This amount includes the cost of the land for the reservoirs and surrounding recreational areas and for construction of the reservoirs. It is recommended that additional funds be allocated for recreational facilities.

2. It is further recommended that the sites for these reservoirs be reserved at the earliest possible date before they are pre-empted for other uses. The Water Resources Board should commission a detailed analysis and evaluation of the sites identified in this report, including geologic surveys, studies of the needs of the regions surrounding the potential sites, and detailed cost estimates for acquisition and development of the reservoirs. These studies should be incorporated in a statewide plan for reservoir development.

RIVER BASIN PLANNING COMMISSIONS

As at the State level, the responsibility for water resources development at the regional and local level is fragmented and divided among many governmental agencies. There is great need for integrated cooperative planning among these local agencies for development of water resources on a broadened geographic base. Water follows natural drainage patterns and cannot be confined within artificial political boundaries. The hydrologic unit — the river basin — is the logical unit for such intergovernmental planning. River basin planning will require a new mechanism to coordinate planning and to establish policy for multi-purpose development of the resource.

1. It is recommended that the State establish and support regional water resources commissions, organized by river basins. Such commissions would be responsible for planning and overall development of the resource. The river basin planning commissions would be responsible to the State Water Resources Board, and if possible, maintained and serviced by the professional staff of that Board. The regional commissions would coordinate the planning efforts of all the smaller, special purpose legal entities, but these agencies would retain their present autonomy. The urban areas and agricultural areas should both be represented on the commissions.

RESOURCE STUDIES

Illinois has large water resources in its streams, lakes, and reservoirs, and in the ground water. In addition, the border rivers and Lake Michigan are important resources. However, these supplies are not uniformly distributed, either geographically or in time. Much can be done to further enhance the availability of water, and it is recommended that:

1. Illinois maintain a strong program of data collection and research to refine knowledge of the resource.

2. The appropriate State agency conduct a detailed systems analysis of the total water resource and the multiple uses for it to the year 2020. Such an analysis would be an extension of the preliminary balancing of supply and demand by counties made in this report. The analysis would consider resource distribution, availability, quality, and the most economical means of meeting all demands upon the resource

through storage, transfer, and conservation of water.

3. Pursue promising research for the ultimate increase of our water resources through such means as artificial recharge of the ground water, evaporation and transpiration reduction, desalination of brackish waters, and weather modification.

WATER SUPPLY

Future demands for water are highly correlated with population and economic activity. Population is estimated to increase from the present 10.5 million to 13 million in 1980 and 18 million in 2020. The manufacturing value added will rise from $14 billion in 1963 to an estimated $23 billion in 1980.

Water supply for rural, municipal, and industrial requirements, exclusive of power generation and irrigation, will grow from 3.3 billion gallons per day (bgd) in 1965 to 5.0 bgd in 1980 and 6.9 bgd in 2020. Water requirements for power generation are very large, amounting to 13.0 bgd in 1965. Further large increases are projected to reach 31.1 bgd in 1980 and 162.8 bgd in 2020. Such demands clearly will require that some waters of the State be re-used several times.

Water use for irrigation is small but growing. It represents an uncertain but potentially very large future demand, depending upon national policies.

Specific actions recommended for Illinois to meet its future water demands with efficiency are:

1. Increasingly store flood runoff for use during periods of low streamflow and drought and for transfer to deficient areas. By these means the State can meet its needs well into the next century. More than 800 potential reservoir sites have been identified and given preliminary evaluation. As recommended above, some of these should be acquired to insure their future availability.

2. The State should investigate means of establishing interconnected water systems throughout Illinois. A related goal will be to bring centrally-supplied water to all the people of Illinois, where practical. Central systems similar to those for rural electrification would supply water to farms, rural residents, and industries. This would do much to insure safe, dependable supplies to all non-urban residents.

3. Every effort should be made to direct substantial new uses for water into locations where large supplies exist.

4. Universal metering of all municipal and industrial uses is desirable to reduce wastage and serve as a basis for intelligent management.

5. Where needed, loans should be offered to municipalities for construction of water supply facilities from the revolving fund proposed as part of the Illinois Resource Development Fund.

POLLUTION CONTROL

The public desires to improve pollution conditions in Illinois waters beyond standards which were accepted or tolerated in the past. Present stream conditions are being controlled to avoid health hazards; this is achieved in part by restricting certain uses. To make full use of our streams and lakes for recreation and to meet the growing need to re-use water, quality standards must be raised.

Increasing pollutional loads will require secondary treatment of wastes generally, and tertiary treatment in some locations. Effluent disinfection will generally be required. In some parts of the State, notably in the Chicago Metropolitan Area, the maximum degree of treatment technically feasible will be required.

Stream water quality criteria which are in effect or being developed in response to the Federal Water Pollution Control Act of 1965 are based upon a combination of scientific knowledge, experience, and judgment. These must be periodically re-evaluated in the light of changed water use and improved technology.

Pollution control will require drastic action by the State, if objectives are to be met. Annual capital costs for waste treatment facilities to control pollution, which currently are $95,300,000, will increase to $207,500,000 by 1980 and $481,800,000 by 2020. Specifically, it is recommended that:

1. Allocation be made from the proposed Illinois Resource Development Fund of $350 million in

the period through 1980 as the State contribution to finance construction of local waste treatment facilities. Such funds are required on a priority basis to assist local communities in meeting the heavy financial burden which will be required. Such State participation is also required, if Illinois is to maximize the effectiveness of Federal grants authorized in the 1966 Federal pollution control legislation. This legislation provides that Federal grants of 30 percent of project costs can be increased to 55 percent on any project to which the State contributes 25 percent, if approved water quality standards are set and the project is part of a metropolitan area-wide plan.

2. Staff and budget available to the Sanitary Water Board should be sharply increased. The present staff of 54 persons should be increased rapidly to a minimum of 130 persons by 1980. The current annual budget of $518,400 should similarly be increased to a minimum of $1,700,000 by not later than 1980.

3. The State should accelerate its research program related to water pollution to find more complete and less costly methods of waste treatment. Particularly noteworthy are the problems of over-fertilization of lakes and streams and effectiveness of tertiary treatment versus low-flow dilution.

4. As a resource of great value, Lake Michigan should be protected from pollution by every reasonable means.

LAND AND WATER MANAGEMENT

Although much has been accomplished in the area of soil and water conservation, the fact is that during the past 30 years only about one-third of Illinois' farms have been planned for conservation and not all of these are actually being managed according to approved farm plans. The State participates in a Federal soil and water conservation program, and the program nationally is also about one-third completed. Much remains to be done.

The traditional concept of soil and water conservation, being largely limited to erosion and runoff control on farms, is outdated by rapid urbanization. The major shifts in land use in Illinois will be from rural to urban. The State and all its citizens, including those in cities, have a vital stake in soil and water management and should participate in establishing a broad program to conserve and develop this vital resource. The regional river basin planning commissions proposed in this plan should serve as an excellent mechanism for such a coordinated soil and water conservation program involving both urban and rural areas.

1. It is recommended that the State, through its legislative representatives, encourage the acceleration of the national soil and water conservation program. Within Illinois, every effort should be made by local districts to extend conservation practices to all areas of the State. The goal is to plan and manage drainage and land use according to sound conservation practices in urban areas as well as on farms.

2. It is recommended that local soil and water conservation districts participate in the regional planning of the proposed river basin commissions and that these districts be extended to include urban as well as rural areas.

CONTROL OF WATER

Despite the expenditure of more than $125 million in Federal, State, and local funds during the past 30 years, Illinois still suffers approximately $30 million in average annual flood damages. Although there have been a number of devastating floods on major streams, the greater part of the damage is the sum of numerous floods on small streams. More than $100 million for flood control projects has been recommended but not funded.

Solution of the mounting flood problem will require a) an accelerated program for construction of recommended and authorized flood control projects, and b) the enactment and enforcement of regulatory measures to prevent indiscriminate encroachment upon the flood plains.

Flood control projects and regulatory measures should be a part of the multi-purpose development of water resources organized by regional river basins. The proposed Water Resources Board and the river basin planning commissions should make recommendations for the coordination of planning efforts of State agencies and local governments for flood control as part of the comprehensive development planning. Specifically, it is recommended that:

1. During the period 1968 through 1980, $100 million be allocated from the proposed Illinois Resource Development Fund for flood control developments as outlined in this report.

2. To expedite the development of flood-plain regulations for all watersheds of the State, funds be provided from the regular appropriations for a cooperative program to secure flood-plain information.

3. To protect the State's investment in its rivers, floodways, and engineering works, funds be appropriated for maintenance.

4. Funds be provided in the regular budget for the procurement of the requisite aerial photography, surveys, mapping, and economic data to plan river basin development.

NAVIGATION

Illinois occupies a unique position with respect to the inland waterway system of the country, with the Mississippi and Ohio Rivers, the Illinois Waterway, and the St. Lawrence Seaway. This is of great economic importance to the State. These waterways should also be used to a greater extent to meet the increasing demand for water-related recreation.

1. It is recommended that the State maintain a strong, independent competence to judge the needs for proposed new commercial waterways and to improve the existing system.

2. It is recommended that the State develop the waterways for recreational use and particularly press for development of the authorized projects.

WATER-RELATED RECREATION

Illinois has great need to provide water-related recreation for its growing population. The State has a great potential for development of an outstanding system of recreational centers connected by linear parkways. Facilities at present are extremely deficient. Illinois has public open space of only 5.7 acres per 1000 population, the lowest in any state.

The recreational needs and opportunities have been studied in detail as reported in the recent publication, **Outdoor Recreation in Illinois,** and in the present report. It is recommended that an accelerated program be initiated to preserve and develop these land and water resources before they are dissipated by urbanization, pollution, and incompatible land and water uses. Specifically, it is recommended that:

1. An amount of $200 million be allocated from the proposed Illinois Resource Development Fund to finance an accelerated program for water-related recreation during the period 1968 through 1980. This program would include land acquisition and development for a variety of purposes and construction of public facilities.

Specifically, it would provide for acquisition and development of land and water for lakes and surrounding parks and nature areas, including strip-mine lakes and marsh-land, flood-plain, and bottom-land lakes; for development of a fish-rearing unit; for purchase and development of at least five streams; for installing boating and swimming facilities on reservoirs, rivers, and lakes. This program would be particularly aimed at meeting the needs for recreation near metropolitan centers, the areas of the State most deficient in recreational facilities.

LAWS AND GOVERNMENT

The legal principles governing water use and the institutional mechanisms are as important as the physical availability of water. Institutional mechanisms recommended for implementation of this water resources plan are discussed at the beginning of these principal findings and recommendations. In Illinois, the legal framework governing water use is an amalgamation of common law, statutes, case law, opinions of the Attorney General, and regulations issued by numerous Federal, State, and local governmental units.

There has been a minimum of legal controversy because of the abundance of water in the past. Increasing competition and new problems are beginning to emerge which will require new approaches in the future. It is specifically recommended that:

1. Legislation be enacted clarifying the present uncertainty in the use of surplus waters impounded in reservoirs during flood periods. A related consideration is legislation permitting the inter-basin transfer of water.

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illinois technical advisory committee on water resources

"If we could first know where we are, and whither we are tending, we could better judge what to do, and how to do it."

Abraham Lincoln

SUMMARY

The early settlers of Illinois found a land rich in the natural resources of its waters, soils, forests, and minerals. From these resources man has built a vast agricultural and economic system. This chapter provides a description of the major resources of Illinois to serve as the basis for planning the development of the water resources of the State.

Water, which is basic to all human needs, is abundant in Illinois in the mighty rivers and the Great Lakes which border the State, and underground in supplies which are replenished by adequate rainfall. Illinois has more than three times as much water as is presently withdrawn for various uses.

Illinois is a broad prairie plain of fertile soils, with topographic relief chiefly along the major river valleys, especially in the northwestern and southern uplands. Underlying Illinois are rock formations which yield the State's mineral wealth.

Manpower is Illinois' greatest resource, measured by a population of more than 10.5 million which supplies a labor force of more than 4.5 million. Illinois' growing population is centered in its metropolitan areas. These are expanding because of a continuing rural to urban shift. This shift reflects the increase in industrial activity which centers in or near the cities, as well as the mechanization of agriculture which has reduced farm labor demands.

The population of Illinois will continue to grow in a pattern responsive to industrial growth. The 1980 State population is estimated at 13 million and the 2020 population at 18 million. Estimates of future water resources needs are based on these population estimates.

The balanced economy of the State is based on its industry and agriculture, which are served by a vast transportation system. Illinois' wealth is reflected in the highest personal income in the Midwest. The industry of the State is concentrated in metropolitan areas, particularly in Chicago. Industry is diversified and specialized with a skilled labor force and will expand in this pattern. The manufacturing value added will rise from $14 billion in 1963 to an estimated $23 billion in 1980.

Illinois is the agricultural heartland of the nation. Despite its predominantly urban population, about 85 percent of the land is in farms which produce cash-grain crops and livestock. Agriculture, and its related businesses, is the most important segment of the State's economy. The trend to mechanized farms and fewer and larger farms will continue. Illinois and Chicago are the center of a national and international transportation network.

Optimum planning, development, and management of the water resources of Illinois are essential to the full development of human resources, and the efficient development and wise use of natural resources.

INTRODUCTION

A description of the State and analysis of its resources are essential to preparing a water development program for Illinois.

The State's description—its geologic and physiographic characteristics—provides the basis for determining sources of ground water, areas for water storage, requirements for soil and water conservation, existing and potential water-related recreational areas, and numerous other factors related to the sources and development potential of the water resources.

An analysis of the State's resources, both human and natural, provides knowledge relating to the distribution, quantity, and quality needs of the water resource. It also provides a measure of the economic capability of Illinois citizens to more fully develop the resource.

The cultural, social, and economic strength and opportunities for Illinois residents are heavily dependent upon the full development and wise use of water. Without adequate supplies of safe water, urban living in an optimum environment is not possible. Without adequate supplies of water, business and industry cannot prosper. Without adequate water, the use of Illinois' many natural resources is impaired and limited. Without adequate water for navigation, the full development of the State's transportation network is limited, as is the potential for distribution of natural resources and finished goods.

One measure of a State's social and economic strength is the variety, distribution, adequacy, and development of the water resource. In addition, a program for the development of the water resource to meet human needs is indicative of a government responsive to the needs of its citizens, and to its own developmental responsibilities.

STATE DESCRIPTION

The North American Midwest is a region with an exceptional productive capacity. The interiors of few other continents are developed with such large population concentrations supported by significant industry and agriculture.

In contrast to the general pattern, the North American Midwest exhibits an association of natural resources, economic activity, and population that constitutes one of the most completely and effectively occupied continental interiors on earth. Illinois is the heart of this large region. Few states in the United States possess conditions so favorable for economic development.

THE FACE OF ILLINOIS

The State, with the exception of northern and southern Illinois, is a humid, glaciated plain encircled by the rougher terrain of the adjacent states. A variety of soil types have developed, but in the main the combination of deep ground moraines, hardwood forests, and extensive prairies has resulted in soils of outstanding productive capacities.

Most of the surface character of the State is the result of its glacial history. Glacial ice has advanced over most of the Midwest at least a half dozen times. After the last glacial period the land surface was veneered by successive layers of angular clay-size particles of windborne material called loess. The parent material for the present soils probably originated from extensive flood plain deposits of water-worked glacial rock material. The prevailing westerly winds in the Midwest carried large amounts of loess onto the upland surfaces, depositing it without regard to elevation. At present, these extensive deposits vary from several feet deep along the Mississippi River to only a few inches in areas farther downwind to the east. It is primarily upon this physical base that the present soils developed.

The majority of the soils in Illinois may be classified as either prairie or forest soil. The area of prairie soils in Illinois centers in the east-central section of the State. These black soils, rich in organic content and lime, have the capacity to hold great amounts of water for long periods of time. They have gained world renown because of their high productivity and capacity to withstand continuous cropping without serious depletion.

The forest soils—less productive than the prairie soils—are yellow to yellowish grey in color and contain relatively little organic material. They have a slowly permeable subsurface layer which has come to be known as clay pan. This clay pan layer is so impervious to the downward movement of water that, once the shallow top layer of soil is saturated, water stands on the surface or runs off rapidly during seasons of heavy precipitation. The forest soils are located in areas of rough, driftless topography and along the eroded borderlands lying between the upland surfaces and the stream flood plains.

Illinois, then, is essentially a broad prairie plain. The plain extends from east to west across the State, bordered on the north by the Rock River Hill Country and on the south by the Mount Vernon Hill Country and the rugged Shawnee Hills (physiographic map in Figure 1).

Near Lake Michigan the elevation is about 580 feet above sea level. The greatest differences in local relief within the State are near the major valleys, especially in the northwestern and southern uplands. For example, hilltops reach a maximum of 775 feet above adjacent lowlands in Pope County along the Ohio River valley. In most areas, however, local relief is less than 200 feet. The total relief of the State is 937 feet, the difference in elevation between Charles Mound in Jo Daviess County, which is 1235 feet above sea level, and a point at the juncture of the Mississippi and Ohio Rivers, which is only 298 feet above sea level. The mean elevation of Illinois is about 600 feet, lower than any of the other north-central states.

Stream and river systems are also a major factor in determining the surface patterns of Illinois. Their effects are most apparent in the unglaciated areas and on the older glacial deposits of western and southern Illinois. Drainage flows generally toward the southwest, except along the eastern side of the State, where it flows toward the Wabash River.

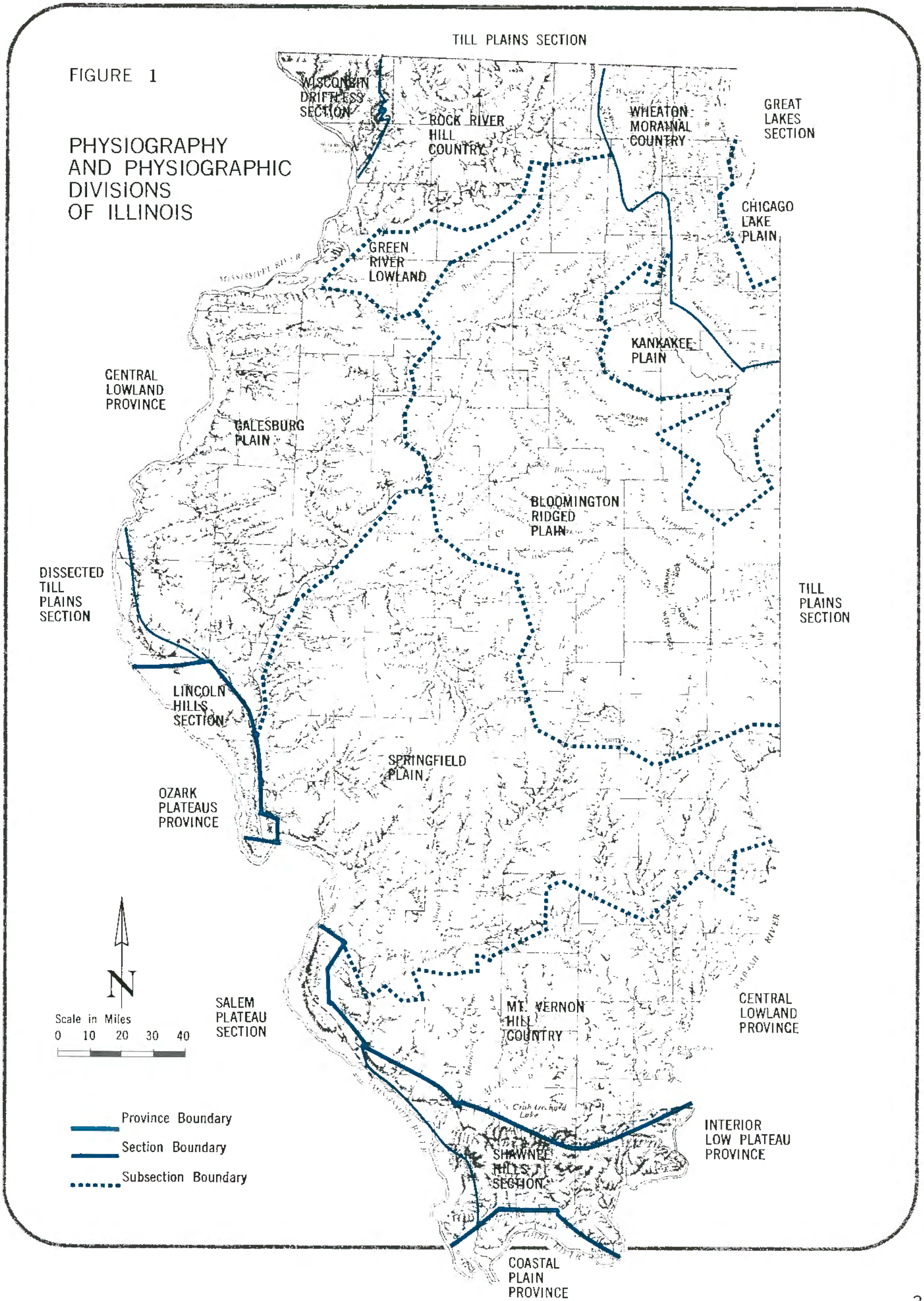
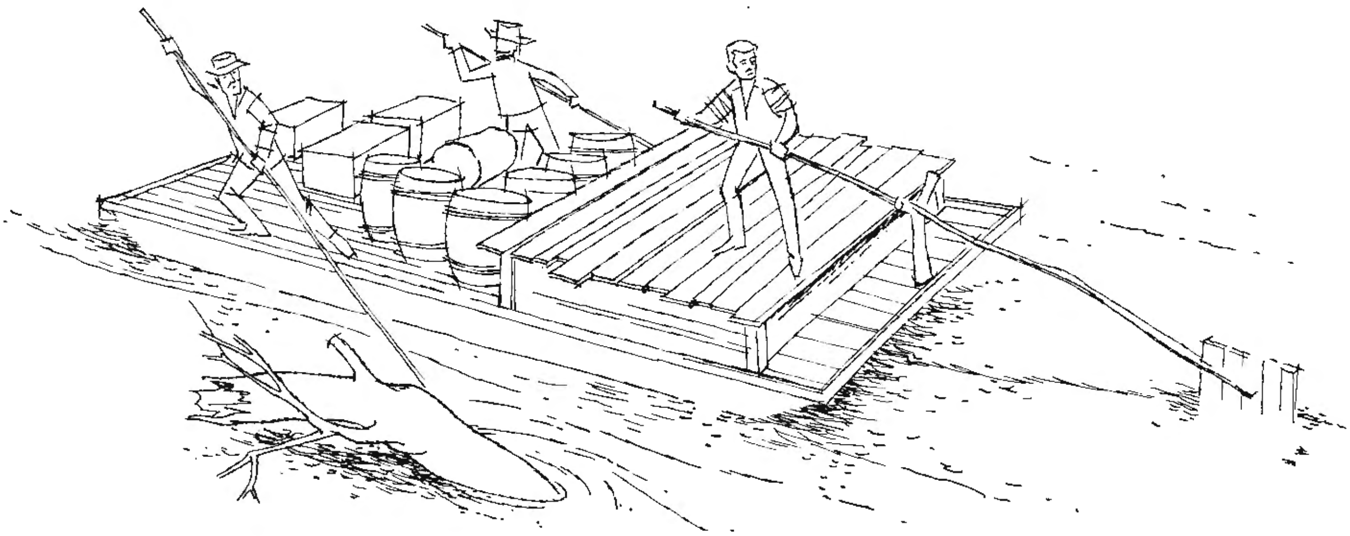


FIGURE 1
PHYSIOGRAPHY
AND PHYSIOGRAPHIC
DIVISIONS
OF ILLINOIS
TILL PLAINS SECTION
WISCONSIN
DRIFTLESS
SECTION
ROCK RIVER
HILL
COUNTRY
WHEATON
MORAINAL
COUNTRY
GREAT
LAKES
SECTION
CHICAGO
LAKE
PLAIN
GREEN
RIVER
LOWLAND
MISSISSIPPI RIVER
KANKAKEE
PLAIN
CENTRAL
LOWLAND
PROVINCE
GALESBURG
PLAIN
BLOOMINGTON
RIDGED
PLAIN
DISSECTED
TILL
PLAINS
SECTION
TILL
PLAINS
SECTION
LINCOLN
HILLS
SECTION
SPRINGFIELD
PLAIN
OZARK
PLATEAUS
PROVINCE
N
Scale in Miles
0 10 20 30 40
SALEM
PLATEAU
SECTION
MT. VERNON
HILL
COUNTRY
CENTRAL
LOWLAND
PROVINCE
WABASH RIVER
Province Boundary
Section Boundary
Subsection Boundary
Crab Orchard Lake
SHAWNEE
HILLS
SECTION
INTERIOR
LOW PLATEAU
PROVINCE
COASTAL
PLAIN
PROVINCE



FROM FRONTIER TO INLAND EMPIRE

Traditionally, empires have developed at seaports and on rivers. Illinois, a thousand miles and more from the sea, has become an inland empire with Chicago a world port to the Atlantic through the St. Lawrence Seaway and river ports to the Gulf of Mexico along the Mississippi.

The waterways were the routes of exploration and transport into the virgin Illinois country. The State's first transportation system was on its rivers, particularly the Mississippi and the Ohio.

The first settlers came along the Ohio River to Illinois. By the early 1800s, the westward movement of the frontier could be seen in villages established one after another along the banks of the Ohio and up its tributaries. Within a dozen years, the migration had extended a hundred miles up the Wabash River. At the time when northern Illinois had only a two-year-old fort called Dearborn, on the present site of Chicago, and the decaying ruins of a French fort at Peoria, much of southeastern Illinois was settled.

The city of Galena was settled in the 1820s to mine the lead ore. Two years later the first paddle wheel steamer reached Galena, and it was soon established as the trading center of the new northwest in the upper Mississippi valley.

In 1848, the Illinois and Michigan Canal was completed to provide a navigable waterway from the Great Lakes to the Mississippi. Large amounts of grain, formerly shipped East via the Illinois River and St. Louis, now went from Chicago through the Great Lakes.

After the Galena and Chicago Union Railroad began successful operation in 1848, the railroad became the dominant influence on settlement and trade. Inland waterway movement gradually diminished.

Settlement did not come early to the Illinois prairie. It may seem strange today that the State's richest lands were the last to be settled. Yet in the early settlement process, timber and easy access to water were the keys to success. The early settlers who came to the Illinois country were from the well drained forested areas of the east and south. They were totally unacquainted with the vast prairie environment. They associated emersed grasslands with malaria, swarms of flies, poor drainage, unplowable sod, and the dreaded prairie fire. Furthermore, with no navigable streams penetrating the big prairie country, access to the interior was difficult. These handicaps prevented settlement until about 1830 when settlers, because of a lack of more suitable land, began to occupy the outer margins of the prairie.

Not until after the Civil War was the prairie brought under large-scale drainage projects. It was possible to drain the surface waters and lower the high water table by digging large open ditches to the streams. Not until such projects had been completed and the tough prairie sod broken could the Grand Prairie of Illinois be put into profitable agricultural production.

Although there have been periods of economic boom and depression that altered land and commodity prices, there emerged very early a clear-cut economy of specialized, highly mechanized, cash-grain agriculture that has dominated the Illinois Grand Prairie down to the present day.

The transformation of the State into an inland industrial empire was just beginning in 1870, primarily because of the new railroads. The railroads were partly the cause and partly the effect which changed hamlets into commercial and industrial cities. Natural resources such as coal and timber, which had been of little significance, became major items of trade.

By 1871, the year of the great fire, Chicago was a transportation center of 300,000, the largest inland city in the country. About 1850, Illinois towns —Chicago, Peoria, and Quincy—began to solve the problems of an urban environment by installing waterworks and sewage systems.

During the period of economic and social readjustment after the Civil War, Illinois industry advanced. The railroad net continued to develop; traffic on the Mississippi declined before railroad competition. Chicago continued to grow and began to solve the land space problem by building some of the first skyscrapers.

Today, located at the crossroads of the world's greatest trading nation, Illinois is one of the country's leading industrial, commercial, agricultural, and exporting states. The Chicago Metropolitan Area is still the industrial giant of the Midwest and the transportation hub of the nation. Illinois is ranked as third largest manufacturing state in the nation. Many of its cities have their own claim to specialized manufacturing. Such a favorable variety of resources for industry, manufacturing, and transportation has made Illinois the second leading exporter of manufactured goods in the United States.

Illinois has a locational advantage for the sale of both consumer and industrial products. The more than 10 million people who live in the State have an annual income exceeding $27 billion. The population center of the nation is located near Centralia, in the south-central portion of the State. Within a 500-mile radius of that center is a population of 54 million, with an annual income of $123 billion.

In addition to an excellent air, rail, and highway transportation network, water transportation is available in Illinois along both of the principal waterway systems of North America, the Great Lakes and the Mississippi Waterway, with its various extensions. The ports of the Chicago area provide ready access to all Great Lakes shipping and, via the St. Lawrence Seaway, to ocean shipping. The Illinois Waterway provides the only direct all-water connection between the two major continental waterway systems. All-season shipping is available from many Illinois communities through the Mississippi River and southern ports for overseas shipment.

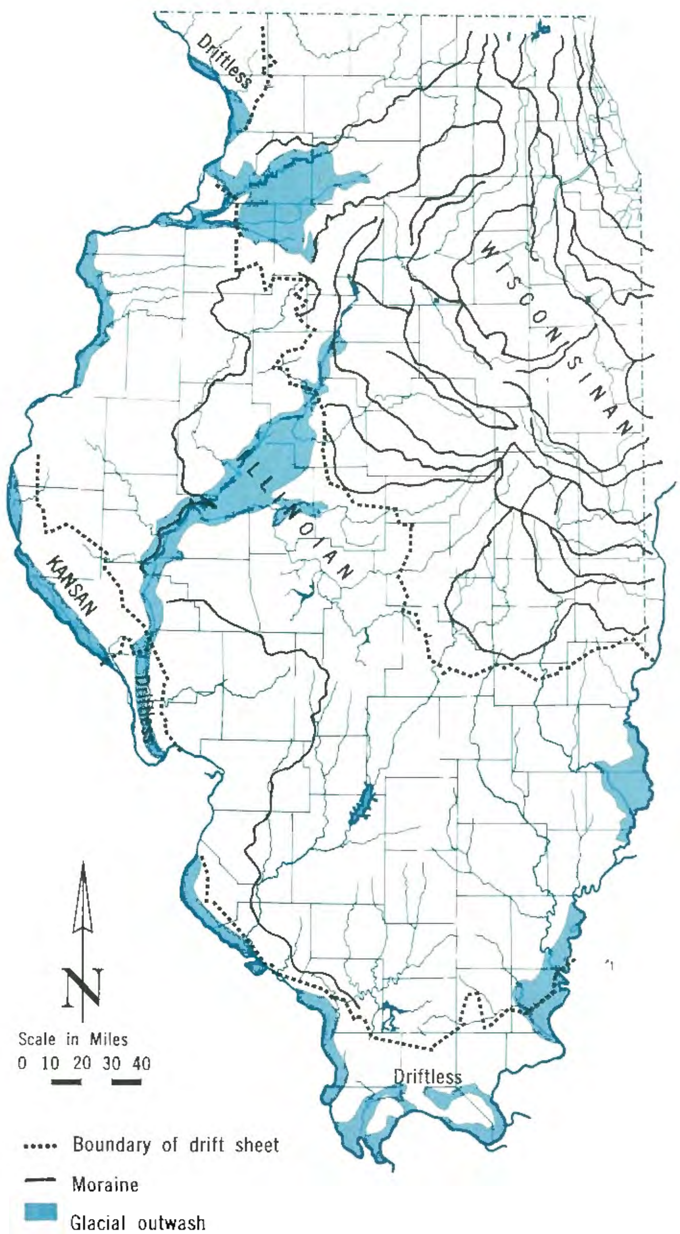
GEOLOGY

The mineral wealth of Illinois results from a long sequence of events recorded in its rocks. The rocks are classified by geologic age and formation.

Granite of the very remote Precambrian geologic age underlies most of Illinois, but it is hidden everywhere by hundreds of feet of younger rocks. These younger rocks, beginning with the Cambrian system, were originally deposited as sediments—sand, clay, shell fragments, or lime mud—in ancient oceans that covered all or parts of Illinois. The sediments were later hardened into firm, layered rocks. During the Pleistocene epoch, beginning some thousands of years ago, the sedimentary rocks were buried under deposits left by the great glaciers that spread outward from Canada over most of the State. These deposits, commonly called drift, were transported by glacial ice and its meltwater, and

FIGURE 2

GLACIAL DEPOSITS



by wind. They are the parent materials for most soils in Illinois.

The glacial history of Illinois, though geologically short, was complex, resulting in a wide variety of glacial deposits and land forms (Figure 2). There were several stages of glacial advances and melting. By the end of the latest stage, the Wisconsinan, most of the land surface of Illinois was underlain by drift from a few feet to more than 500 feet thick. The thickest drift occurs where the glaciers buried old valleys or built moraines. The glacial deposits are valuable today because they provide sand, gravel, and clay for building purposes and are important sources of ground water.

The layered bedrock formations, from tens to hundreds of millions of years old, consist mainly of shales, sandstones, and limestones. They are mined for coal, cement-making materials, crushed stone, marble, agricultural limestone, clay, molding and glass sands, fluorspar, and lead and zinc ores. Some of the sandstones and limestones function as underground reservoirs for ground water, oil, and gas.

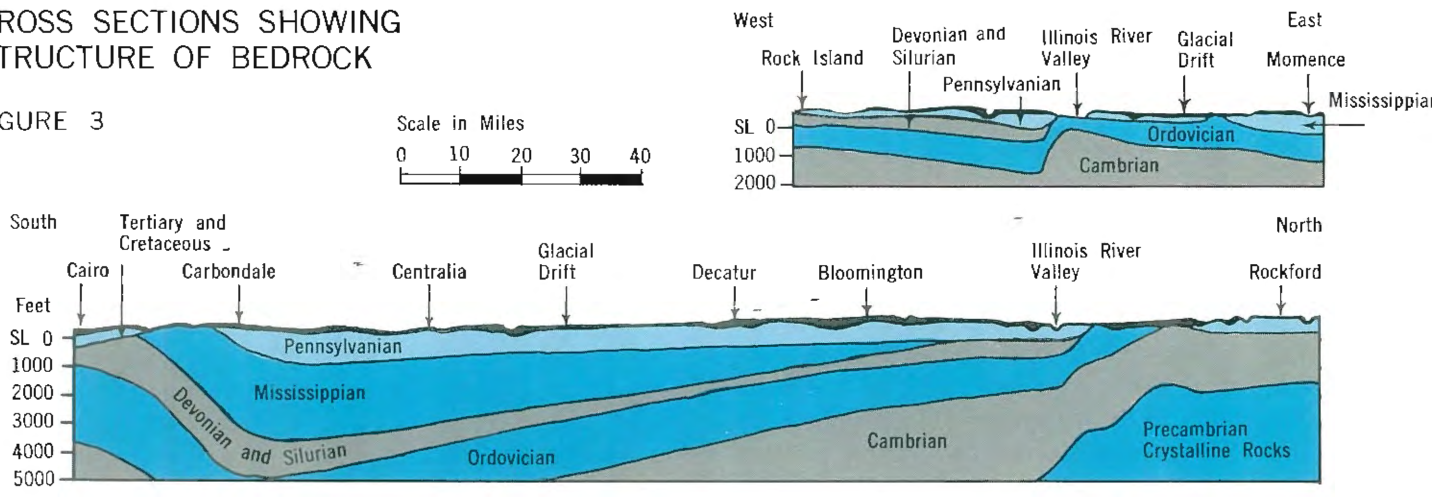
Although the sedimentary rocks of Illinois were originally deposited as relatively flat-lying beds on the sea floor, they have been warped into an oval spoon-shaped depression called the Illinois Basin, the center of which is in southeastern Illinois (Figure 3). Rock layers dip and thicken toward the center. For example, the thickness of the sedimentary rocks in White County is estimated to be more than 12,000 feet; whereas the thickness of the sedimentary rocks beneath the Mississippi valley along the western edge of the Illinois Basin is less than 4000 feet.

Within the Basin are the great coal reserves of the Pennsylvanian-age rocks and, in succession toward the outer edge, the older rocks appear. In the eastern and western parts of the Basin are arch-like structures called the LaSalle Anticlinal Belt and the DuQuoin-Louden Anticlinal Belt. Accumulations of oil along these structures have been of great economic importance to Illinois. In addition, ground-water conditions are profoundly influenced by the LaSalle Anticlinal Belt in northern Illinois.

The bedrock formations have been fractured or faulted as well as folded. Rocks along some extensive faults in southern Illinois have been displaced up to more than 3000 feet. An extensive fault zone of lesser displacement—the Sandwich Fault Zone—occurs in northern Illinois.

CROSS SECTIONS SHOWING STRUCTURE OF BEDROCK

FIGURE 3



CLIMATE

Illinois has a climate favorable to the health and vigor of man and the plants and animals he grows.

The climate of Illinois varies from humid continental, cool summer weather in the north to a humid sub-tropical, warm summer type in the extreme south. Fluctuations in temperature may be great from day to day and week to week. For most of the State, the winter season is predominantly cold, with some snow in most areas. Temperatures below zero are common during the winter months. The summers, on the other hand, are frequently rather hot with temperatures in the mid-eighties in south and central Illinois.

A major asset of the climate is the precipitation, which is well distributed throughout the State and normally adequate for agricultural and water supply requirements. With an average freeze-free period of 160 to 190 days, serious freeze damage to major crops is uncommon. Major droughts are rare, but small-scale droughts which persist for a part of the growing season are common, especially in the southwestern and southern parts of the State.

Storm systems with widespread precipitation move through Illinois most frequently during the winter and spring months. Summer storms cover a smaller area, but the heat and high moisture content of the atmosphere promote intense localized thunderstorm activity, which occasionally is accompanied by hail and windstorms. Tornadoes occasionally inflict damage in localized areas. Variable periods of pleasant, dry weather occur in the fall.

Latitude is the principal control for both temperature and precipitation, with the northern part of the State normally cooler and drier than the south. Mean annual precipitation ranges from 32 inches near Lake Michigan to 46 inches in the Shawnee Hills of southern Illinois. During the warmer half of the year, the precipitation from north to south ranges from 20 to 24 inches; whereas it ranges from 12 to 23 inches in the colder half of the year. The driest month is February, and the wettest month varies from March in the southern region to June in the extreme north.

The contrasts in winter temperatures are relatively strong in Illinois because of its north-south length. The extreme north has frequent snowstorms, and below-zero temperatures are not uncommon. In the extreme south, temperatures drop to zero on an average of approximately one day per winter and snow falls only occasionally. The soil freezes to a depth of about 3 feet in the extreme north, compared with 8 to 12 inches in the extreme south. During summer, the temperature distribution is fairly uniform throughout the State. For example, the north-south range in July mean temperature is only about 8 degrees Fahrenheit.

Summer brings periods of uncomfortably hot and humid weather, especially in the south. In the north, the uncomfortable weather usually persists for only a few days until cool air from Canada arrives, but this cool air does not always penetrate to the southern region of the State. Normally, the hottest month is July and the coldest month is January.

TRANSPORTATION

Illinois, the center of America's vast railway, airway, and highway systems and the junction where the Great Lakes and Inland Waterway shipping meet, can justly claim to be the crossroads of North America.

Illinois has tremendous wealth in her transportation resources. The transportation network in the State has, to a great extent, stimulated the industrial progress Illinois has experienced over the past 50 years. Virtually all economic activity is dependent upon the transportation resources available to the area. Particularly is this true of manufacturing. Few, if any, manufacturers make products from materials that are all available at one place. The raw materials must be transported to the factory, and the finished product distributed to a variety of markets.

Improvements in the Illinois Waterway, completion of the Interstate Highway System, increase in global air traffic through Chicago, and the improved St. Lawrence Seaway will further enhance Illinois' position as a world crossroads.

Few areas in the world are as well served by so many different means of transportation with so dense a network of routes and with such efficiency as is Illinois. The quantitative statistics are impressive. As of 1963, Illinois had 11,005 miles of railroads; 102,339 miles of State, local, and Federal rural roads; 24,719 miles of streets; 35,660 miles of pipelines; and 1,024 miles of inland waterways. Thus, the transportation system totals more than 170,000 route miles, or 3 miles for every square mile of Illinois.

Chicago is the railroad center of the nation. Most major railroads have lines radiating out of Chicago. The major use of rail transportation in Illinois is for intercity freight shipments, although there is also intrastate, interstate, and through rail traffic. Minerals including coal, stone, gravel, and sand are the chief commodities shipped by this means, but agricultural products including corn and soybeans also make up a large percentage of the tonnage.

Illinois ranks fifth among the states in total mileage of roads. The Interstate Highway System in Illinois, much of which is still under construction, links the State with all parts of the country. When this system is completed, Illinois will have almost 1600 miles of interstate highways. State highways connect the interstates to the secondary district and township roads. The secondary roads are generally used for farm to market traffic.

In 1963, vehicles registered in Illinois totaled 4,259,000. The bulk of these, or 3,737,000, were automobiles; the remainder were trucks and busses and publicly owned vehicles.

Distributed around the State are 68 public airports of various types. Chicago's O'Hare International Field, which is the busiest airport in the world, is the most important of these. In 1963 it was used by more than 16 million passengers. Because of this tremendous volume of air traffic, Chicago is the airline center of the United States.

Since the opening of the St. Lawrence Seaway in 1959, Chicago has become an important world port. Ocean going ships can now transport goods from all over the world through the Seaway and the Great Lakes to Chicago and other Great Lakes ports. In turn, products from all parts of the United States can be shipped out of the country via the Seaway. In 1964 the Port of Chicago traffic through the Seaway totaled 4,563,105 tons, inbound and outbound.

From Chicago many commodities are shipped through the Illinois River system to the Mississippi River and southward. Inland waterways freight shipments through the Port of Chicago totaled 14,617,-061 tons in 1964.

Barge traffic is heavy on the Ohio and Illinois Rivers for shipments between various Illinois river towns. Most of the river barge shipments are bulky items, mainly minerals such as coal, oil, and gravel.

The Great Lakes, because of their depth, can carry large tankers and freighters. Winter ice and occasional fluctuation in water levels in the lower lakes cause the only problems limiting Great Lakes transportation. Coal, iron ore, limestone, and wood pulp are the chief products shipped on the Great Lakes.

WATER RESOURCES OF ILLINOIS

Illinois has an abundant supply of water, but the supply is distributed unevenly over the State. The water available is computed to be more than three times the present usage. However, water usage, both domestic and industrial, has increased markedly during the past few years and will continue to do so. Development of the total resource so that adequate, clean, and safe water is available to all the people of the State will require a wise management program. The water resource must be developed for many purposes and its quality protected against pollution.

MID-CONTINENT ISLAND

Illinois is almost an island; in a sense the State is surrounded by fresh water. Along its western border flows the mighty Mississippi and to the south and east are the Ohio and Wabash. Lake Michigan lies to the northeast. This is far from all, for large supplies of water are readily available within the State from the great rivers such as the Rock, the Illinois, and the Kaskaskia, as well as from many smaller streams.

Man has improved or expanded these natural sources of surface water by impounding them in reservoirs which are often used for soil and water conservation and recreation as well as for water supply. Illinois now has more than 900 bodies of water which may be classed as lakes or reservoirs. Several large multi-purpose reservoirs provide excellent water supplies for communities throughout central and southern Illinois. Seven similar water reservoirs are planned or under construction. The natural lakes in the State are found almost exclusively in the extreme north, and are used primarily for recreation.

GROUND WATERS

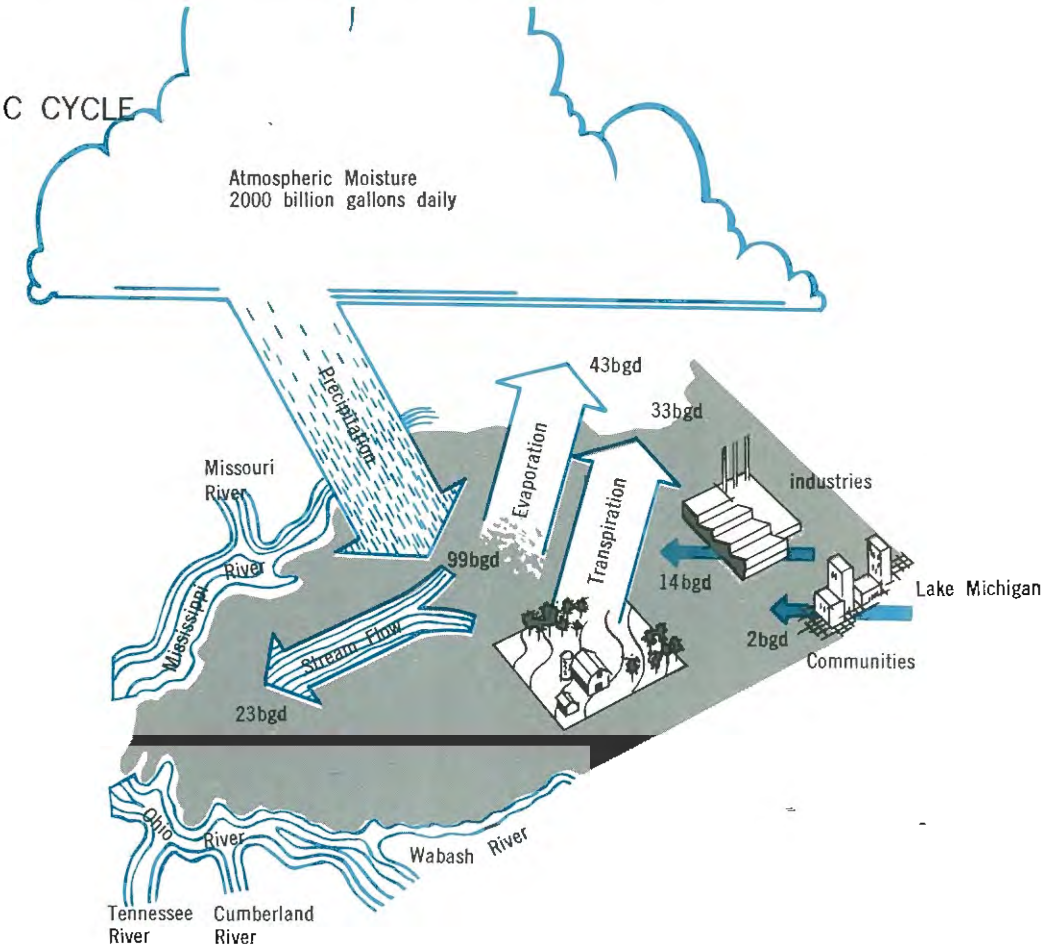
Out of sight, but important as sources of water supply, are the ground waters below the land surface. Aquifers with high water yield, found in deposits of sand and gravel, limestone or sandstone, are distributed in an uneven pattern throughout the State. The northern glaciated part of Illinois has adequate sources of ground water. Except for Chicago which pumps its water from Lake Michigan, municipal supplies in northern Illinois are from ground-water wells. Much of the rest of the State gets its supply from rivers. The deep rock formations of the north become deeper in the south and central portions of the State and eventually yield salt water. In areas west of the Illinois River and in the southern tip of the State, ground-water conditions are generally unfavorable.

Illinois' water resources are as large today as when this area was a wilderness, and so far as modern science can determine, they will be undiminished and constantly renewed by a great inflow of atmospheric moisture or water vapor in the air, which averages 2000 billion gallons per day (bgd) (Figure 4). From this source of moisture, the rather inefficient processes of nature cause only about 5 percent to fall as rain or snow, yet this mere 5 percent averages 99 bgd for the State.

Evaporation from land and water surfaces and the transpiration from growing plants have first call on this water; together they consume and return to the atmosphere about 76 bgd. Some 23 bgd of streamflow, including ground water, is available from within the State, which, when added to the dependable flow of record on the Mississippi and Ohio, as well as the present pumpage and diversion

HYDROLOGIC CYCLE

FIGURE 4



from Lake Michigan, brings the grand total mean daily surface and ground water supplies available to Illinois to 53 bgd. This is an immense amount of water—more than three times the present usage in Illinois and one-sixth of the water usage for all purposes in the entire United States.

PRECIPITATION

Of course, water is not uniformly available either in place, in time, or in quality. Variations in precipitation, and thus in the water resource, are in part due to the great north-south dimension of Illinois. Within the 385 miles of latitude, there is variation in storm tracks and in distance from the primary moisture source in the Gulf of Mexico.

Runoff in the form of streamflow varies by area in much the same pattern as precipitation, and if spread over the State, would vary in depth from about 15 inches per year in the south to 8 inches in the north. The higher runoff in southern Illinois, in conjunction with more rolling or hilly land surface, lends itself well to the development of surface-water impoundments.

As is well known, rainfall and streamflow also vary in time. To an extent, these variations are cyclic with the seasons of the year, but wide deviations from the average trend are more the rule than the exception. In addition to the seasonal and day-to-day changes, there are the occasional extended periods of extreme weather conditions which bring drought and flood. Such periods of record become the subject of intensive study and are important guides to engineering, planning, and design for soil and water conservation and control.

WATER QUALITY

Water also varies widely in quality, and this has been and still is the subject of intensive study in Illinois through the analysis and correlation of thousands of water samples each year. Water does not exist in the chemically pure form of H_2O, but contains dissolved and suspended material from both natural and man-made sources. Also, there is no universally ideal water quality for all purposes. Illinois waters are usually mineralized to a degree, are moderately hard, and may contain iron and various other substances. Two points are important in this regard: information on water quality is available; chemical, physical, and biological treatments can adjust any original element of natural water quality within desirable limits, provided the cost can be justified.

It has been said that Illinois has better records on its water resources than any comparable area in the world. Full and economic development of water resources requires knowledge of more than data on rainfall and streamflow. Even the list of closely related physical factors is long. Topographic and geologic maps determine the location of dam sites, and rate of evaporation and sedimentation influence the design of reservoirs. Data on air temperature and humidity are needed in the design of air conditioning equipment, an important use for water. Recent experience has demonstrated that accurate information concerning water quality is equally important.

USES OF WATER

Present and projected uses of water in Illinois are factors of importance in our water resources knowledge and are subjects of continuing study. Present use of water in Illinois by major user categories is approximately 13 bgd for thermal power stations, 1.4 bgd for other industrial uses, 1.8 bgd for municipal use, and smaller amounts for agricultural uses. These growing uses, which presently total some 16.3 bgd, compare with a potential useful resource of about 53 bgd.

Much water is used on a once-through basis and is not actually consumed. It is taken from the streams, rivers, and from the ground and much of it is returned. The condition of the water returned is of increasing concern. An important function of the rivers and streams is to carry away wastes, but pollution, from normal domestic and industrial use, and from misuse, is a major problem in the State.

The streams and rivers and lakes of Illinois are increasingly used for recreation. The water must be clean, safe, and pleasant for swimming and boating, and to support fish life. The recreational use of the waters of the State requires a revised standard of sanitary treatment.

If the demand for recreation is to be met, Illinois must make full use of its waters. Waterways should be opened to public access through surrounding parklands. Existing and new lakes and reservoirs must be expanded and developed with new recreational facilities.

THE ECONOMY OF ILLINOIS

A well balanced combination of agriculture, manufacturing, service industries, business, and transportation gives Illinois a strong, stable economy that is integrated into the national economy.

The Illinois economy has grown more rapidly than its population, which indicates significant productivity gains in industry and agriculture.

Illinois is a leading export state, ranking first in total value of export goods, first in agricultural exports, and second in export of manufactured goods. Among the major products exported from Illinois in terms of value are machinery, food and food products, and transportation equipment. As the greatest storehouse for the nation's products, Illinois has outstanding warehouses for grain, cold storage, natural gas, steel, and other commodities. In addition to an excellent rail, air, and highway transportation network, Illinois has water transportation on both of the principal waterway systems of North America—the Great Lakes and the Mississippi.

AGRICULTURE

Illinois is a leading producer of farm products. Although the Illinois population is predominantly urban, more than 30 million acres, or about 85 percent of the land area is in farms. Most of the State is a relatively level plain of productive soils. Illinois farms primarily produce cash-grain crops and livestock products. A number of farm products are used as raw materials for manufacturing and processing industries. The annual, recurring production and distribution process and the related agricultural and food business are the most important segment of the State's economy.

Feed and oilseed crop production is the foundation of Illinois agriculture. High quality soils coupled with a long growing season and ample, well-distributed rainfall provide an excellent environment for field crop production. While corn and soybeans are the most important crops, wheat, oats, seed, and hay and pasture crops are also important to the farm economy.

Most of the corn is grown as feed for livestock. Swine, beef cattle, and dairy herds are the predominant livestock enterprises, with poultry and sheep important on some farms. Because of the abundant feed supply and the central location of the State, large numbers of feeder cattle and sheep are shipped into Illinois for fattening. Emphasis on production of specialized crops with high yields per acre has increased the feed supply for the expanding livestock industry.

Several significant changes in Illinois agriculture have affected the economy of the State. Increased mechanization of many farm processes has caused a pronounced increase in the size of farms and a corresponding decrease in the number of farms during the last 40 years. Generally, the large farms are in cash-grain and livestock producing localities. The remaining smaller farms are in the less productive areas and around the larger cities.

The mechanization of processes has reduced the number of farm owners and farm workers. During the last 40 years, more than 750,000 people have migrated from farming to other jobs, often in businesses related to agriculture.

Increased crop yields from high-producing plants have reduced the number of acres of land in crop production. This is evident in areas near large metropolitan centers, where urban expansion and highway development have taken over much of the farmland. Cook County has had a 35 percent decrease in farmland during the last few years.

Federal farm programs designed to reduce production of certain surplus farm products, in order to bring a better price to the farmer, have also reduced the number of acres in production. The decrease in acres planted, however, has been largely offset by increasing technical ability concerning more productive plants, use of fertilizers, and more efficient machinery.

The steadily increasing population with a higher demand for food and food products would normally require a greater land area. This has not been true because of increased efficiency in production methods, which have in turn increased the value of the average farm.

If the present trend continues, an increasing proportion of the farm labor force will be released from farm work to move to other employment. The increase in farm income, and the attraction of rural and suburban living which draws people out of the cities, will continue to make the social and economic differences between farm and non-farm people less distinct.

In spite of the constant change, there is stability in the basic pattern of Illinois agricultural production and in the relationships among geographic regions of the State. The general trends are expected to continue. Farms will continue to get larger and farm labor will increasingly be supplied by the operator and members of his family. With its natural resources and locational advantages, Illinois is likely to intensify efforts to produce feed crops. Expansion of the already well-established livestock industry is expected with a growing population and increased emphasis on meat in the diet.

MINERALS

Although Illinois is not normally thought of as a mining state, it ranked eighth in mineral production in 1965. The value of mineral production has exceeded $600 million each year for the past decade and was $618.5 million in 1965. Minerals and mineral products produced in Illinois include coal, crude oil, stone, cement, clay products, sand, gravel, silica sand, fluorspar, zinc, lead, natural gas, tripoli (amorphous silica), lime, natural bonded molding sand, and ganister. The mineral fuels, coal and petroleum, are the leading products, accounting for more than 65 percent of the total value produced in the State. Coal regained the top position in 1964 after having been second to oil since 1954. Table 1 gives mineral production, value, and major producing counties for the State for 1965.

Illinois has the largest known reserves of bituminous coal in the nation. It has been estimated that the State has more than 140 billion tons of coal in the ground in beds more than 28 inches thick. Around the edge of the Illinois Basin, where the coal lies at shallow depths, it is mined by stripping. Coal in the ground that is defined as strippable is estimated to be in excess of 20 billion tons. In 1965, there were 97 mines (both underground and strip) operating in 29 counties that reported production. Strip mining of coal took place in 19 counties and accounted for about 56 percent of the total coal mined within the State during the year. Coal-burning electric generating plants are the single largest consumer of Illinois coal.

The State's major petroleum producing area is the deep part of the Illinois Basin in the south-central and southeastern parts of the State, but significant production has also come from central and western Illinois. There are presently about 400 producing oil fields (or pools) in the State. In 1965, Illinois produced 63.7 million barrels of oil worth $186.7 million and ranked eighth in the United States in crude oil production. Although production came from 41 counties, the top four counties accounted for slightly more than 50 percent of the total.

Illinois is the second largest producer of crushed and broken limestone and dolomite in the nation, ranking after Pennsylvania. In 1965, the State's commercial quarry operators produced a reported 43.3 million tons, which was valued at $57.8 million. Although 60 counties reported production of stone, the top three—Cook, St. Clair, and Kankakee—accounted for 41 percent of the total.

In terms of dollar value produced, cement is the fifth largest mineral industry in the State. The four plants, located in LaSalle, Lee, and Massac Counties, produced $30.6 million worth of Portland cement and $1.9 million worth of masonry cement.

Illinois has a sizeable and widespread clay products industry. Forty-eight plants located in 25 counties reported operation in 1965. These plants produced pottery, stoneware, drain tile, sewer pipe, building tile, face and common brick, special heat-resistant brick, and processed clay for absorbent uses. The total value of clay products manufactured in Illinois in 1965 was $52.5 million.

In 1965, sand production in Illinois totaled 13.4 million tons worth $11.4 million; gravel production was 18.2 million tons worth $16.5 million. The Metropolitan Chicago Area was the largest producing region, accounting for more than half of the State totals. Consumption is tied closely to construction, and thus to population centers. The leading sand and gravel producing counties in 1965 were McHenry and Will.

Illinois is one of the leading producers of high-quality silica sand in the United States. Production of this commodity is concentrated in LaSalle County, with lesser production from Ogle County. The most important use for this sand, accounting for about half of the consumption, is in the manufacture of glass. In 1965, the State produced 3.6 million tons of silica sand worth $12 million.

For many years Illinois has led the nation in the production of fluorspar, accounting for 66.1 percent of the domestic shipments in 1965. The fluorspar district is centered in Hardin County, with smaller deposits in Pope County. Illinois producers shipped a total of 159,140 tons of finished fluorspar in 1965, and it had an average value of $49.40 per ton, f.o.b. the mine.

Lead and zinc concentrates are produced as primary products from metal mines in Jo Daviess County in northwestern Illinois and as co-products from the fluorspar mines of extreme southeastern Illinois. In 1965, the State's mines produced 18,314 tons of zinc valued at $5.4 million, and 3005 tons of lead valued at $940,000.

In addition to the minerals and mineral products mentioned above, Illinois produced several other commodities. Tripoli (amorphous silica) was produced in Alexander County; lime was produced at plants located in Adams and Cook Counties; natural bonded molding sand was produced from pits in Henry, Fayette, and Rock Island Counties; and some natural gas was produced at various places in downstate Illinois.

TABLE 1 SUMMARY OF ILLINOIS MINERAL PRODUCTION FOR 1965

Material	Unit	1965[2] Quantity	Value at plants Total	Average	Leading Producing Counties
Coal — Bituminous	tons	58,232,480	$217,789,475	$ 3.74	Fulton, Williamson, Perry
Crude Oil	bbls	63,708,000	186,664,440	2.93	Fayette, Marion, Lawrence
Limestone and Dolomite	tons	43,293,426	57,805,266	1.34	Cook, St. Clair, Kankakee
Cement — Portland 376 lb.	bbls	9,358,412	30,621,967	3.27	LaSalle, Lee, Massac
Cement — Masonry 280 lb.	bbls	615,276	1,906,897	3.10	
Clay Products	—	——	52,459,500	—	LaSalle, Cook, McDonough
Sand	tons	13,424,000	11,356,000	0.85	McHenry, Will, Winnebago
Gravel	tons	18,194,000	16,508,000	0.91	McHenry, Kane, Will
Silica Sand	tons	3,631,000	11,991,000	3.30	LaSalle, Ogle
Fluorspar	tons	159,140	7,861,165	49.40	Hardin, Pope
Zinc	tons	18,314	5,347,688	292.00	Hardin, Jo Daviess, Pope
Lead	tons	3,005	937,560	312.00	Hardin, Pope, Jo Daviess
Other Materials[3]	—	——	17,251,042	—	
Total Value			$618,500,000		

[1] Table based on figures from the U.S. Bureau of Mines, the Illinois State Department of Mines and Minerals, and the Illinois State Geological Survey.

[2] Subject to revision.

[3] Includes natural gas, lime, tripoli, natural bonded molding sand, and sandstone.

MANUFACTURING

Illinois is the third largest manufacturing state in the nation. Chicago is the center of manufacturing, but many Illinois cities have important specialized industries. Moline has the largest steel-plow factory in the world; LaSalle is noted for sand and gravel production; Decatur is the soybean capital of America; Danville is the largest brick manufacturer in the nation; Rock Island has the largest manufacturing arsenal in America; Peoria manufactures heavy equipment; Springfield is known for its electronic and heavy equipment industry; and downstate, mineral production of coal and fluorspar is important.

The diversification of industry in Illinois, which is not only extremely broad but applies to many classes of industry, is one of its prime attributes. Diversification is accompanied by a degree of specialization that is equalled in few other areas of the country. This is especially true in the printing, petroleum, refining, chemicals, electric and non-electric machinery, and scientific instruments industries.

Value added by manufacturing for recent years gives some indication of the magnitude and growth of manufacturing in Illinois. In 1958 value added exceeded $11 billion; in 1963 the value added exceeded $14 billion. The preliminary estimate for 1980 indicates a value added figure in excess of $23 billion. Estimates for 1980 by county are shown in Table 2.

TABLE 2 MANUFACTURING VALUE ADDED

County	1963*	1980	County	1963*	1980	County	1963*	1980
Adams	125.1	156.9	Hardin	N.A.	.2	Morgan	27.2	37.6
Alexander	2.7	7.6	Henderson	.4*	1.3	Moultrie	7.6	14.2
Bond	10.7	10.6	Henry	20.4	36.6	Ogle	53.8	91.2
Boone	23.9	38.9	Iroquois	16.7	29.3	Peoria	266.3	331.7
Brown	.3*	.2	Jackson	11.9	34.1	Perry	11.5	30.3
Bureau	23.2	48.9	Jasper	4.3	8.7	Piatt	10.2	12.2
Calhoun	.2*	.2	Jefferson	10.1	21.5	Pike	4.3	9.1
Carroll	4.6	11.8	Jersey	2.1*	3.1	Pope	N.A.	.2
Cass	3.0	8.8	Jo Daviess	3.6	16.0	Pulaski	1.6	4.6
Champaign	41.6	84.8	Johnson	.4*	1.5	Putnam	N.A.	52.4
Christian	15.4	24.7	Kane	349.4	631.0	Randolph	20.5	42.5
Clark	4.8*	15.3	Kankakee	180.8	248.5	Richland	10.7	22.7
Clay	6.5	13.7	Kendall	52.2	101.9	Rock Island	280.5	400.0
Clinton	13.5	19.1	Knox	63.7	131.3	St. Clair	236.4	290.5
Coles	44.2	58.1	Lake	436.0	644.4	Saline	2.7	7.4
Cook	8,942.2	14,257.4	LaSalle	203.8	366.8	Sangamon	118.2	202.3
Crawford	29.9	29.5	Lawrence	6.9*	14.0	Schuyler	2.0*	3.6
Cumberland	1.6	6.9	Lee	28.8	36.9	Scott	.4*	1.4
DeKalb	90.5	148.6	Livingston	20.9	27.2	Shelby	5.9	13.2
DeWitt	7.9	12.0	Logan	43.3	45.5	Stark	2.4	3.2
Douglas	18.9*	31.1	McDonough	12.9	24.6	Stephenson	77.1	147.9
DuPage	152.2	327.0	McHenry	114.9	264.3	Tazewell	315.1	402.2
Edgar	13.6	29.8	McLean	68.1	97.7	Union	6.2	11.2
Edwards	2.2	3.7	Macon	201.1	282.9	Vermilion	151.2	230.2
Effingham	10.0	25.7	Macoupin	7.6	13.5	Wabash	8.4	18.5
Fayette	5.4	19.4	Madison	457.6	597.6	Warren	4.2	14.2
Ford	8.2*	18.3	Marion	13.3	31.0	Washington	3.6*	7.9
Franklin	5.4	12.8	Marshall	5.5	11.1	Wayne	11.0*	11.6
Fulton	31.8	43.3	Mason	2.6*	7.9	White	2.7	9.4
Gallatin	.5*	2.7	Massac	8.7*	11.4	Whiteside	110.5	179.8
Greene	3.5	10.6	Menard	1.4*	3.4	Will	230.6	344.7
Grundy	21.6	39.7	Mercer	.2*	4.2	Williamson	31.5	56.1
Hamilton	1.9	6.6	Monroe	1.2*	1.5	Winnebago	464.1	743.5
Hancock	3.6	9.0	Montgomery	16.2	36.6	Woodford	5.3	8.7
						Total	14,557.1	23,077.4

N.A. — Not available

Numbers are in millions of constant 1963 dollars.

* 1963 county value-added estimates do not sum to the State total. Value-added figures are deleted for certain counties in order to meet non-disclosure regulations of the State and Federal governments.

Value added is an important measure of industrial water requirements. At present, 16 billion gallons of water a day is withdrawn from Illinois water sources; 14 billion gallons per day is used by industry. This extremely high withdrawal rate for industrial water indicates the importance of estimates to 1980. The estimates for 1980 industrial water requirements in this water resources plan are based upon the value added data and upon present and anticipated use of water by certain industries in various areas, developed by the Illinois State Water Survey.

The types of manufacturing in the metropolitan areas of the State illustrate the diversity of the State's economy. The Chicago area is the graphic arts center of the United States and also a center for the electronic industry. The Chicago area produces basic steel, steel products, bakery products, beverages, textiles, paper mill products, industrial chemicals and has a large meat packing industry.

The Rockford area is the machine tool center of the Midwest. It is also a metal working center. Major automobile and tire manufacturing plants are located at Belvidere. The Quad-Cities area is a center for the manufacturing of farm machinery.

In the Peoria area, farm machinery production, grain milling, and the making of beverages are major industrial enterprises.

The Springfield area has major farm machinery, grain milling, and electronic industries. In the Champaign-Urbana area, electronics is a major undertaking as well as the hydrogenation of vegetable oils.

In the Decatur area, grain milling, metal working, and the manufacture of automobile tires are substantial enterprises. In the East St. Louis area, steel, steel products, oil refining, and meat packing are major industrial activities.

THE LABOR FORCE

The Illinois labor force totals 4,595,000. The proportion of the total population in the labor force in Illinois is higher than that for the nation. Sixty percent of the population 14 years or older is in the State's labor force, compared with 58 percent for the nation.

The distribution of employment has shifted in recent years among industry groups and among areas. The greatest employment gain has been in non-manufacturing industries other than agriculture. This reflects the primary shift from farming, which brought about a 28 percent reduction in farm employment from 1950 to 1960. During that period, employment in manufacturing increased at a lesser rate than in previous years. Because of change in productivity, new jobs barely matched displacements, but recent trends indicate that manufacturing employment will increase at a higher rate in the future.

Table 3 shows the anticipated increase in industrial employment for the period from 1963 to

TABLE 3
MANUFACTURING EMPLOYMENT BY MAJOR INDUSTRY

Estimated for 1963 and 1980

Industry	1963	1980
Ordnance	N.A.	2,600
Food and Kindred Products	115,439	113,100
Tobacco	N.A.	300
Textiles	6,949	5,100
Apparel	40,203	29,900
Lumber and Wood Products	11,105	10,600
Furniture and Fixtures	23,539	24,100
Paper and Allied Products	36,735	45,200
Printing and Publishing	95,658	117,900
Chemicals	47,519	71,200
Petroleum Refining	11,356	10,600
Rubber and Miscellaneous	28,700	48,100
Leather and Leather Goods	16,112	12,900
Stone, Clay, and Glass	38,130	47,600
Primary Metals	96,981	99,800
Fabricated Metal Products	123,177	146,700
Non-electrical Machinery	177,302	193,800
Electrical Machinery	167,132	214,000
Transportation Equipment	40,614	23,500
Instruments	36,963	65,500
Miscellaneous Manufacturing	36,468	36,800
Total	1,150,082	1,319,300

N.A. — Not available

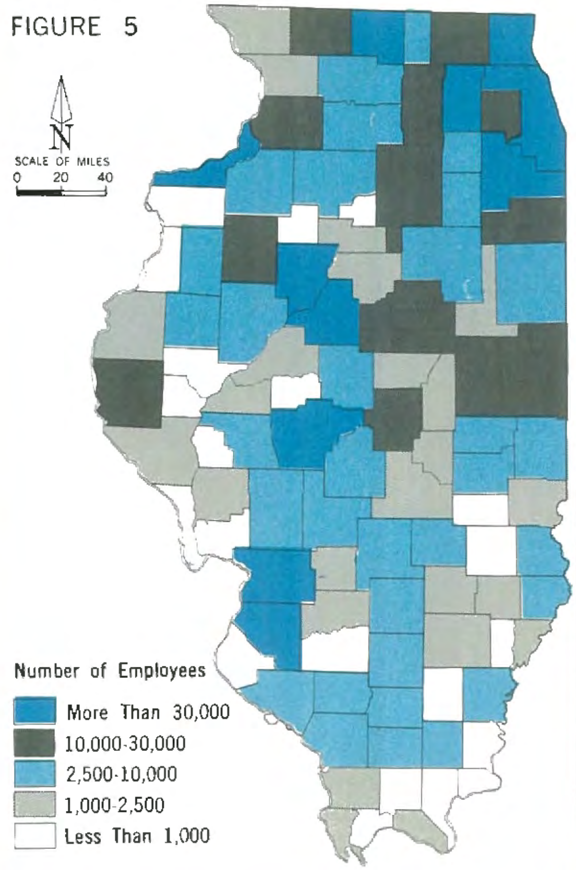
1980. According to the 1963 Census of Manufacturers, 1,150,082 people were employed in manufacturing, 81 percent of them in metropolitan areas located on Illinois' waterways. The Chicago area had 71 percent of the total industrial employment; 10 percent was distributed among Peoria, East St. Louis, and the Rock Island-Moline area. The other metropolitan areas of Rockford, Springfield, Decatur, and Champaign-Urbana accounted for 6 percent of the industrial employment, while the remaining 13 percent was distributed throughout other areas of the State. The distribution of employment is shown in Figure 5.

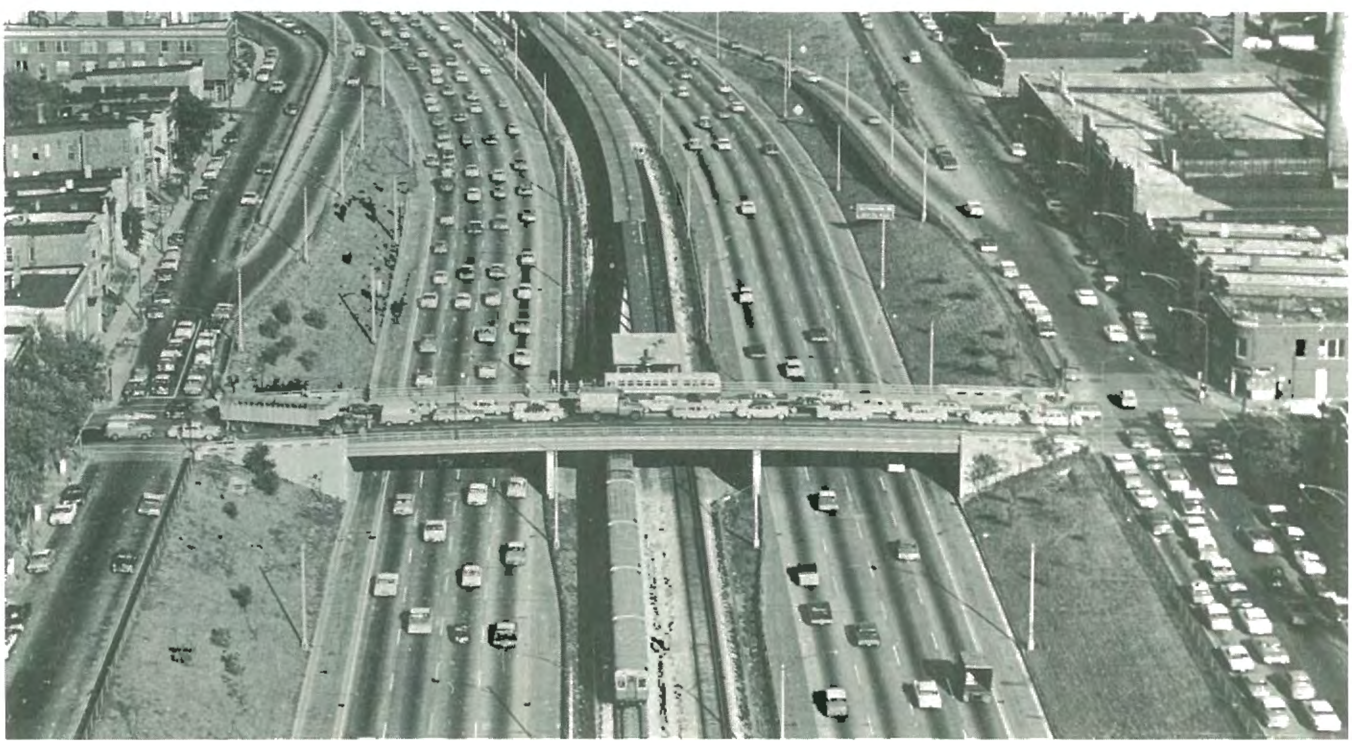
Illinois has a labor force of great skill and productivity to support the diversified, specialized industry. The labor force is slightly less than one-third female. A relatively small proportion of the total could be classified as unskilled. The high level of productivity is reflected in the total cost per unit of output, which is among the most advantageous in the nation. The level of wages in Illinois reflects a competitive industrial climate based on mass consumption.

The quality of the State's manpower resource depends largely upon public education and vocational training. Illinois has one of the largest and most comprehensive systems of public and private higher education in the United States, and an elementary and secondary system serving all areas of the State. The current expansion of the junior college system will increase the supply of technically and vocationally trained labor.

TOTAL NONAGRICULTURAL EMPLOYMENT BY COUNTIES, 1960

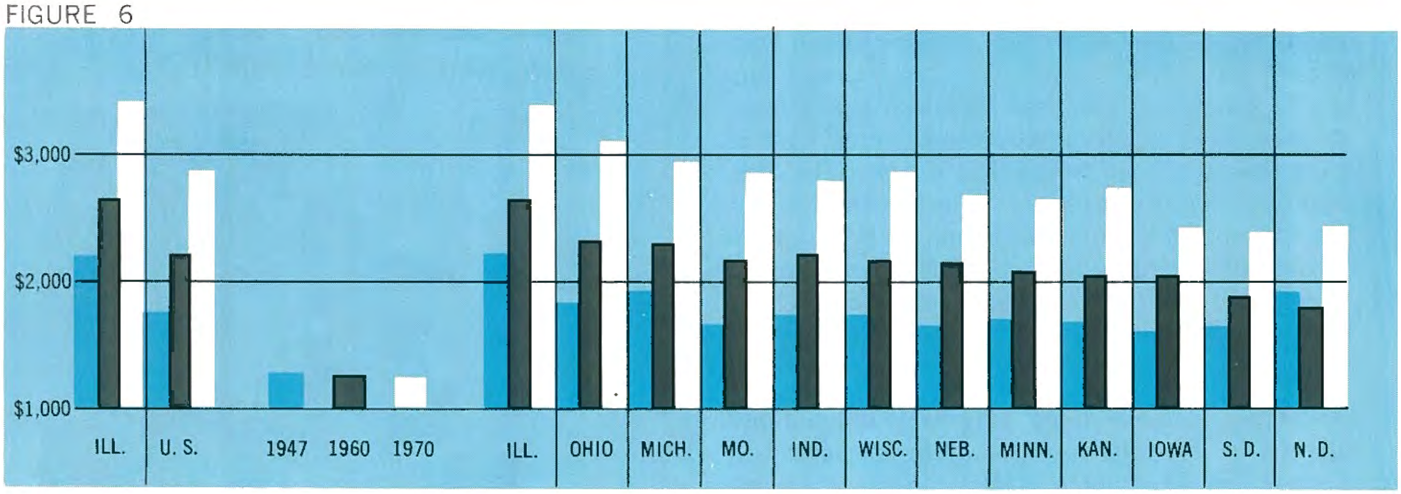
FIGURE 5





PERSONAL INCOME

FIGURE 6



PERSONAL INCOME

Personal income is another measure of the growth of Illinois' economy and of the relative rates of growth by counties. Illinois has the highest total personal income of the Midwestern states (Figure 6). Illinois' personal income in 1950 was about $16 billion; by 1954 it had increased to almost $20 billion; in 1960 it exceeded $26 billion; and in 1963 it exceeded $30 billion. Personal income is estimated for 1980 to be in excess $53 billion (Table 4).

As personal income increases, domestic water use often increases significantly. It is from the personal income data provided here that measurements of domestic and commercial water requirements are estimated.

Figure 7 shows 1963 and 1980 total personal income by economic regions.* Personal income data were developed from studies being conducted by the University of Illinois, Bureau of Economic and Business Research, under contract with the Department of Business and Economic Development as one part of the Illinois State Plan.

* Gilpatrick, Eleanor. March 12, 1965. Suggested Economic Regions in Illinois by Counties. Bureau of Economic and Business Research, University of Illinois.

TOTAL PERSONAL INCOME BY ECONOMIC REGIONS, For 1963 and 1980

FIGURE 7

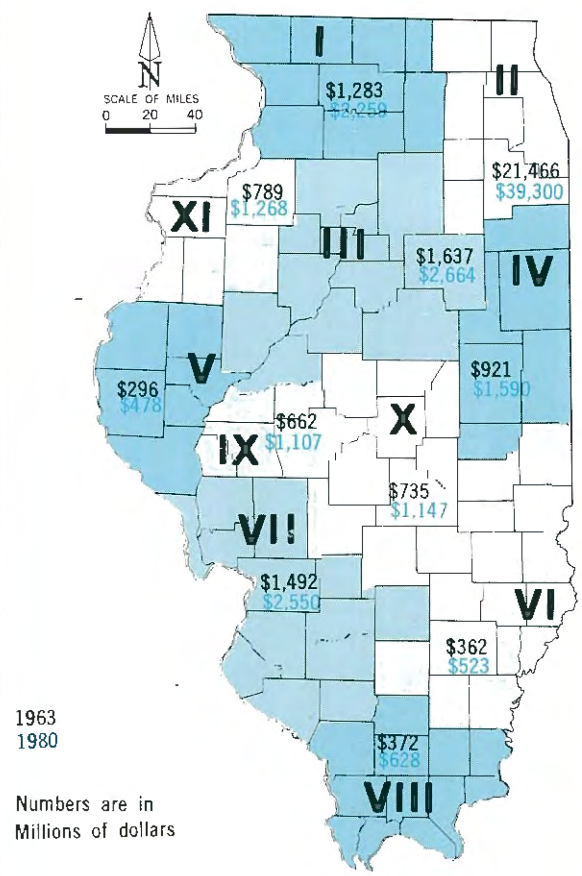
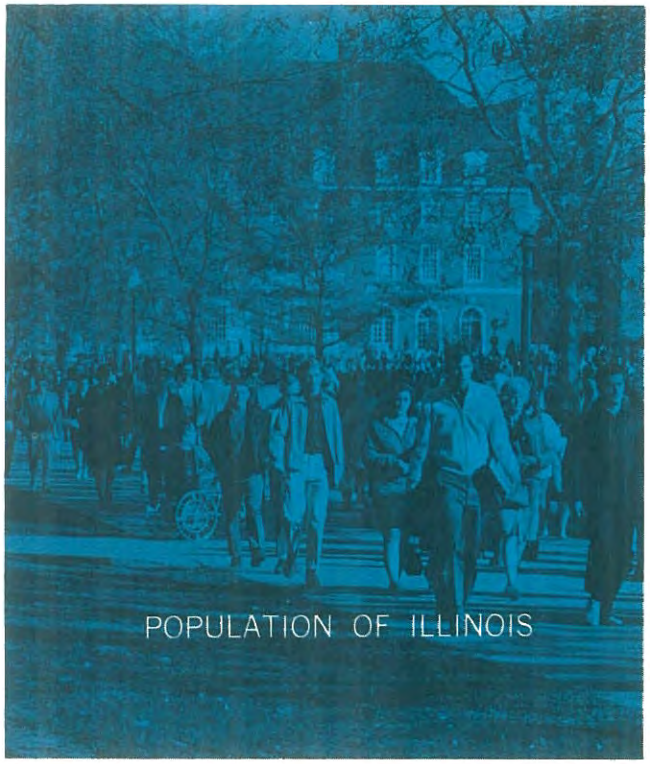


TABLE 4

TOTAL PERSONAL INCOME BY COUNTY

County	1960	1963	1980*	2020*
Adams	113	131	232	1,020
Alexander	18	20	26	76
Bond	20	23	37	110
Boone	49	55	91	342
Brown	9	9	13	36
Bureau	79	87	117	334
Calhoun	9	10	16	47
Carroll	40	43	55	134
Cass	27	31	40	124
Champaign	212	254	463	2,177
Christian	70	79	99	243
Clark	25	30	37	107
Clay	24	27	34	82
Clinton	39	44	79	284
Coles	74	84	128	445
Cook	15,741	17,600	31,070	130,807
Crawford	38	44	70	296
Cumberland	15	18	25	78
DeKalb	115	128	210	780
DeWitt	34	38	48	115
Douglas	43	53	83	338
DuPage	1,088	1,286	2,983	15,520
Edgar	40	48	61	187
Edwards	11	13	16	46
Effingham	38	43	72	275
Fayette	30	34	44	117
Ford	42	50	78	305
Franklin	57	61	82	238
Fulton	83	91	134	437
Gallatin	10	11	14	41
Greene	29	33	53	158
Grundy	58	66	102	394
Hamilton	11	13	18	62
Hancock	39	45	63	95
Hardin	7	7	10	29
Henderson	16	18	22	54
Henry	107	117	162	520
Iroquois	81	99	146	548
Jackson	68	69	146	713
Jasper	16	19	27	84
Jefferson	48	55	81	306
Jersey	26	30	46	139
Jo Daviess	38	43	59	175
Johnson	9	10	18	83
Kane	627	714	1,407	6,527
Kankakee	191	225	417	1,950
Kendall	52	61	118	531
Knox	134	151	252	1,033
Lake	765	884	1,879	9,233
LaSalle	253	280	452	1,691
Lawrence	29	33	49	190
Lee	76	83	116	346
Livingston	87	101	139	441
Logan	64	76	118	488
McDonough	49	55	88	337
McHenry	251	291	613	2,998
McLean	175	202	320	1,202
Macon	247	278	511	2,121
Macoupin	70	79	129	386
Madison	463	532	822	3,560
Marion	62	68	112	337
Marshall	27	29	37	85
Mason	31	37	51	169
Massac	22	26	51	267
Menard	21	26	34	116
Mercer	34	37	45	113
Monroe	30	35	56	172
Montgomery	54	62	93	353
Morgan	65	76	120	496
Moultrie	25	30	38	100
Ogle	88	98	160	588
Peoria	419	464	786	3,116
Perry	29	32	56	195
Piatt	33	40	55	170
Pike	34	40	60	213
Pope	4	5	6	18
Pulaski	10	11	14	41
Putnam	10	11	35	200
Randolph	45	51	91	326
Richland	24	28	42	165
Rock Island	369	415	720	3,080
St. Clair	458	528	1,008	4,612
Saline	34	36	48	136
Sangamon	326	378	686	3,264
Schuyler	14	16	22	66
Scott	11	13	16	44
Shelby	38	45	66	178
Stark	17	18	23	57
Stephenson	102	116	196	762
Tazewell	221	255	475	2,074
Union	27	31	56	262
Vermilion	206	240	403	1,711
Wabash	24	28	42	162
Warren	46	51	67	196
Washington	23	26	45	157
Wayne	30	35	56	242
White	30	35	51	187
Whiteside	123	138	240	953
Will	495	564	1,128	5,276
Williamson	74	85	157	755
Winnebago	506	579	1,132	5,054
Woodford	53	62	95	348
Total	26,573	30,014	53,514	228,351

* In 1963 Dollars
Numbers are in Millions of Dollars



The human resource as reflected in its population is Illinois' greatest resource. Illinois population has grown steadily over a number of years. The greatest growth has been in the metropolitan areas of the State. Suburban growth and annexations to corporate cities have been responsible for population growth in urban areas, offsetting slight declines in some cities. The population will continue to grow in the same pattern, through 2020 (Figures 8a, b, and c).

A high proportion of the people in the State live in its urban areas. The population shift from rural to urban areas which has marked the past 50 years will continue, although the decline in agricultural areas will level off. County population patterns will continue to reflect the rural to urban shift and industrial growth. The decline in southern and western Illinois is expected to be reversed or to continue at a lesser rate.

Planning for water resources development is based on estimates of the future population of the State. Requirements for water supply and treatment

POPULATION BY ECONOMIC REGIONS, 1960

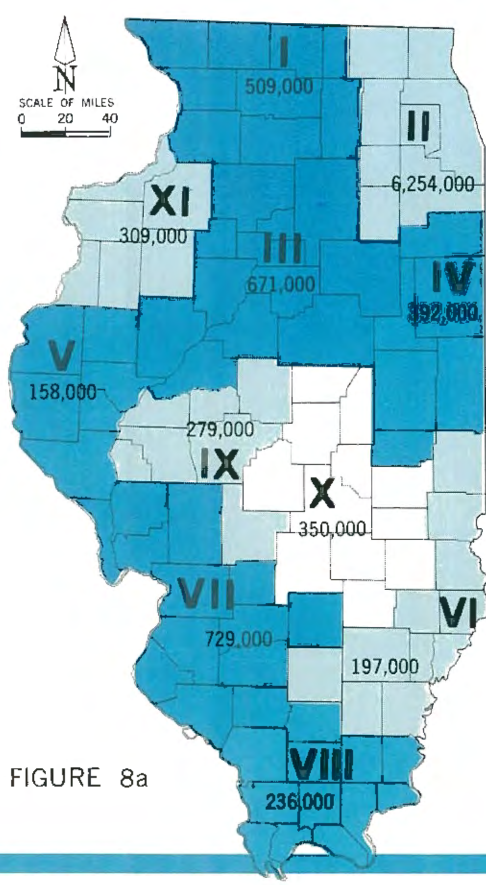


FIGURE 8a

POPULATION BY ECONOMIC REGIONS 1980 AND PERCENT OF CHANGE FROM 1960

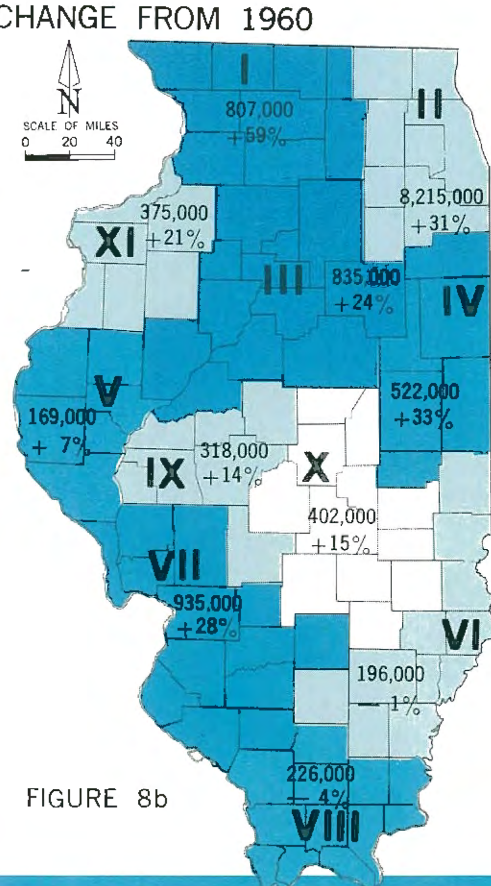


FIGURE 8b

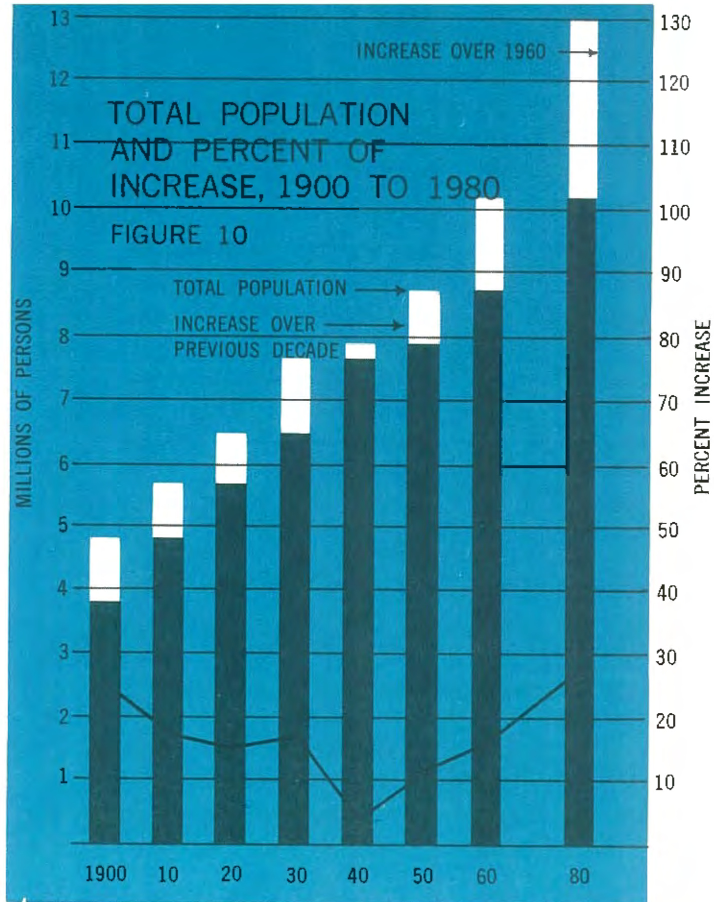
as well as for the related recreational needs are determined from population estimates.

The estimates of population and its distribution for this water resources plan are based on historic trends, adjusted to certain predicted influences. County populations for 1960 are given in Figure 9.

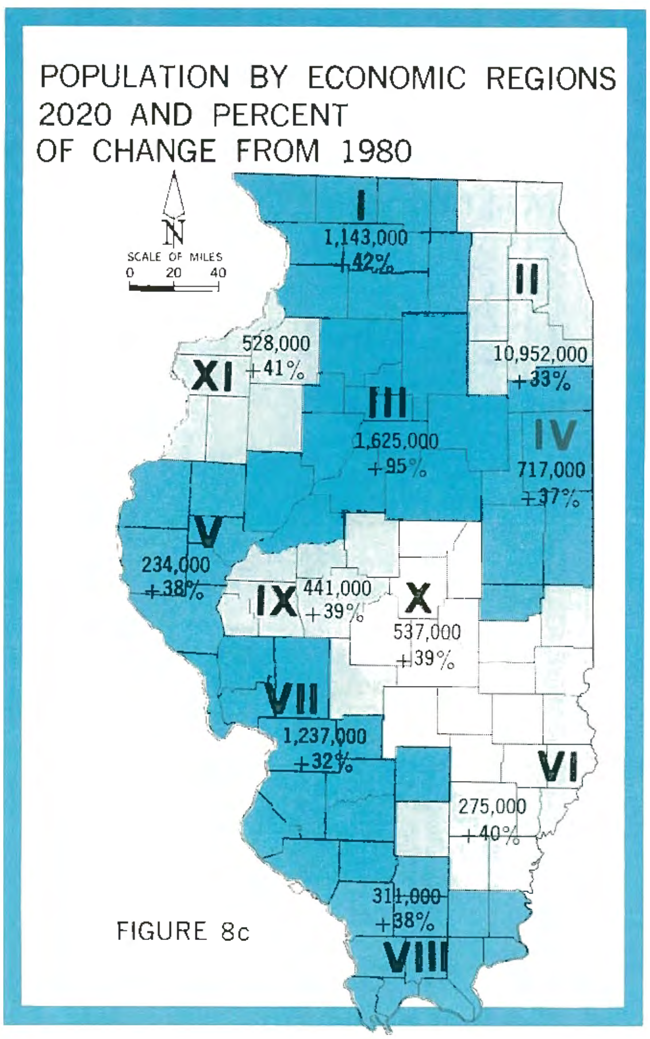
STATE AND URBAN GROWTH

In 1960 Illinois' total population was more than 10 million, and the State ranked fourth in the nation. Only California, New York, and Pennsylvania had more people.

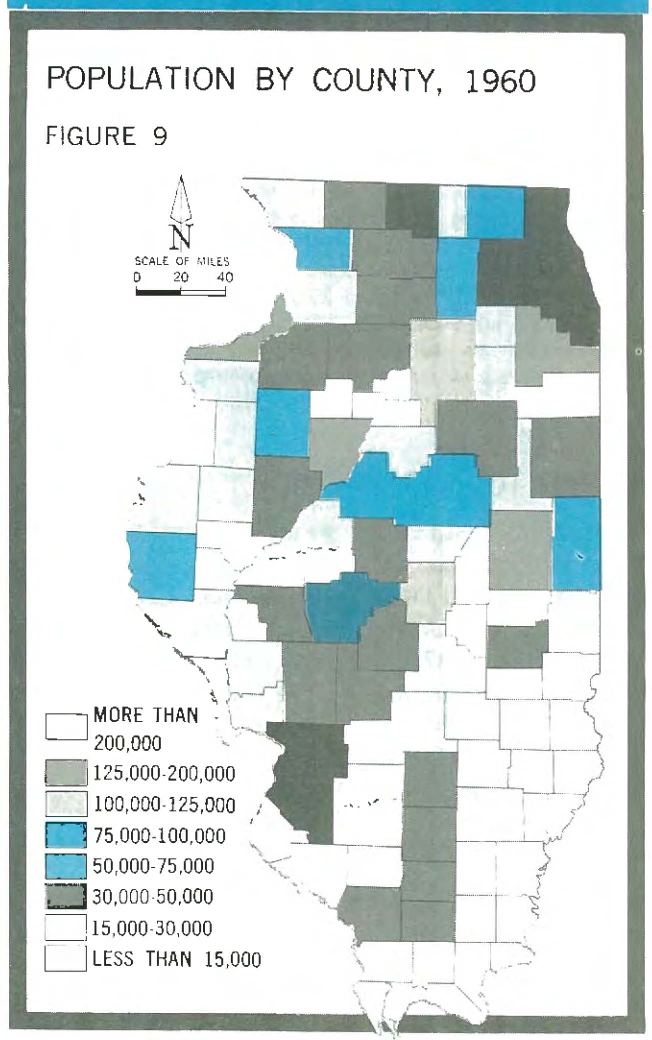
The steady growth in Illinois' population is shown in Figure 10. The 1960 census showed an increase of 15.7 percent in the decade from 1950 to 1960. This increase of 1,368,982 was the largest gain ever recorded during a 10-year period for Illinois. Illinois' rate of growth for those years was somewhat less than the national average of 18.6 percent, but the numerical increase was larger than all but six other states.



TOTAL POPULATION AND PERCENT OF INCREASE, 1900 TO 1980
FIGURE 10



POPULATION BY ECONOMIC REGIONS 2020 AND PERCENT OF CHANGE FROM 1980
FIGURE 8c



POPULATION BY COUNTY, 1960
FIGURE 9

From 1900 to 1930 the population increased from 15 percent to 18 percent each decade. It increased only 4 percent from 1930 to 1940 and 10 percent from 1940 to 1950.

A high proportion of Illinois residents live in urban areas. In 1960 the urban population of the State was 80.7 of the total; rural population was 19.3 percent (Table 5). The urban percentage is much higher than the national average of 69.9 percent. Only four states have a larger proportion of their total population living in urban areas.

TABLE 5

PERCENTAGES OF URBAN AND RURAL POPULATIONS

Census	Total Number	Urban Number	Urban Percent	Rural Number	Rural Percent
* Current urban definition					
1960	10,081,158	8,140,315	80.7	1,940,843	19.3
1950	8,712,176	6,759,271	77.6	1,952,905	22.4
* Previous urban definition					
1960	10,081,158	7,650,562	75.9	2,430,576	24.1
1950	8,712,176	6,486,673	74.5	2,225,503	25.5
1940	7,897,241	5,809,650	73.6	2,087,591	26.4
1930	7,630,654	5,635,727	73.9	1,994,927	26.1
1920	6,485,280	4,403,677	67.9	2,081,603	32.1
1910	5,638,591	3,479,935	61.7	2,158,656	38.3
1900	4,821,550	2,616,368	54.3	2,205,182	45.7
1890	3,826,352	1,719,172	44.9	2,107,180	55.1
1880	3,077,871	940,540	30.6	2,137,367	69.4
1870	2,539,891	596,042	23.5	1,943,849	76.5
1860	1,711,951	245,545	14.3	1,466,406	85.7

* Urbanized areas were defined for the first time in the 1950 census. The purpose of the definition was to better separate the urban and rural population in the vicinity of larger cities. In the urban definition used prior to 1950, the urban population comprised all persons living in incorporated places of 2500 inhabitants or more and areas classified as urban under somewhat different special rules relating to population size and density. In general, the current urban definition comprises all persons living in urbanized areas and in places of 2500 inhabitants or more outside urbanized areas, whether incorporated or not.

RURAL TO URBAN SHIFT

Concurrent with the general increase in the State's population, there has been a major rural to urban shift in Illinois. In less than 100 years, the proportion of rural to urban residents has been reversed. In 1870 the rural population was 76.5 percent of the total; in 1960 the urban population was 75.9 percent of the total (1950 census definition). In 1870 Chicago had 300,000 people. From 1870 to 1960 Chicago's population increased by a factor of more than 10, while the State as a whole increased by a factor of only 3.9.

The primary causes of the population shift were migration from rural to urban areas and the natural population increase (excess of births over deaths) in urban areas. Migration was caused by technological advances in agriculture, which decreased farm manpower demands, and by the increasing labor demands by industry, which is usually concentrated in or near cities. Job opportunities of all kinds are more plentiful in urban areas.

Illinois had a high population density of 180.2 persons per square mile in 1960. Ohio is the only other of the 13 Midwestern states which is more densely populated. The predominance of the urban population in Illinois is reflected in the high density.

THE SPRAWLING CITIES

During the past 100 years, and particularly during the past 50 years, Illinois' population has increased largely through the growth of cities. Since 1900, the increase in population is almost entirely the result of increases in urban population. Since 1900, urban population increased 5 million, or 95.7 percent of the total increase of 5.25 million. Urban population growth has accelerated since 1940.

The major population growth in Illinois has been in the eight metropolitan areas, Chicago, East St. Louis, Peoria, Rockford, Rock Island, Springfield, Champaign-Urbana, and Decatur (Figure 11). In 1960 the population of these standard metropolitan statistical areas was 7,754,932, or 76.9 percent of the State's population (1950 census definition). In

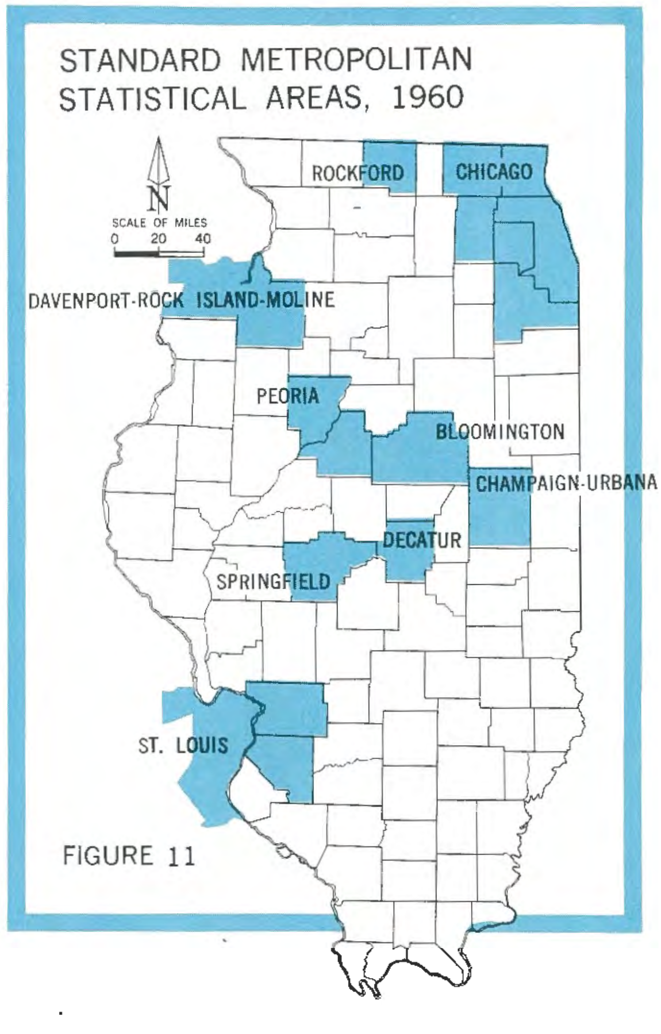


FIGURE 11

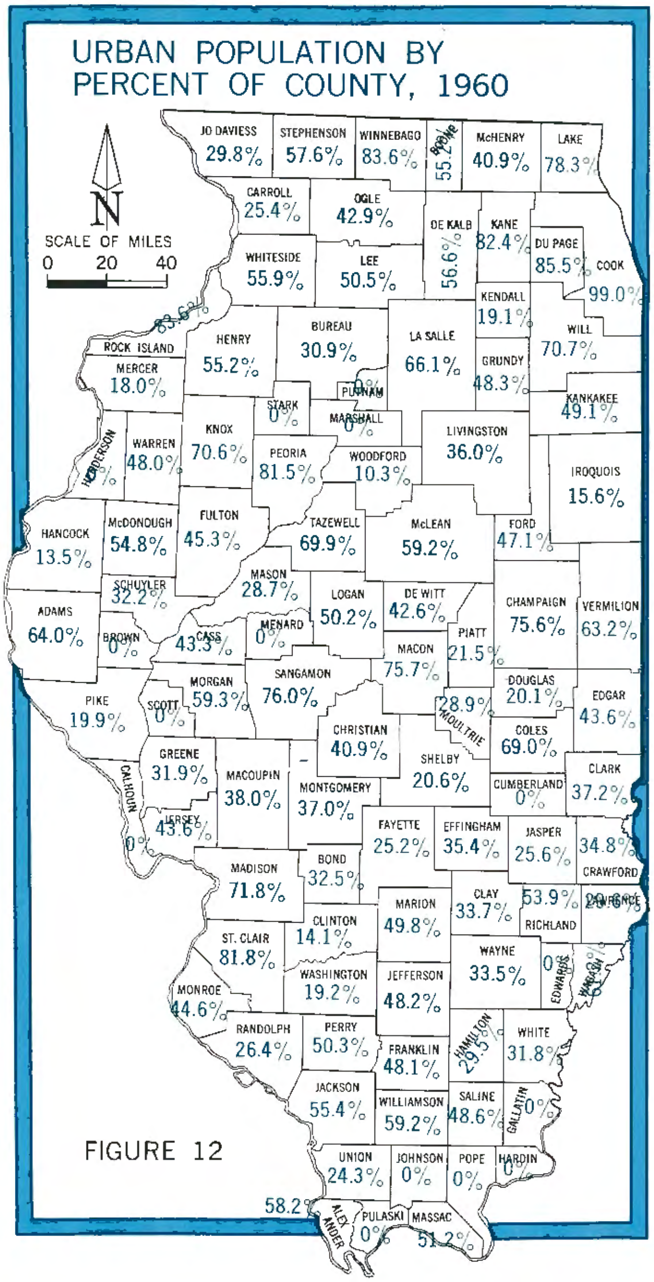


FIGURE 12

1950 the same metropolitan areas had 73.9 percent of the total population. The increase in the population of the metropolitan areas for the decade was 96 percent of the State's total population increase (Figure 12).

The phenomenal suburban growth has offset a population decline in some corporate cities. The 1960 census showed that some of the nation's major cities had lost population. Examples in Illinois were Chicago, which had a net loss of 1.9 percent, and Peoria, which had a net loss of 7.8 percent. The Chicago Metropolitan Area, outside the corporate city, increased by 71.5 percent, and the area outside Peoria grew by 33.9 percent.

Data in the 1960 census suggest that cities have continued to grow primarily by extending their corporate boundaries by annexing adjacent territory. In addition, many new cities have sprung up in metropolitan areas, particularly near Chicago.

COUNTY PATTERNS

As might be expected, in view of the rapid growth of urban areas, population growth has not occurred uniformly throughout the State. From 1950 to 1960, 51 counties gained population and 51 counties lost population. Changes in county population patterns are shown in Figure 13. Outside the metropolitan areas, particularly in the southern and western parts of the State, the trend has been one of very slow growth or even loss of population, because net out-migration has exceeded the natural increase.

Illinois' population appears to be concentrated in a relatively few counties in a fairly well established pattern. From 1940 to 1960, there was a fairly uniform pattern of growth and decline. Metropolitan regions which have gained population since 1940 are all in the northern, east-central, or southwestern parts of the State. The largest gains were in regions which not only contained cities with diversified economies, but were also adjacent to metropolitan areas.

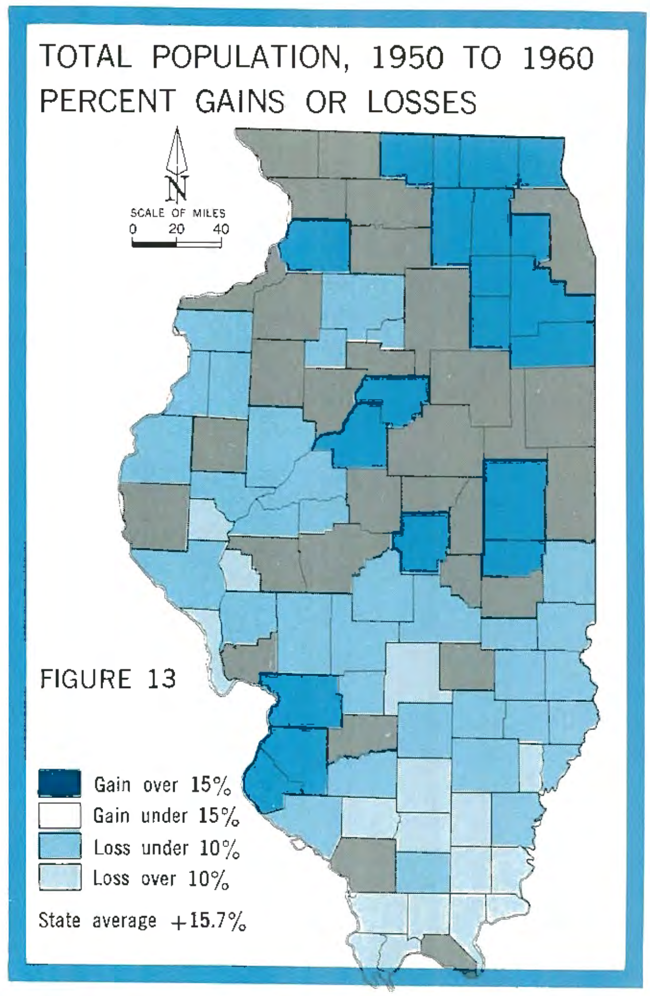


FIGURE 13

POPULATION CHANGE

The two factors responsible for population change are natural increase (excess of births over deaths during a particular period) and migration. If no one moved into or out of a particular area during a particular time, the natural increase would thus determine the growth or decline in population. In the decade from 1950 to 1960, natural increase was the most important factor in Illinois' population growth. The natural increase of more than 1.2 million represented 89.5 percent of the total increase. The remaining 10.5 percent was due to net in-migration. In other words, that many more people moved into Illinois than left the State. The in-migration accounts for growth in particular areas of the State and was less to urban areas of the State than to other areas. This counteracted the long-time pattern of rural to urban shift in population within the State, and indicates that cities have continued to grow largely through annexation.

FUTURE GROWTH

This analysis of the population suggests that future population distribution and growth in Illinois will depend, to a large extent, on the rate of industrial expansion and diversification. Projections of recent trends indicate that future growth will be concentrated in metropolitan areas and in industrialized areas which are rapidly reaching metropolitan status.

The pattern of urban growth has significant implications for water resources planning. The spreading urban areas must be assured of an adequate and safe supply of water. In some cases this will mean developing new sources of surface or ground water. Urban development intensifies pollution problems and makes pollution control increasingly imperative. Also, urbanization which encroaches on the natural flood plain or changes drainage patterns must be controlled.

Population growth in non-diversified areas and in most non-metropolitan areas will depend, to a large extent, on their success in attracting new and diversified industries. Particularly in southern Illinois, opportunities for growth do exist. Water, coal, and other natural resources, as well as human resources, exist in abundant quantities in southern Illinois. It may be assumed that the rural to urban shift and out-migration will eventually level off. This will arrest the decline in rural population. Recent trends, as well as discussions with industrialists throughout southern Illinois, indicate that a decline in out-migration is already occurring. Further development of water resources and new technologies in the use of coal and other natural resources offer significant opportunities for growth in certain areas of southern Illinois.

In spite of out-migration from southern and western Illinois, these economic areas continue to have a large supply of labor. The labor potential includes not only workers living there, but also former residents of the area who would like to return if employment opportunities existed.

POPULATION ESTIMATES

Population estimates are shown for 1980 and 2020 for the State, for its eleven component economic regions, and for each of the 102 counties (Tables 6 and 7 and Figures 8a, b, c, 14, and 15). The estimates are based on an historic ratio adjusted to certain predictable growth factors peculiar to Illinois.

It is assumed that the pattern of population distribution anticipated to 1980 will continue to 2020. That is, agricultural decline will level off and the

TABLE 6

POPULATION AND PERCENT OF CHANGE BY ECONOMIC REGION

Region	1960	1980	Percent of Change 1960 to 1980	2020	Percent of Change 1980 to 2020
I	508,716	807,000	+58.63	1,143,000	+41.64
II	6,254,021	8,215,000	+30.52	10,952,000	+33.32
III	670,782	835,000	+24.48	1,625,000	+94.60
IV	391,963	522,000	+33.18	717,000	+37.36
V	157,505	169,000	+ 7.30	234,000	+38.46
VI	197,090	196,000	— 0.55	275,000	+40.31
VII	729,233	935,000	+28.22	1,237,000	+32.30
VIII	236,120	226,000	— 4.29	311,000	+37.61
IX	278,614	318,000	+14.14	441,000	+38.68
X	350,251	402,000	+14.77	537,000	+38.68
XI	309,242	375,000	+21.26	528,000	+40.80
TOTALS	10,081,158	13,000,000	+28.45	18,000,000	+38.46

TABLE 7 ILLINOIS COUNTY POPULATIONS

County	1960	1965	1980	2020
Adams	68,467	69,600	75,000	104,000
Alexander	16,061	14,600	11,000	15,000
Bond	14,060	13,800	15,000	21,000
Boone	20,326	21,700	45,000	62,000
Brown	6,210	5,800	6,000	8,000
Bureau	37,594	37,000	45,000	98,000
Calhoun	5,933	5,400	5,000	7,000
Carroll	19,507	19,300	25,000	35,000
Cass	14,539	14,100	15,000	21,000
Champaign	132,436	145,400	200,000	270,000
Christian	37,207	35,900	38,000	53,000
Clark	16,546	15,900	16,000	21,000
Clay	15,815	15,100	16,000	22,000
Clinton	24,029	24,500	30,000	41,000
Coles	42,860	43,500	60,000	73,000
Cook	5,129,725	5,400,000	6,600,000	8,000,000
Crawford	20,751	20,300	18,000	25,000
Cumberland	9,936	9,300	10,000	14,000
DeKalb	51,714	56,700	87,000	118,000
DeWitt	17,253	16,800	17,000	25,000
Douglas	19,243	19,300	20,000	28,000
DuPage	313,459	385,000	440,000	935,000
Edgar	22,500	21,700	25,000	35,000
Edwards	7,940	7,200	8,000	11,000
Effingham	23,107	23,800	32,000	44,000
Fayette	21,946	20,400	22,000	30,000
Ford	16,606	16,600	17,000	28,000
Franklin	39,281	36,100	36,000	48,000
Fulton	41,954	40,800	44,000	62,000
Gallatin	7,638	7,100	6,000	8,000
Greene	17,460	16,500	18,000	28,000
Grundy	22,350	23,900	30,000	65,000
Hamilton	10,010	9,100	9,000	12,000
Hancock	24,574	23,500	20,000	28,000
Hardin	5,879	5,300	4,000	6,000
Henderson	8,237	8,000	9,000	12,000
Henry	49,317	50,200	61,000	84,000
Iroquois	33,562	33,500	35,000	45,000
Jackson	42,151	45,700	60,000	83,000
Jasper	11,346	10,700	11,000	15,000
Jefferson	32,315	30,500	33,000	41,000
Jersey	17,023	17,700	20,000	28,000
Jo Daviess	21,821	21,600	25,000	35,000
Johnson	6,928	6,000	5,000	7,000
Kane	208,246	237,500	280,000	478,000
Kankakee	92,063	99,800	130,000	180,000
Kendall	17,540	20,300	30,000	65,000
Knox	61,280	63,300	70,000	107,000
Lake	293,656	333,000	435,000	743,000
LaSalle	110,800	113,200	145,000	296,000
Lawrence	18,540	17,400	17,000	33,000
Lee	38,749	39,300	50,000	83,000
Livingston	40,341	41,000	45,000	62,000
Logan	33,656	34,900	40,000	55,000
McDonough	28,928	28,900	40,000	55,000
McHenry	84,210	95,000	120,000	205,000
McLean	83,877	87,200	125,000	173,000
Macon	118,257	124,400	140,000	180,000
Macoupin	43,524	42,700	46,000	62,000
Madison	224,689	242,000	310,000	420,000
Marion	39,349	38,100	42,000	62,000
Marshall	13,334	12,800	15,000	33,000
Mason	15,193	15,000	15,000	21,000
Massac	14,341	14,400	14,000	19,000
Menard	9,248	9,000	9,000	12,000
Mercer	17,149	17,000	19,000	26,000
Monroe	15,507	16,300	20,000	28,000
Montgomery	31,244	30,500	32,000	48,000
Morgan	36,571	37,200	40,000	55,000
Moultrie	13,635	12,900	13,000	18,000
Ogle	38,106	39,700	50,000	69,000
Peoria	189,044	202,400	215,000	472,000
Perry	19,184	18,100	19,000	28,000
Piatt	14,960	15,000	16,000	30,000
Pike	20,552	19,500	20,000	28,000
Pope	4,061	3,600	4,000	6,000
Pulaski	10,490	9,500	7,000	10,000
Putnam	4,570	4,400	12,000	33,000
Randolph	29,988	29,700	35,000	41,000
Richland	16,299	15,800	18,000	25,000
Rock Island	150,991	156,800	190,000	263,000
St. Clair	262,509	268,000	360,000	450,000
Saline	26,227	23,200	20,000	28,000
Sangamon	146,539	153,200	176,000	242,000
Schuyler	8,746	8,300	8,000	11,000
Scott	6,377	6,100	6,000	8,000
Shelby	23,404	22,900	27,000	33,000
Stark	8,152	8,100	9,000	14,000
Stephenson	46,207	47,100	65,000	90,000
Tazewell	99,789	115,300	135,000	296,000
Union	17,645	16,600	14,000	19,000
Vermilion	96,176	99,800	120,000	166,000
Wabash	14,047	13,500	15,000	21,000
Warren	21,587	21,100	26,000	36,000
Washington	13,569	12,900	15,000	21,000
Wayne	19,008	17,900	18,000	25,000
White	19,373	18,400	19,000	26,000
Whiteside	59,887	62,700	70,000	111,000
Will	191,617	224,000	280,000	461,000
Williamson	46,117	44,800	45,000	62,000
Winnebago	209,765	237,000	390,000	540,000
Woodford	24,579	26,600	30,000	65,000
Total	10,081,158	10,650,000	13,000,000	18,000,000

population will increasingly center in urban areas in a continuing trend to 2020.

The population estimates show an increase in Illinois' total population from 10,650,000 in 1965 to 13,000,000 in 1980. This is an increase in 15 years of 2,350,000 people. An increase of 5 million is anticipated for the 40-year period from 1980 to 2020 for a total 2020 population of 18,000,000.

These estimates reflect historic considerations of recent growth trends as well as judgment as to the many influences upon population growth. Therefore, some counties, particularly in southern Illinois, which have heretofore lost population, show at least a small population increase from 1965 to 1980. In addition, these estimates reflect a significant increase in north-central Illinois, particularly along the Illinois Waterway. The location of the new steel industry at Hennepin in Putnam County and other industrial activities in that general area indicate that within a period of 15 to 20 years a major industrial complex employing thousands of workers and offering excellent living opportunities will exist in the Illinois Basin.

Three primary influences other than measures of natural increase and migration were considered in estimating population: 1) the effect of the Interstate Highway System upon the distribution of the 1980 population; 2) the effect of increased coal mining and industrial development upon Illinois, particularly southern Illinois; and 3) the anticipated growth of institutions of higher education, particularly the growth of the state universities.

From discussions with the Board of Higher Education, it was determined that the enrollment level for the University of Illinois at the Urbana campus is nearing saturation, and that most of the growth of state universities will occur at other locations.

The estimates for this water resources plan reflect the best judgment of staff members of State agencies who verified and checked them. No method of population estimation can be exact, particularly on a detailed county or city level. The location of one industrial facility or the expansion of a community facility such as a junior college can significantly affect that community. The larger the region or area for which estimates are made, the more refined the estimate can be and the less chance there is for error.

The 2020 estimates are based upon the same relative distribution of the State's total population as is estimated for 1980. Two major adjustments were made for 2020, after consultation with State agencies. First, it was assumed that Cook County's relative percentage of the State's population would decrease by 2020 because of the density of existing development and limited capacity for expansion. Secondly, indications are that the significant growth now occurring in the Illinois River Basin from Peoria to Chicago will accelerate by 2020.

WATER RESOURCES PLANNING

The importance of reliable estimates of future population in planning the development of Illinois' water resources cannot be overstated. The estimates of future requirements for water supply and water and sewage treatment facilities in this report

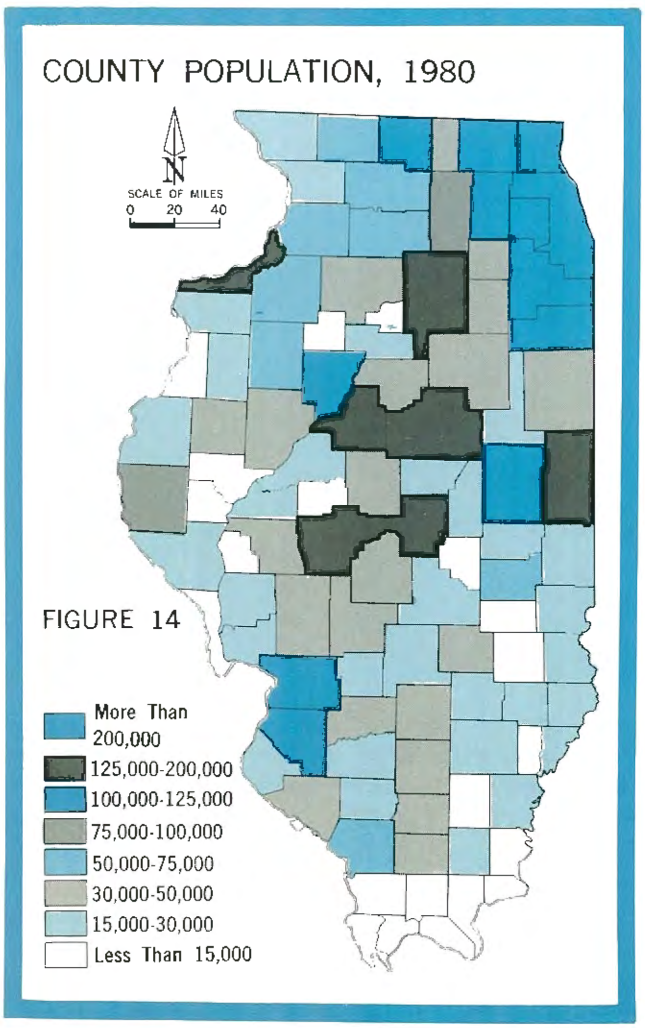


FIGURE 14

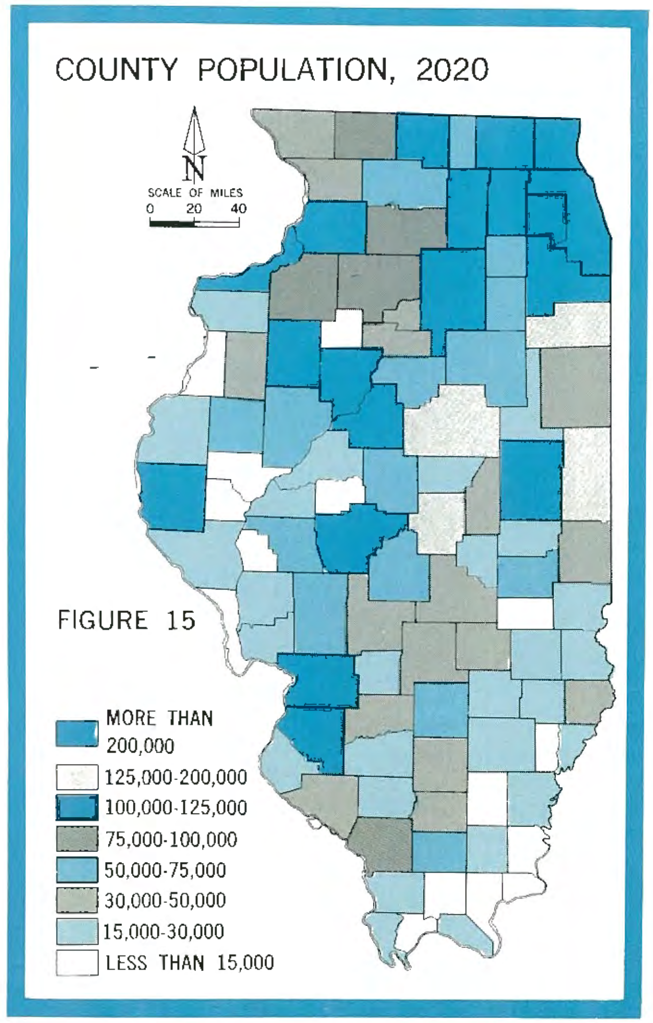


FIGURE 15

are based on population estimates. To do this, it was necessary to apportion regional population estimates by counties.

The more accurately local population estimates are made, the more accurately water and water-related needs can be assessed. Further, any limitations on industrial or population growth for a particular region imposed by available water resources can be anticipated.

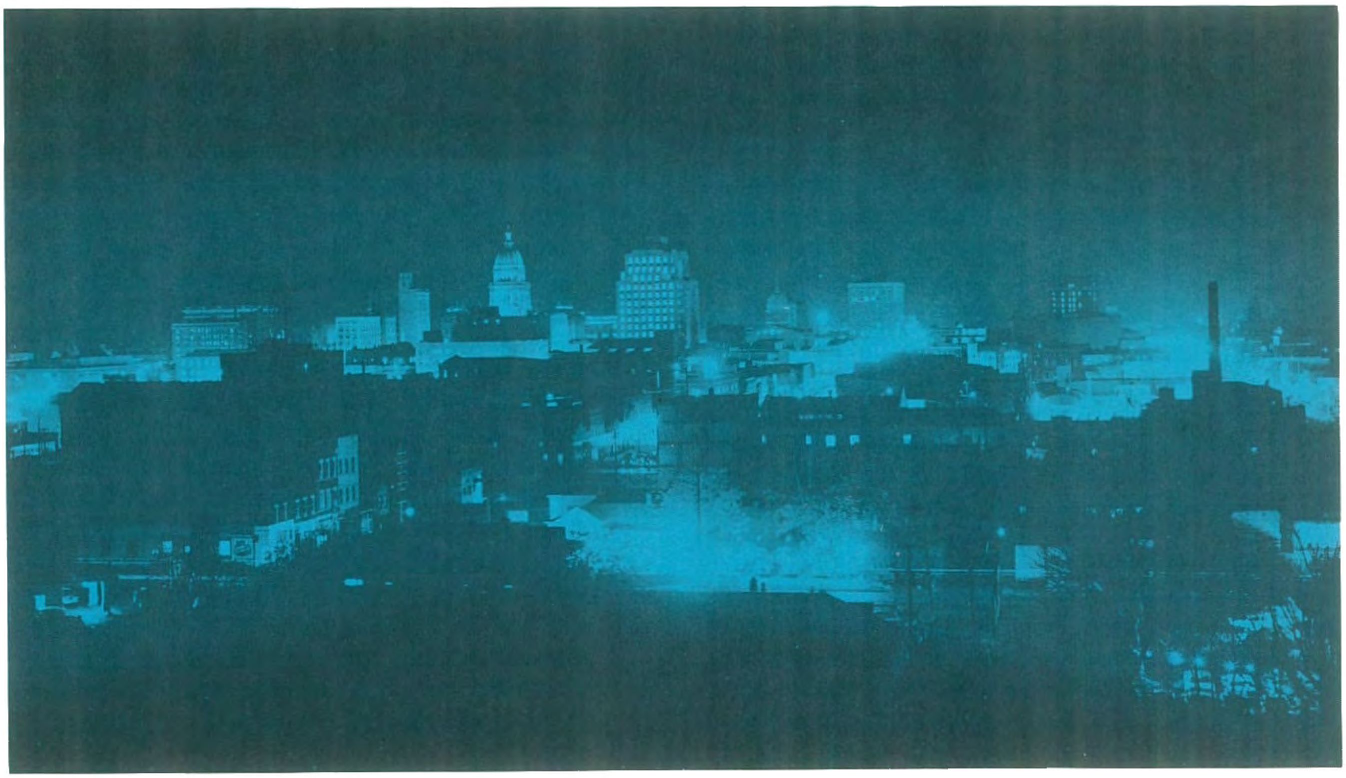
The general approach to planning Illinois' water resources has been not only to consider the State's total requirements for the development of the water resource, but also to give particular attention to specific cities or areas of the State where water resource problems may be acute. These case study areas reflect a sampling of the State's cities and urban areas, as well as rural areas, and are geographically distributed throughout Illinois. The case studies cover essentially all combinations of conditions that exist within Illinois that affect water resources. Estimates of water resource needs are made for this water resources plan from population information.

POPULATION RESEARCH

The estimates of Illinois county populations for 1980 and 2020 are based upon the population study being prepared by Southern Illinois University under contract with the Department of Business and Economic Development. Population estimates for the State and its eleven component economic regions are a part of the research for the Illinois State Plan, which includes this water resources study, as well as a capital facilities inventory and analysis and a study of the economy of Illinois. The research is financially aided by a grant from the United States Department of Housing and Urban Development.

The Southern Illinois University population estimates are based upon the cohort survival method of estimation, which includes a migration analysis. These tentative estimates will be verified by comparison with the economic studies being prepared by the University of Illinois, Bureau of Economic and Business Research. The Bureau is preparing regional studies of personal income, inter-regional trade, and related data.

The apportionment of the regional estimates to counties was based upon historic ratios which were developed by comparing the recent percentage distribution of county population in each region to a longer-term percentage distribution of population. Since historic ratios do not always reflect present or anticipated growth trends, it was necessary to revise certain county estimates and reapportion the regional totals based upon knowledge of future conditions. This was done in consultation with experts in various State agencies, including the Department of Business and Economic Development, the Illinois State Water Survey, the Department of Public Health, the Board of Higher Education, the Northeastern Illinois Planning Commission, the Southwestern Illinois Metropolitan Area Planning Commission, and other research institutions.



CONCLUSIONS AND RECOMMENDATIONS

I. The experience of developing this water resources plan has indicated the importance of reliable estimates of population and economic activity. The Department of Business and Economic Development is charged by law as the official State planning agency and the statistical coordination unit of the State Government.

- It is recommended that the Department of Business and Economic Development establish a population and economic study unit within its Research and Development Division to provide, annually, estimates of statewide population and economic activity on a regional and county by county basis. Such information is essential to the continuing planning and research activities of the several State water agencies, as well as useful to all agencies of the State Government.

II. A related recommendation has been generated by the population and economic section of this chapter. This refers to the need for follow-up studies on the impact a major water resource development or developments may have on an area after a project has been completed. Economic, population, and other studies are made prior to the installation of a given project, but impact studies currently are not made in these areas following completion of the project. Such investigations or studies, showing project impact on economic and population conditions for 5, 10, 15, and 20 years or more after development, should prove particularly important for future State activities in water resources management and planning. At present, few if any of these kinds of studies are carried out by the State or Federal Governments. The Corps of Engineers, during the past two years, has realized the significance of this type of follow-up or impact study and has indicated a desire to utilize it in their future operations.

- It is recommended that the State of Illinois consider initiating a research program to conduct such impact studies. This program should be coordinated through the Division of Research and Development, Department of Business and Economic Development, in cooperation with the Waterways Division of the Department of Public Works and Buildings and the U. S. Army Corps of Engineers, when Federal projects are involved. Other appropriate State and local agencies would be involved in this program as the project circumstances dictate.

ACKNOWLEDGMENTS

This chapter on the resources of Illinois was prepared by the Department of Business and Economic Development, with the assistance of numerous individuals, agencies, and references. Substantial material was taken from the **Atlas of Illinois Resources**, prepared by the Department of Geography of the University of Illinois and published by the former Division of Industrial Planning and Economic Development. Substantial material was used from **Outdoor Recreation in Illinois**, prepared by the Department of Business and Economic Development, with the assistance of the Department of Conservation.

The preliminary chapter material was prepared by Mr. Wayne Verspoor, the material on economic activity and population by Mr. Allan Johnston, both of the Department of Business and Economic Development. Special appreciation is extended to Dr. Hubert E. Risser and Dr. Robert E. Bergstrom of the State Geological Survey for the sections on geology and mineral resources. Appreciation is also extended to staff of the University of Illinois, Southern Illinois University, Department of Public Health, Board of Higher Education, and the Illinois State Water Survey.

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chapter two / water resources

illinois technical advisory committee on water resources

"All the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers come, thither they return again."

Ecclesiastes 1:7

SUMMARY

Stream gaging station.

Water resources are constantly changing in time and space and must be continuously measured and studied if we are to use this resource wisely and eventually control it for man's benefit.

This chapter presents a complete but condensed summary of Illinois water resources, based on records collected by State and Federal agencies. It deals with meteorologic conditions which cause mean annual precipitation to vary from 32 inches in the north to more than 46 inches in the south and to average about 36 inches. Special attention is given to floods and droughts. The opportunities for increasing our water resources through weather modification and artificial recharge of the ground water are discussed with the indication of future promise.

The runoff at 97 long-term measuring stations on Illinois streams is summarized in tables and graphs. Average annual runoff is equivalent to a depth of about 9.7 inches over the State.

For many purposes water can be used directly from the streams, but streamflow is highly variable. Therefore, it becomes important to store runoff during high flow for use during dry seasons and droughts. The present storage capacity in lakes, reservoirs, and ponds is equivalent to a depth of 0.44 inches over the State. Corps of Engineer projects presently being built or authorized will add an additional 0.36 inches of conservation storage. The potential storage which could be created by additional reservoirs is 2.85 inches, or about six times the present capacity.

Ground-water resources in Illinois are large, but not uniformly distributed over the State. They have the capability of expanded use to nearly 7 billion gallons per day.

Evaporation from lake surfaces, which ranges from 30 to 38 inches annually in Illinois, is ordinarily balanced by direct precipitation falling on the water surfaces. Of greater consequence is the evapotranspiration from soil and plants, which annually consumes about 26 inches of water over the entire landscape. Reduction of this water requirement is a fruitful area for research.

Sedimentation of reservoirs has been studied, and its rate of accumulation can be reasonably well predicted. Loss of reservoir capacity through silting is a serious problem and is an important reason for accelerating the program to reduce soil erosion.

Extensive information is available on the chemical water quality of streams and the ground water, and this is summarized and discussed. Most waters of the State are highly mineralized and need to be treated for some uses.

Analytical field kit used about 1910.

INTRODUCTION

Water is basic to all human needs. To understand the past and present uses of water and to predict the future, we must consider various social, economic, institutional, and legal implications of the supply and use of water. Water itself must be studied and understood in great detail if it is to be used wisely. This is the subject of this chapter on water resources.

Water is not a static material which can be measured once and thereafter known. It is constantly changing from year to year, even from minute to minute. Water is not distributed uniformly; in a state as large as Illinois there is considerable geographic variation. In addition, man's use of water increasingly changes both the quality and quantity of the water resources.

If engineering works are to be designed to withstand the extremes of flood and drought and to operate efficiently, predictions of precipitation, streamflow, evaporation, sedimentation, and other characteristics must guide the development of our water resources. The past is the best available guide to the future. In Illinois and in the United States, few such records extend back more than 75 years and most of them are for much shorter times. Valuable as these records are, they cover a shorter period than desirable to guide the design and operation of important engineering works which affect the lives and welfare of the people of Illinois.

The answer to our inadequate knowledge of the resource is to continue and intensify these measurements. As water becomes more valuable, and as we use a higher proportion of what is available, such greater effort is well justified. In the meantime we must make the best use of the records we have by careful analysis of all available information. Most Illinois water resource records are as good as those for any area in the world.

FIGURE 1 ▶

The temporal variability — the frequency of high and low annual amounts of precipitation expected at any point at least once in every 5 years and once every 50 years—can be determined from the maps. For example, in extreme southern Illinois the highest annual precipitation expected at least once every 5 years is more than 56 inches (Figure 1a). Once every 50 years, portions of this area will have 72 inches or more in a single year. In the same area, the annual precipitation will be less than 38 inches at least once every 5 years (Figure 1c), and once every 50 years it will be less than 30 inches.

FIGURES 2, 3, and 4 ▶

The probability of precipitation in any month and at any location in the Sate can be calculated by using the probability graphs with a normal precipitation value chosen at any point on the associated map.

For example, the January map (Figure 2a) shows the normal precipitation to be 4 inches in portions of extreme southern Illinois. The January probability curve indicates that 20 percent of the time, or two years in ten, the January precipitation will be 140 percent of normal. In the 4 inch area this value will be 5.6 inches or more.

PRECIPITATION

Precipitation is, of course, the original source of all water and includes rainfall and snowfall. The geographic patterns, the quantity, and the seasonal and annual distribution of precipitation in Illinois are the basis for evaluating present and future water resources of the State. Droughts and storms or other unusual weather conditions are also significant in water resources planning.

Variability is the most significant characteristic of the annual precipitation in Illinois. The average ranges from 32 inches in the extreme northeast to more than 46 inches in the extreme south. The recorded amounts of precipitation not only vary across the State, but also from year to year (Figure 1).

Normal monthly precipitation varies from north to south from October through May, with the lowest amounts in the north and highest in the south (Figures 2, 3, and 4).

Normal monthly precipitation varies from east to west from June through September and is heaviest in western Illinois. Thunderstorms produce more than 70 percent of the normal precipitation in the warm months. Thunderstorms are highly variable, which is the primary reason for the great difference in precipitation in various areas of the State and at various times during a given warm season.

February normally has the lowest precipitation throughout the State. The highest precipitation normally falls in March or April in southern Illinois, in May in south-central and eastern Illinois, and in June in the remainder of the State.

SNOWFALL

The gradation in the pattern of the average annual snowfall in Illinois is quite extreme, ranging from 9 inches in the south to more than 33 inches in the north (Figure 5a). The temporal variability in annual snowfall also is quite extreme (Figures 5c and 5d). At points in northern Illinois, annual snowfall totals range from a low of 10 inches or less to a high of more than 60 inches in a 50-year period. In portions of extreme southern Illinois the annual totals can be expected to range from less than 1 inch to more than 50 inches during a 50-year period.

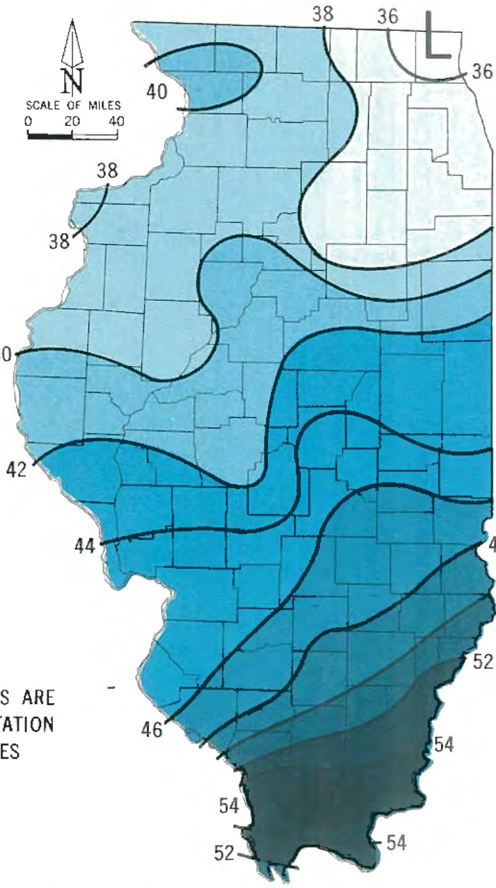
Normally, snowfall is an insignificant portion of the total annual amount of precipitation. Snowfall produces 10 percent of the average annual precipitation in northern Illinois and only 2 to 3 percent of the precipitation in southern Illinois.

About one-fourth of the total snowfall in Illinois is produced by heavy snowstorms of more than 6 inches. Southern Illinois has from five to seven heavy snowstorms in a 20-year period; parts of northern Illinois have eighteen such storms in an average 20-year period.

In northern Illinois snow depths have exceeded 25 inches at least once during the 60-year period, 1901 through 1960. In southern Illinois the deepest snowfalls were from 15 to 20 inches (Figure 5b).

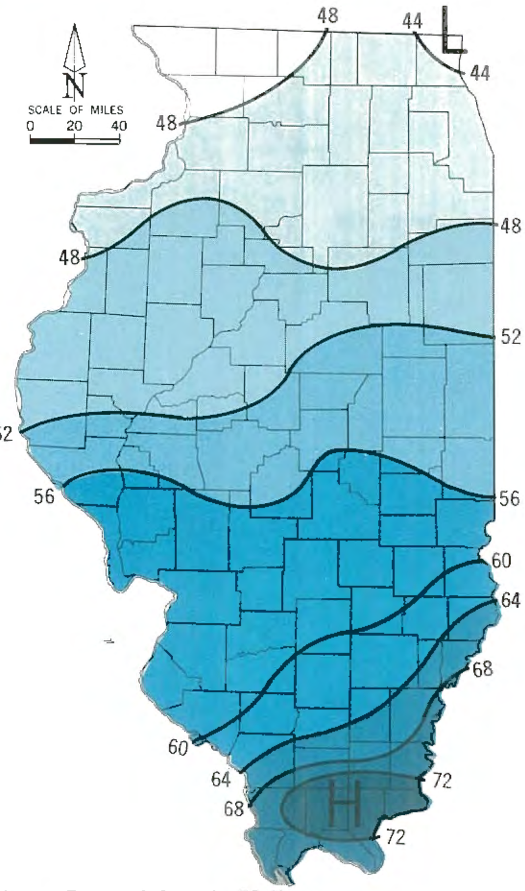
FIGURE 1

FREQUENCY OF ANNUAL MAXIMUM AND MINIMUM PRECIPITATION

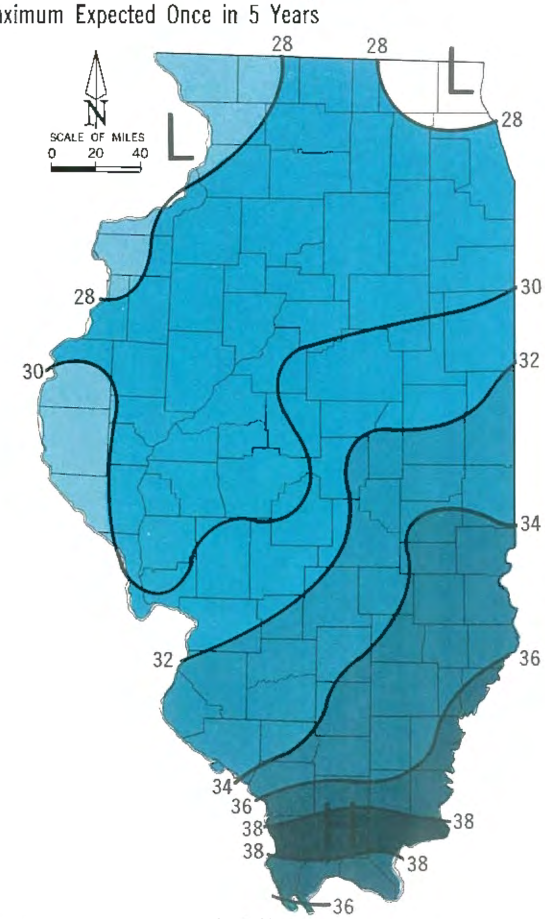


NUMBERS ARE PRECIPITATION IN INCHES

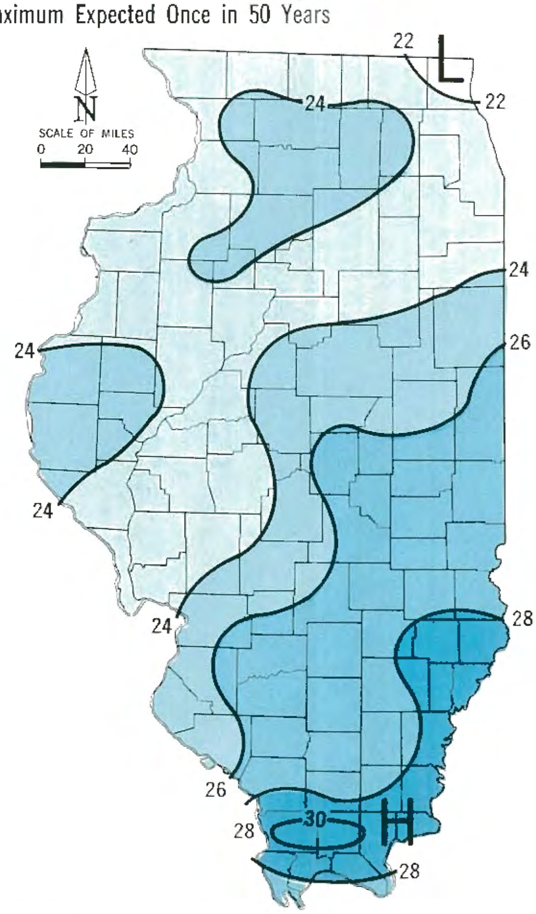
a. Maximum Expected Once in 5 Years



b. Maximum Expected Once in 50 Years



c. Minimum Expected Once in 5 Years



d. Minimum Expected Once in 50 Years

FIGURE 2

NORMAL MONTHLY PRECIPITATION AND PROBABILITY CURVES FOR MONTHLY TOTALS

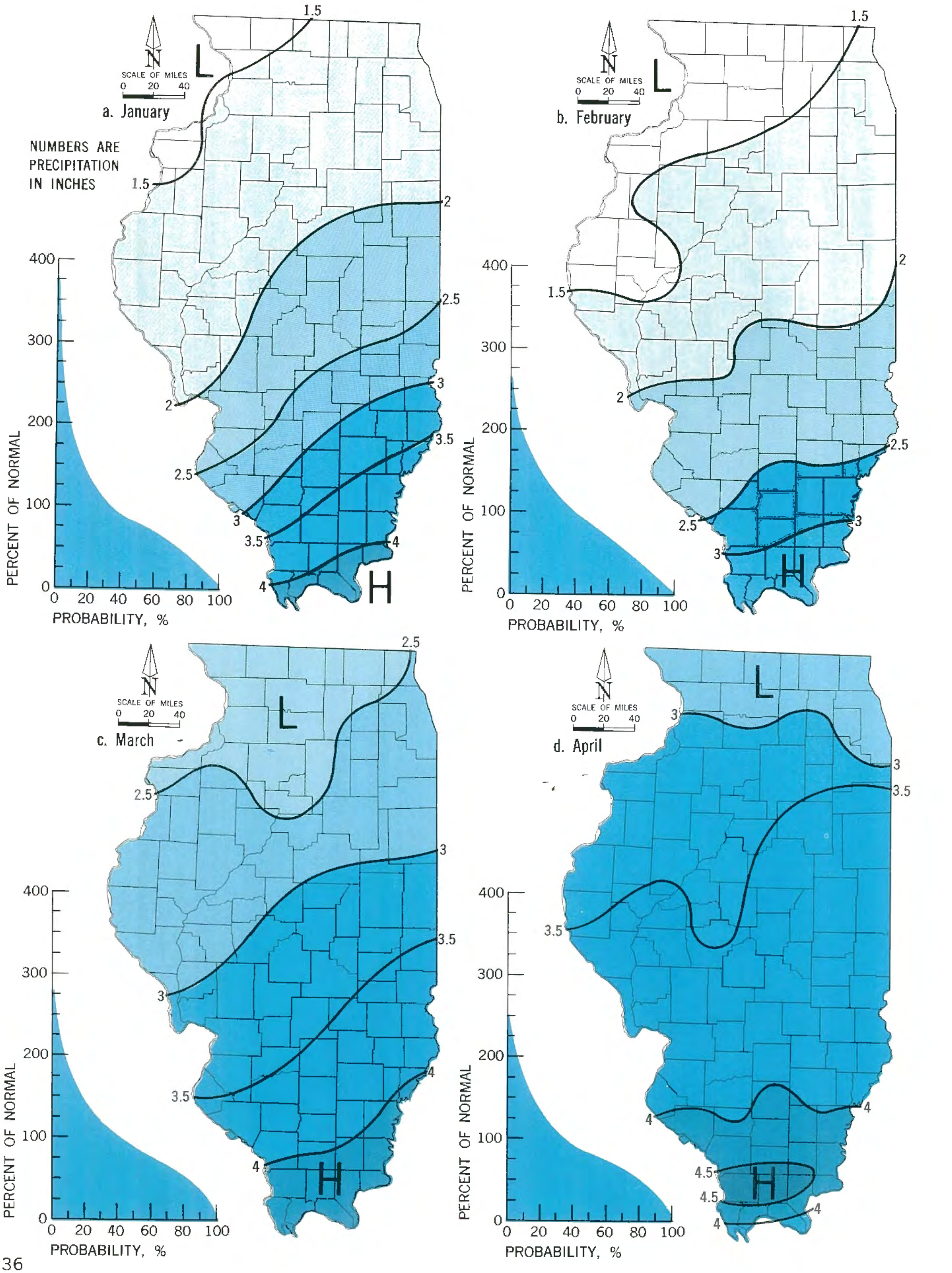


FIGURE 3

NORMAL MONTHLY PRECIPITATION AND PROBABILITY CURVES FOR MONTHLY TOTALS

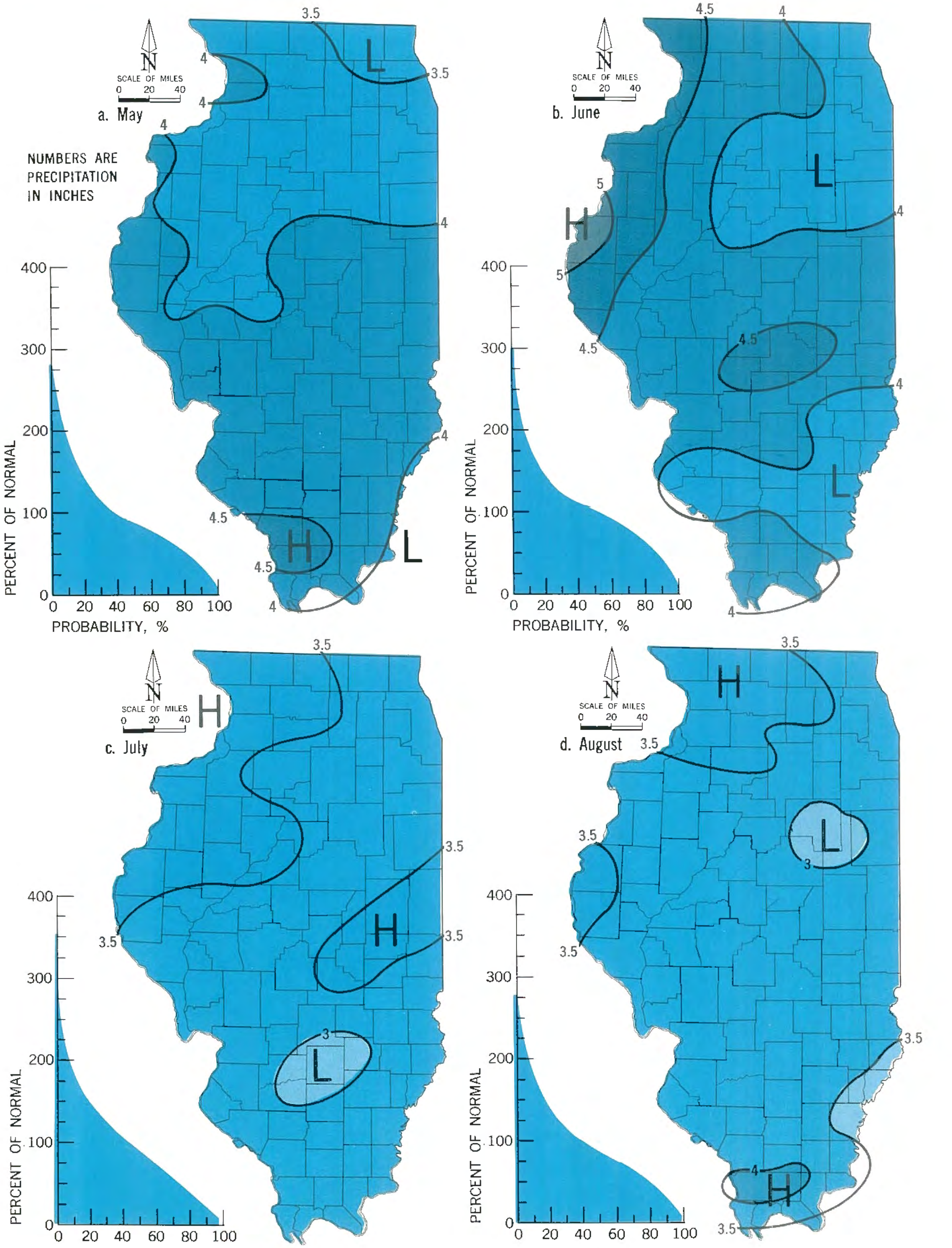


FIGURE 4
NORMAL MONTHLY PRECIPITATION AND PROBABILITY CURVES FOR MONTHLY TOTALS

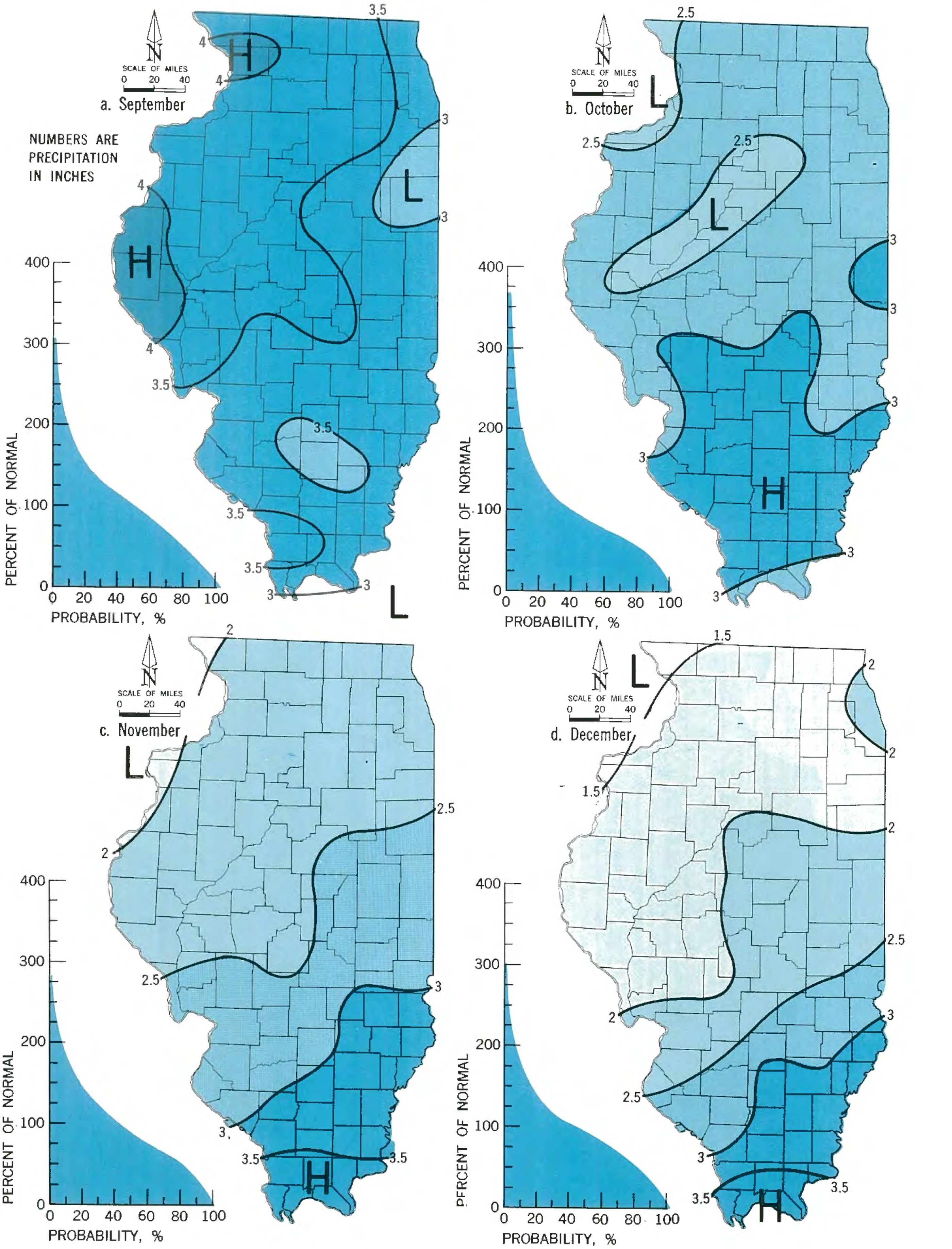
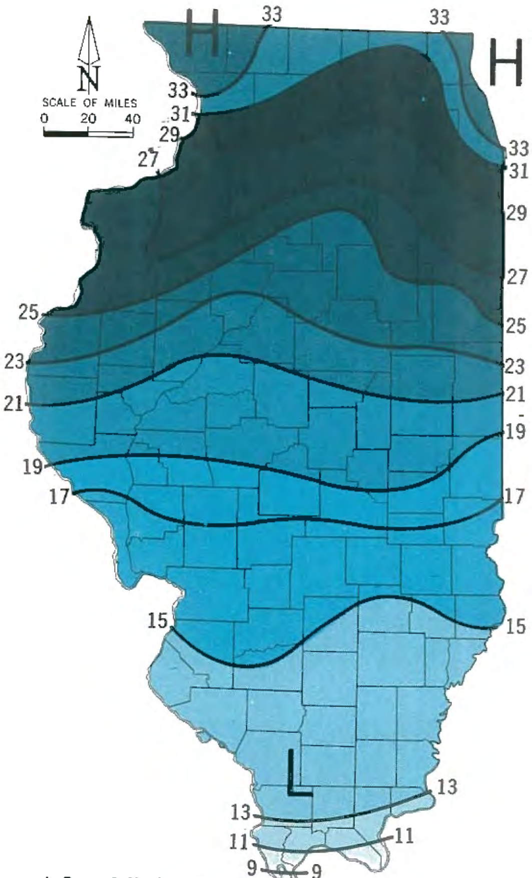
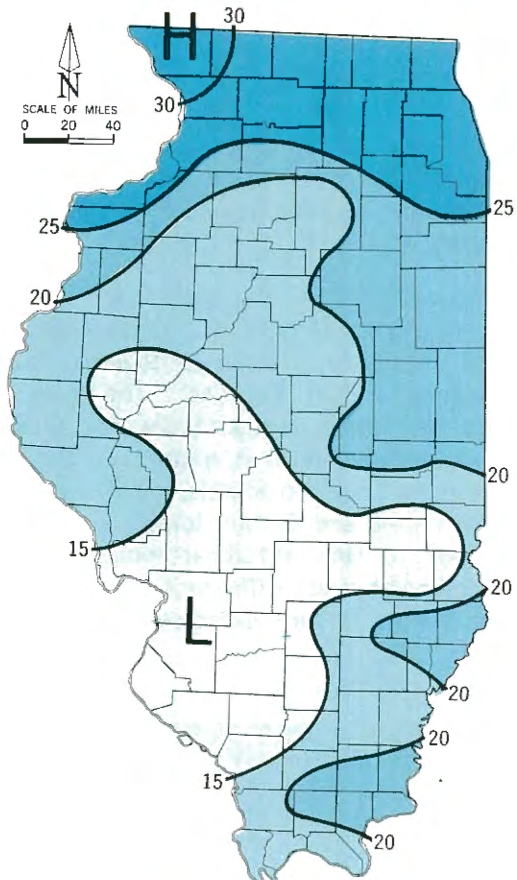


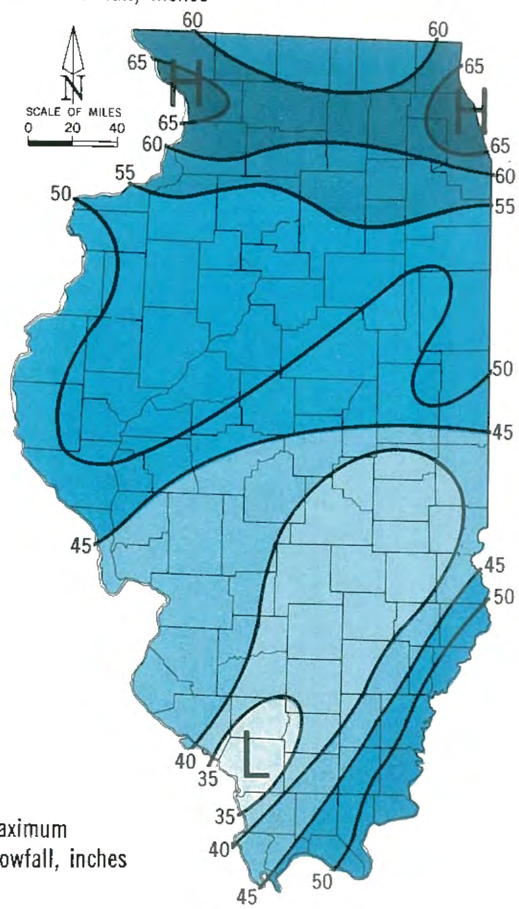
FIGURE 5
SNOWFALL PATTERNS



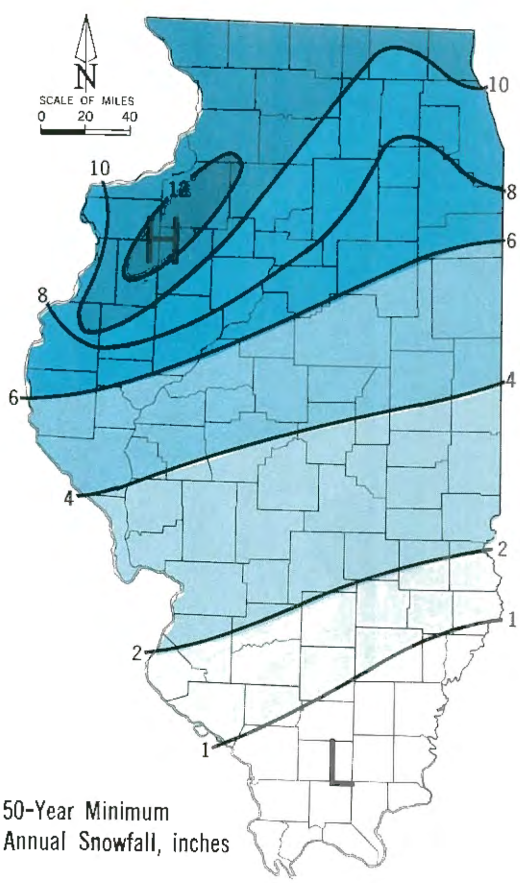
a. Average Annual Snowfall, inches



b. Record Maximum Snow Depth, inches



c. 50-Year Maximum Annual Snowfall, inches



d. 50-Year Minimum Annual Snowfall, inches

TEMPERATURE

Temperature is an important influence on the use of water resources for industrial cooling and air conditioning and for irrigation, which includes lawn watering.

Temperature in Illinois varies from north to south in all seasons (Figure 6). In summer the north-south difference is 8 to 10 degrees; in winter the difference is 16 degrees. The Lake Michigan shoreline, where temperatures are relatively cool in summer and warm in winter, and the hill country in extreme southern Illinois, where mean maximum temperatures are slightly lower, are two of the exceptions to the latitudinal temperature patterns. The greatest areal difference in monthly temperatures occurs in the colder season (Figures 7a and 7b).

FIGURE 7

The mean monthly temperature graphs (Figure 7a) can be used to obtain actual values for any month and area of the State, and these in turn can be used with the temperature-determination graph (Figure 7c) to find the mean maximum, mean minimum, the once-in-ten-year mean maximum and mean minimum temperatures, and the daily extremes for any month. For example, the northern Illinois mean monthly temperature for April is 49 degrees in Figure 7a. Figure 7c shows that the mean maximum April temperature is 11 degrees above the mean, or 60 degrees in northern Illinois. Further, data on the graph show that 10 percent of the time the April mean maximum temperature will be more than 24 degrees above the monthly mean, or in northern Illinois will exceed 73 degrees in one year out of ten. The record highest daily temperatures in April, on the average, will be 35 degrees above the 49-degree mean monthly temperature of the area.

FIGURE 6

MEAN MAXIMUM AND MINIMUM TEMPERATURES IN SUMMER AND WINTER

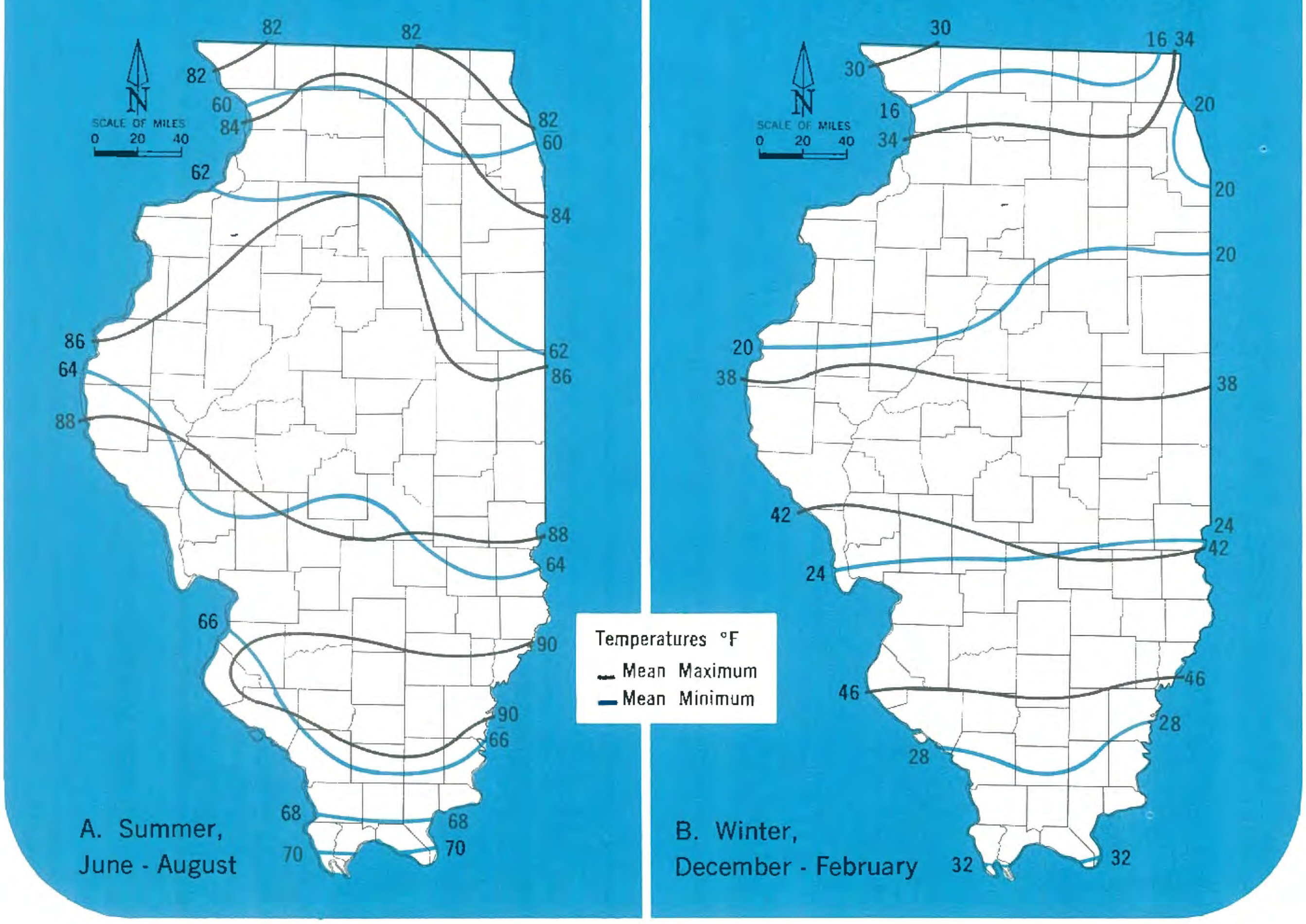
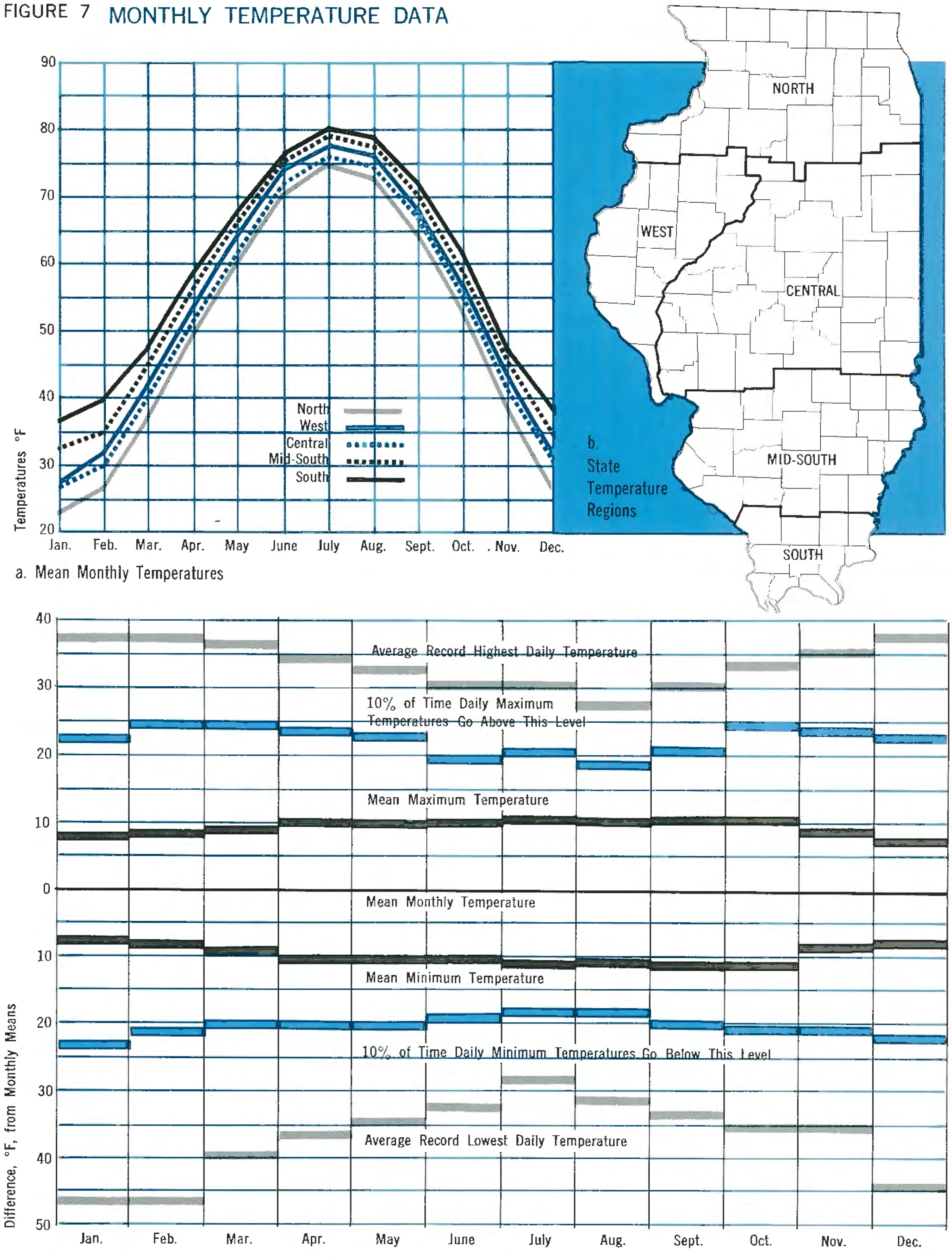


FIGURE 7 MONTHLY TEMPERATURE DATA



c. Temperature — Determination Graphs For Each Month

VALUES ARE READ FROM THE TOP OF THE LINE ABOVE ZERO AND FROM THE BOTTOM OF THE LINE BELOW ZERO.

DROUGHTS

Drought is an important but difficult condition to define. Meteorologically, drought is defined as a relatively extreme deficiency of precipitation. A 12-month period of deficient precipitation in Illinois is considered to be a drought, if the average precipitation across the State is less than 75 percent of normal, and if the period ranks as one of the five driest on record at 25 percent of the 60 long-term rainfall recording stations in the State. Using this method of identifying a drought, a number that expresses the severity of the drought can be derived; thus, droughts can be compared and ranked.

Droughts of four different durations—6-month, 12-month, 24-month, and 36-month—are discussed. Information is given for their time and geographic distribution, area-depth frequencies, actual patterns, point frequencies of deficient precipitation, and meteorology. The results are based primarily on data from the 1906 through 1965 period, which in general is the period of extensive precipitation data for the entire State.

Time Distribution

Droughts do not occur in cycles in Illinois. Droughts of the four durations occurred indiscriminately throughout the 1906 through 1965 period, but there have been notably fewer in the 24 years since 1941 than in any other 24 years of the 60-year sampling period. The most severe droughts in Illinois since 1941 were those in the 1953 through 1955 period, and these droughts were concentrated in the southern half of the State. The only other droughts since 1941 occurred in the 1962 through 1964 period. The patterns and ranks of the two most recent 12-month droughts in Illinois are shown in Figures 8c and 8d. The patterns for the first (worst) and the second ranked 12-month droughts which ended in 1934 and 1931, respectively, are shown in Figures 8a and 8b.

In the 1906 through 1965 period there were sixteen 6-month droughts, thirteen 12-month droughts, ten 24-month droughts, and nine 36-month droughts. The major period of droughts in Illinois was the 1930 through 1941 period, when five of the thirteen 12-month droughts since 1906 occurred. Three of the four worst occurred in the 1930 through 1936 period.

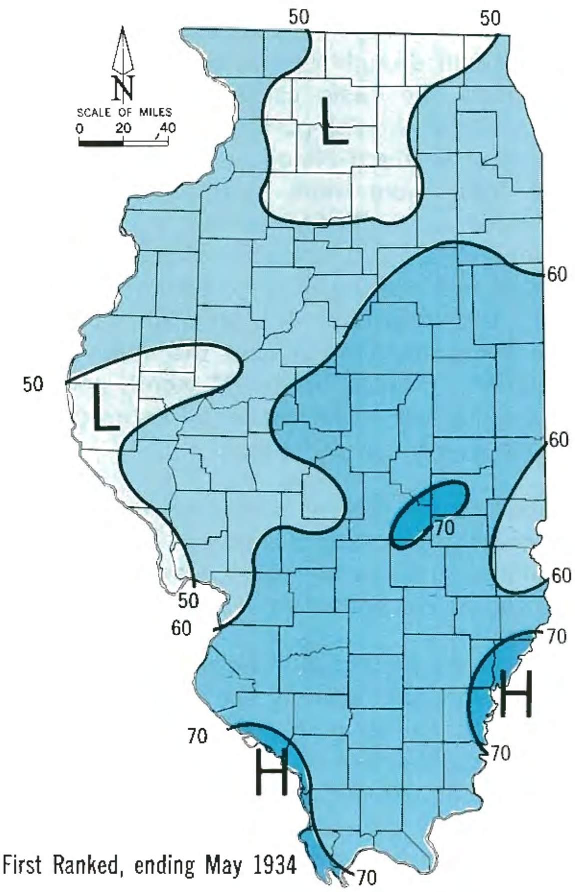
There were no significant differences in the severity or number of dry periods before and after 1906. However, the droughts of the 1930 through 1936 period were marked by precipitation deficiencies greater than any of those measured in the 1856 through 1905 period. Hence, the droughts in the 1930 through 1936 period in Illinois must be considered the design droughts of record.

Drought Patterns and Geographic Distribution

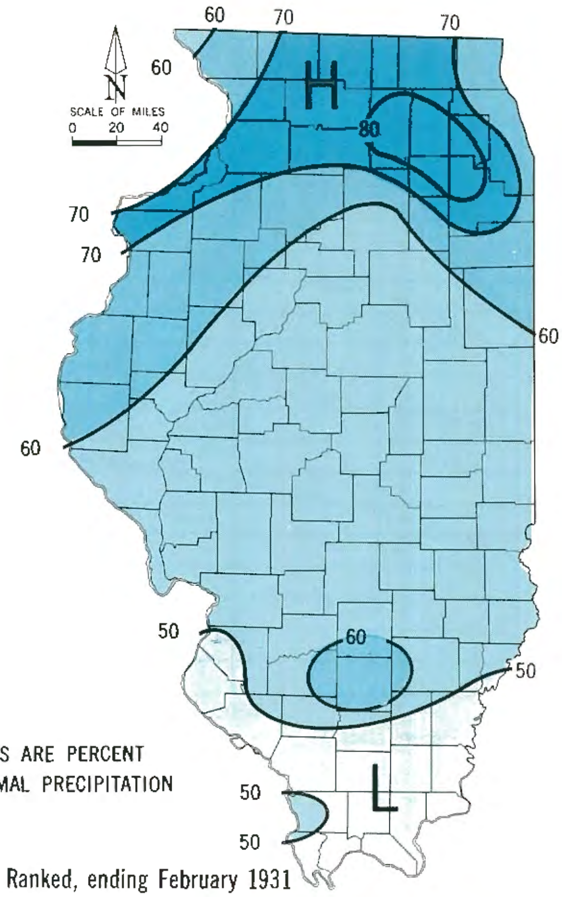
The 12-month droughts are considered representative of the drought regime in Illinois. The patterns of four actual 12-month droughts in Figure 8 indicate considerable areal variability. By the definition used, these droughts are statewide, but one or more areas had the most extreme precipitation deficiency in each drought. The drought ending in July 1954 was the worst on record in south-central Illinois, where precipitation was lower than 50 percent of normal; 80 miles north precipitation was above normal. The drought ending in February 1931 (Figure 8b) ranked as the most severe on record in extreme southern Illinois and in east-central Illinois. In the remaining parts of Illinois the 12-month drought ending in May 1934 (Figure 8a) produced the lowest 12-month totals during the 1906 through 1965 period.

The severe areas of the 12-month droughts have occurred most frequently in southwestern, northeastern, and extreme southern Illinois and least frequently in eastern and central Illinois. Seven of the thirteen 12-month droughts were most severe in a region in west-southwestern Illinois. The other three drought durations had similar areal-frequency distributions, although the areas of maximum frequency for the severe drought areas of 24-month and 36-month droughts are in extreme southern Illinois, rather than in west-southwestern Illinois.

FIGURE 8 PATTERNS OF ACTUAL 12 MONTH DROUGHTS

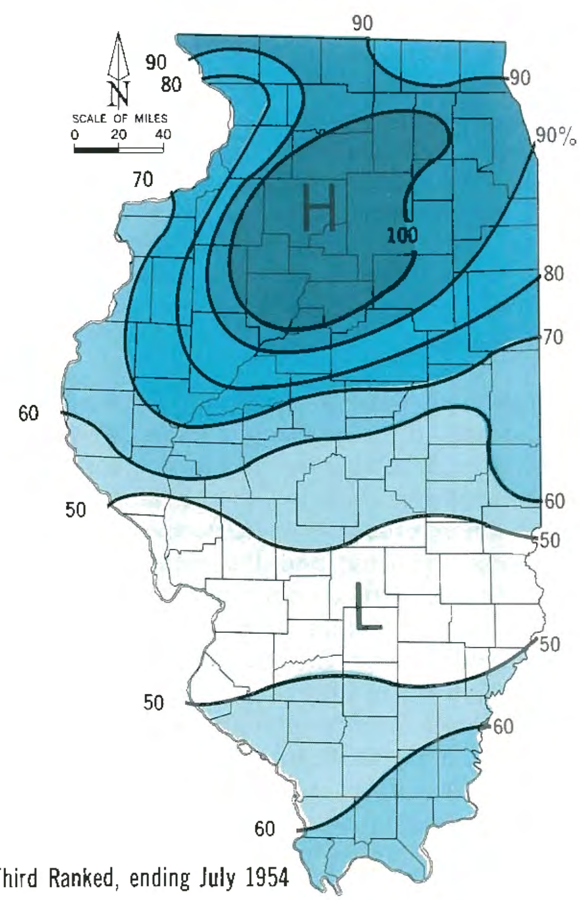


a. First Ranked, ending May 1934

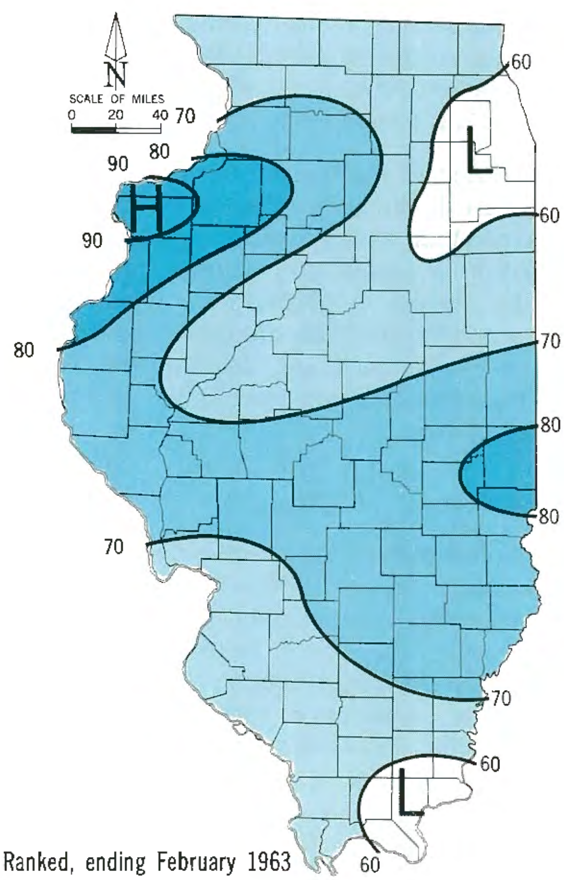


NUMBERS ARE PERCENT OF NORMAL PRECIPITATION

b. Second Ranked, ending February 1931



c. Third Ranked, ending July 1954



d. Fifth Ranked, ending February 1963

FIGURE 9

DROUGHTS EXPECTED TO OCCUR AT LEAST ONCE EVERY 20 YEARS

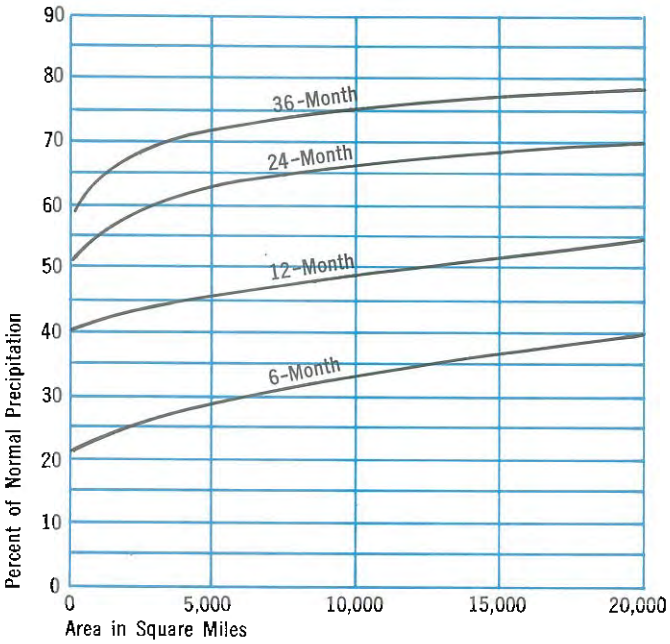


Figure 9 indicates that at least once in a 20-year period, 6000 square miles of Illinois will experience less than 30 percent of normal precipitation in a 6-month period. Similarly, the severest 12-month droughts to be expected will be associated with precipitation deficiencies of 55 percent of normal over 20,000 square miles.

Comparison of the frequency maps for the different durations of droughts (Figures 10-13) reveals that, in general at all frequencies, precipitation will be lowest in southern and southwestern Illinois and will be highest in northeastern Illinois. Precipitation droughts in Illinois are most frequent and most severe in southern and southwestern Illinois and are least frequent and least severe in northern and eastern Illinois.

Meteorology of Droughts

A complete meteorological description of all droughts in the 1906 through 1965 period is impossible, since the necessary weather data is not available for the years prior to 1940. A meteorological description of the severe 1953 through 1955 droughts illustrates the atmospheric conditions and the causes of a specific Illinois drought. A general expression of the meteorology of all droughts is provided by a comparison of the drought-frequency patterns with other climatological patterns derived from available surface-weather data collected throughout the 60-year sampling period.

The meteorological conditions associated with the 12-month drought ending in July 1954 (Figure 8c) indicate the basic causes for this drought. The number of frontal passages in the severe drought area of southern Illinois was near-normal, but many of these were weak, rapidly-moving systems not conducive to heavy rainfall. In this particular drought area it rained less often than normal; when rain fell, the amounts were frequently less than 0.5 inch in a day. The atmospheric moisture content was near-normal, but the above-normal temperatures throughout the 12-month period kept the humidity low. The number of hours of rainfall was only 34 percent of normal.

The drought pattern is inversely related to the mean annual precipitation pattern. In areas where the annual precipitation is greatest, the droughts are most severe and most frequent (Figure 11).

The mean pattern of thunderstorms and the drought frequency and severity are related. Thunderstorms account for 50 percent of the rainfall in southern and southwestern Illinois, where droughts are most severe and frequent; they account for less than 40 percent of the rainfall in northern Illinois, where droughts are least severe and least frequent. Severe short-duration rainstorms and other severe weather such as hail and lightning are most frequent in the south-central area, where droughts are most frequent, which shows a correlation between droughts and other weather extremes. Convective-type clouds, on the average, are more frequent in the parts of Illinois where droughts are most frequent and severe. In general, these comparisons of climatological data and droughts suggest that decreased convective activity during droughts is the major cause of the differences in the severity and frequency of droughts.

The basic weather pattern for droughts in Illinois consists of a blocking continental high pressure system, accompanied by a strong band of westerlies in southern Canada. In the Illinois area, such a situation produces rapidly-moving, weak lows and frontal systems, and the major low pressure systems frequently do not cross the State. The position of the major drought areas within Illinois is largely determined by the position of these large-scale drought-producing circulation patterns relative to the State. Since droughts are most severe and frequent in the southern half of Illinois, it appears that these large-scale drought-producing conditions are frequently positioned as they were in the 1953 through 1954 period.

FIGURE 10 FREQUENCY OF 6-MONTH DROUGHT PERIODS

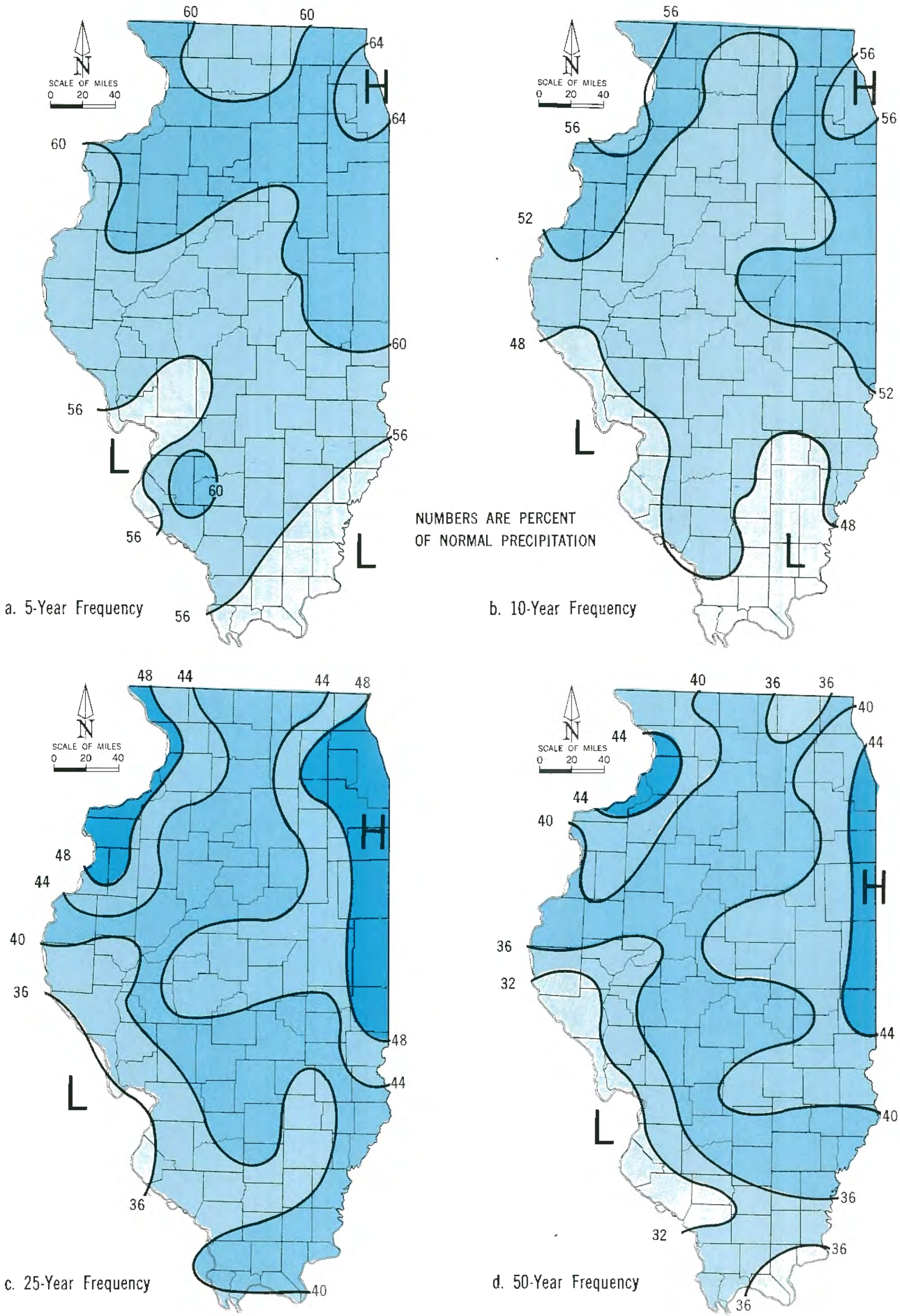


FIGURE 11

FREQUENCY OF 12-MONTH DROUGHT PERIODS

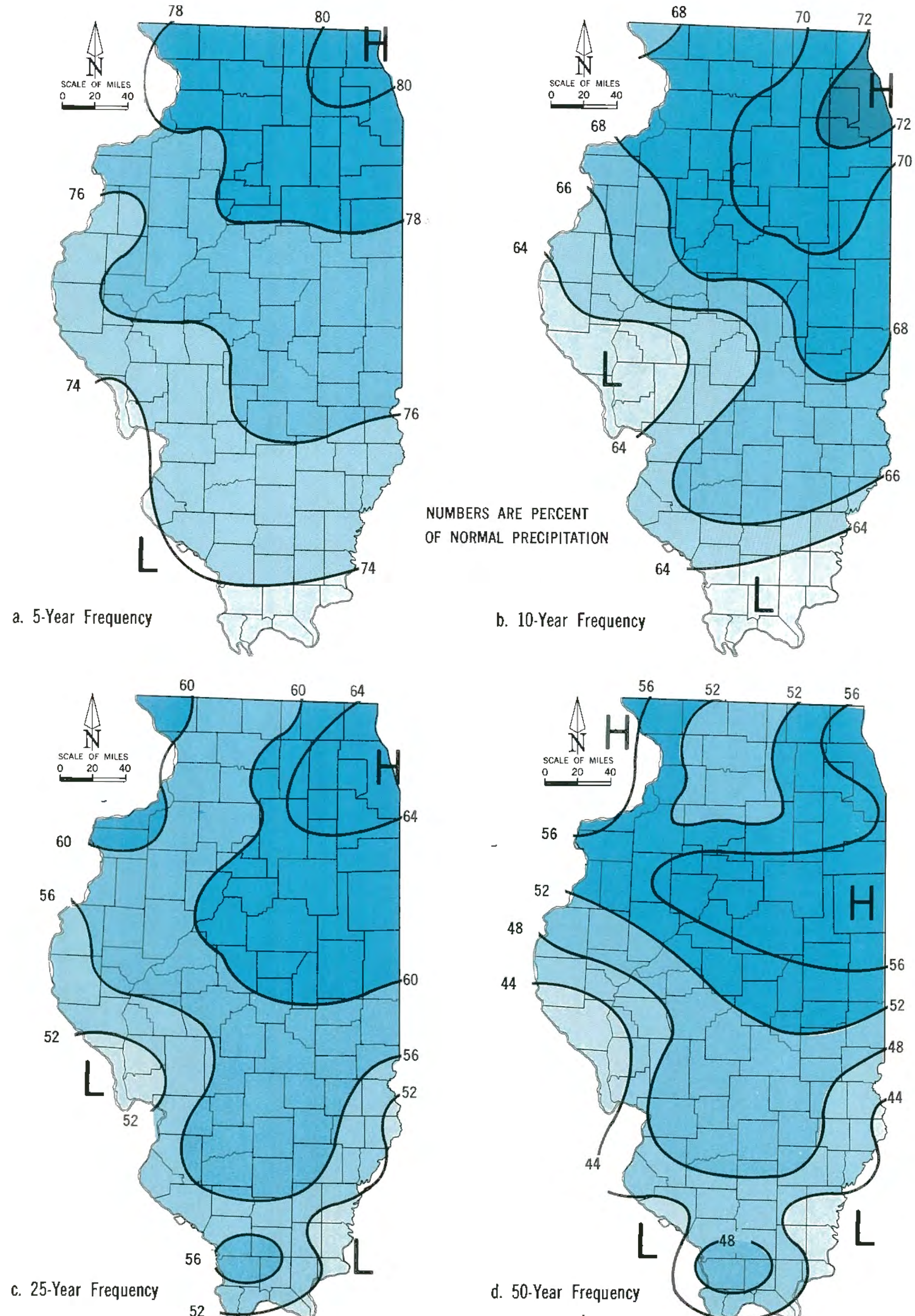


FIGURE 12

FREQUENCY OF 24-MONTH DROUGHT PERIODS

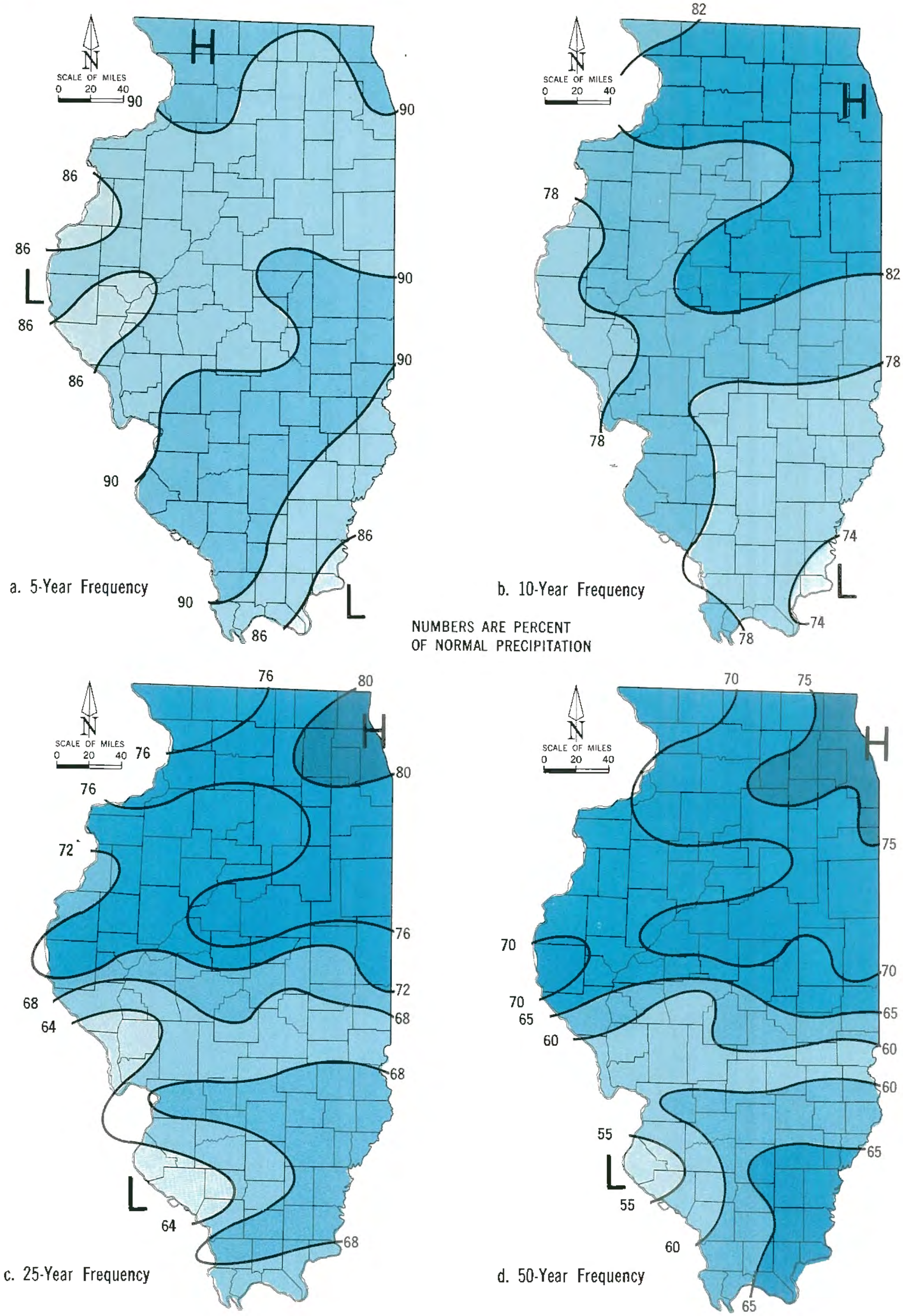
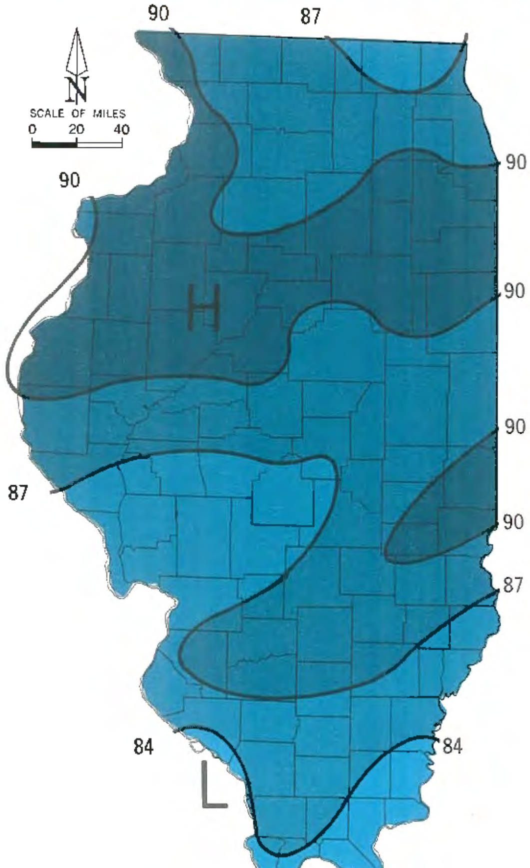
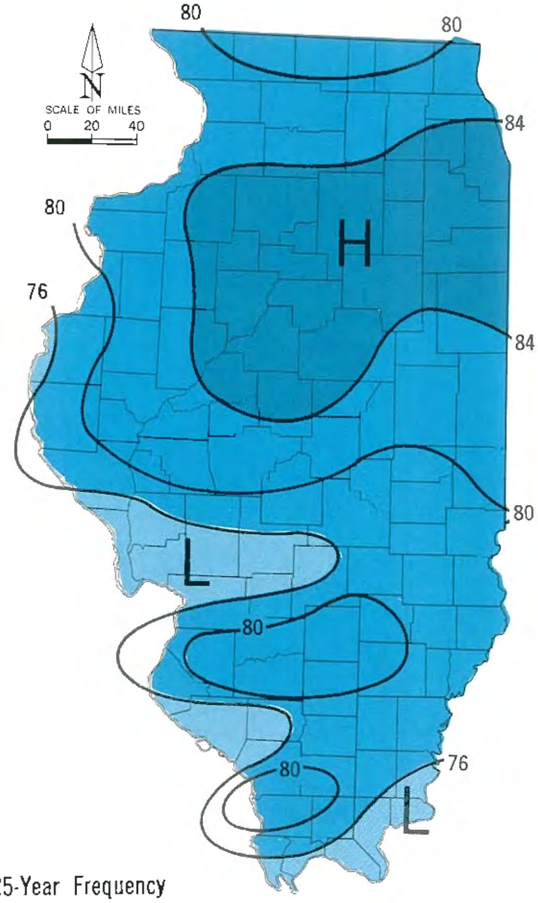


FIGURE 13

FREQUENCY OF 36-MONTH DROUGHT PERIODS

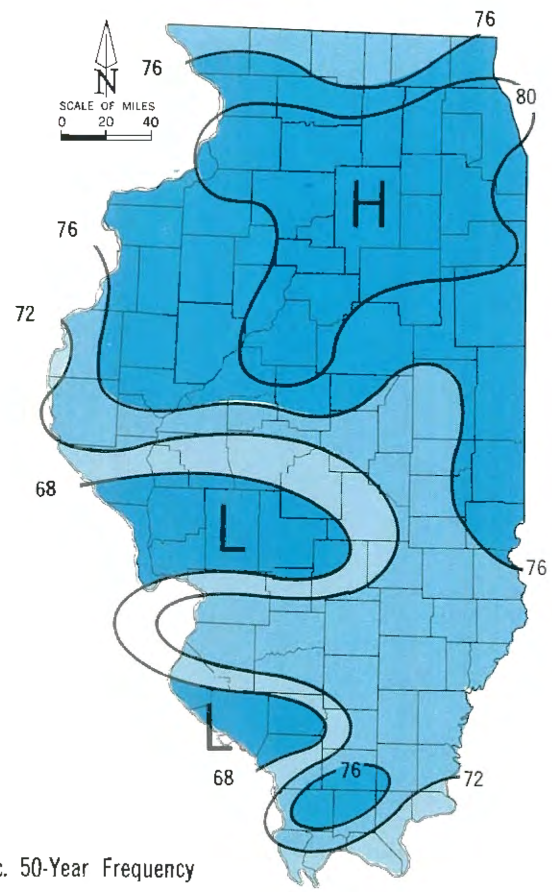


a. 10-Year Frequency



b. 25-Year Frequency

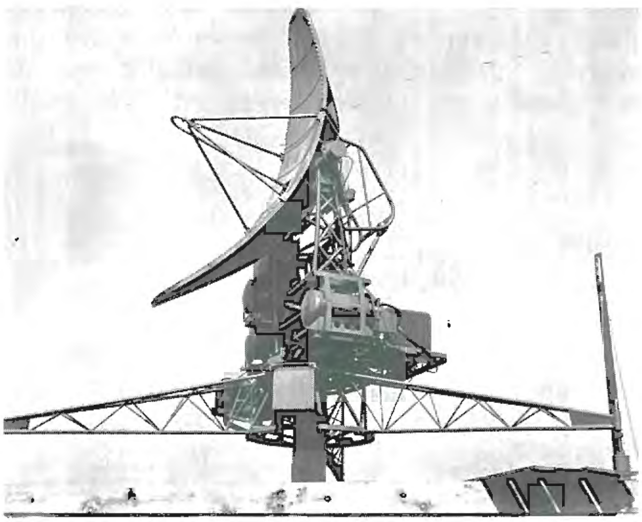
NUMBERS ARE PERCENT OF NORMAL PRECIPITATION



c. 50-Year Frequency

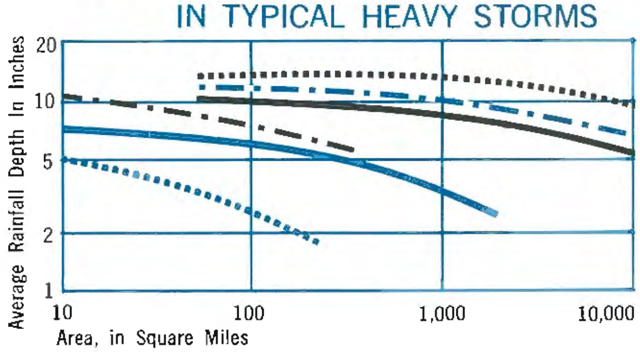
HEAVY RAINSTORMS

Flood-producing storms may occur at any time in Illinois, but the frequency is greatest from late spring to early fall. Winter storms are restricted mostly to the southern part of the State. Basically, flood-producing storms are of two types: the cold-season storms over a large area, which frequently produce copious rainfall for periods of from two to five days; and the warm-season storms of mid-April to mid-October in which the major portion of the storm rainfall usually occurs in less than 24 hours and is much more intense at the storm center than in the cold-season storms. In the excessive rainstorms of late spring to early fall, the areal extent may vary from a few square miles to thousands of square miles (Figure 14), depending upon the current (synoptic) weather conditions with which the storms are associated.



Radar antenna used for tracking and studying storms and measuring precipitation.

FIGURE 14 AREA—DEPTH RELATIONS IN TYPICAL HEAVY STORMS

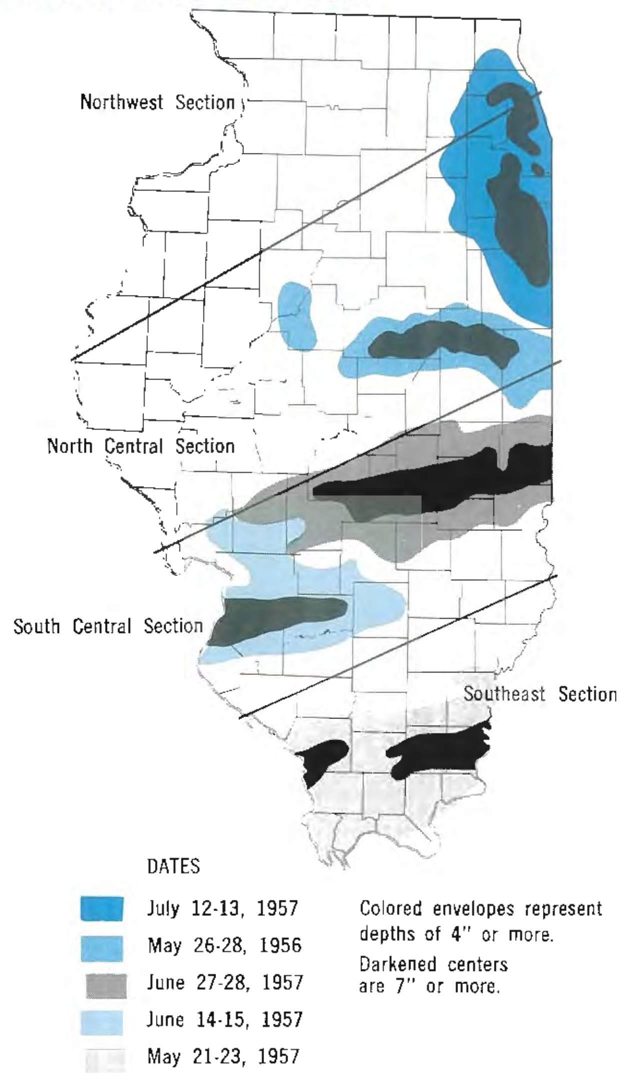


Date	Duration	Location
May 5-9, 1961,	96 Hours;	South Central—Southeast
June 27-28, 1957,	18 Hours;	South Central
January 20-24, 1937,	120 Hours;	Southeast
July 18, 1952	6 Hours;	Northwest
May 20, 1959,	6 Hours;	North Central
June 6, 1961,	4 Hours;	North Central

The characteristics of outstanding flood-producing storms are illustrated in Figure 14, through the use of area-depth relations for selected storms of winter, spring, and summer. Locations correspond to those sections used in previous rainfall frequency studies and outlined in Figure 15.

FIGURE 15

MAJOR RAINSTORMS DURING 1956 AND 1957

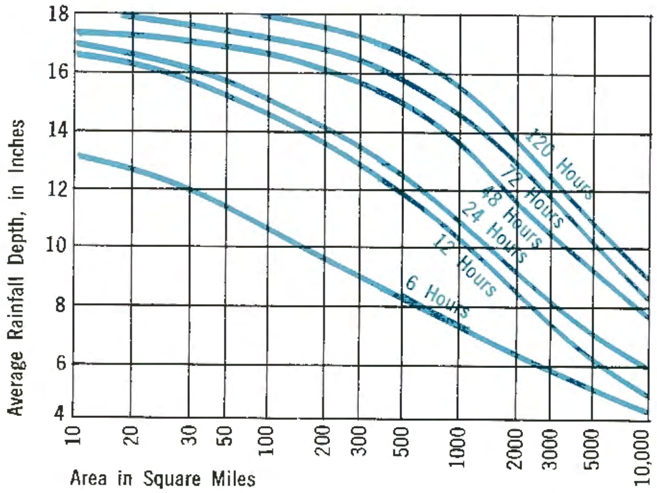


Distribution of Severe Rainstorms

Historically, the most severe rainstorms have occurred in the south-central section of the State. When the centers of the ten heaviest rainstorms during the 50-year period, 1914 through 1963, were plotted, it was found that the probability of such a storm is much greater in south-central Illinois than in other parts of the State. However, when the definition of an extreme storm was broadened to include 25 storms of large areal extent in the same period, the region most likely to have such a storm shifted to the southeast. This

FIGURE 16

AREA DEPTH ENVELOPE OF ILLINOIS STORMS, 1887 - 1965



shift is due primarily to the strong tendency for cold-season storms to occur in the extreme southern part of the State.

Severe rainstorms of large areal extent are most likely to occur in late spring and early fall. Of 127 storms in which the average rainfall for periods of 48 hours or less exceeded 3 inches over an area of 10,000 square miles, approximately 38 percent occurred in May, September, and October. Storms with the heaviest rain intensities at their centers occur predominately in summer, but these storms tend to cover a smaller area than spring and fall storms.

Storms with durations of 72 hours or less are generally elliptical in shape and are most frequently oriented from WSW-ENE through W-E to WNE-ESE.

Figures 16, 17, and 18 show storm envelopes and probable maximum estimates of precipitation in heavy rainstorms in Illinois. Figure 19 shows the frequency distribution of point rainfall in each of four climatic sections for varying time periods.

FIGURE 17

PROBABLE MAXIMUM PRECIPITATION

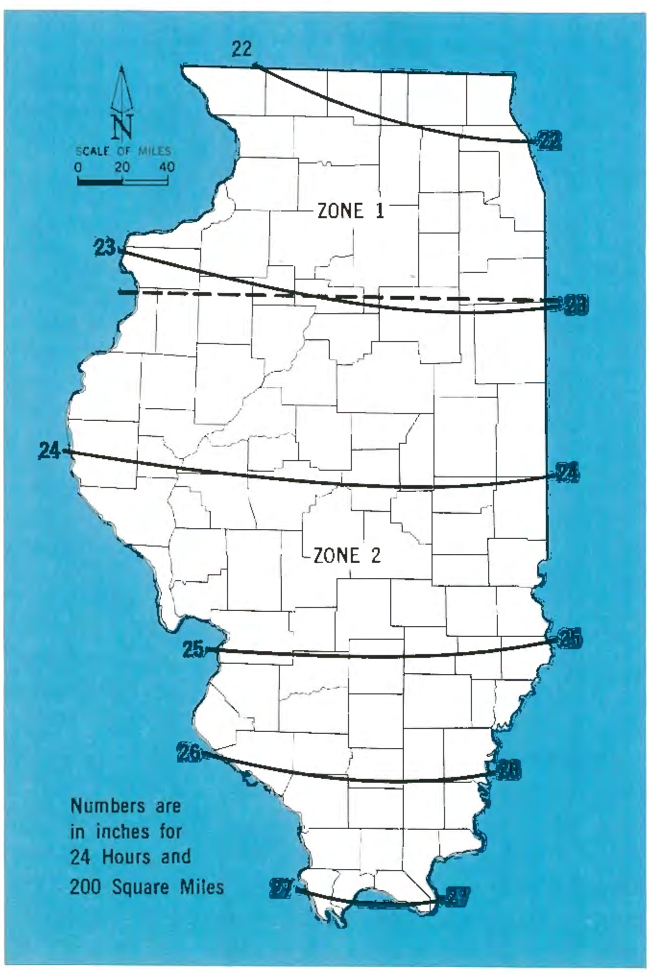
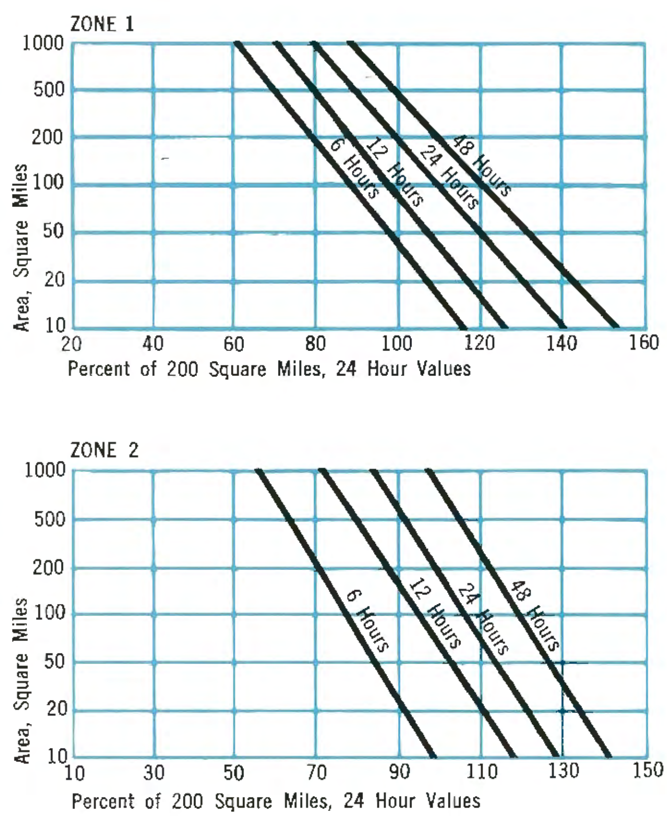


FIGURE 18

DEPTH — AREA — DURATION RELATIONS

Percentages to be Applied to 200 Square Miles, 24 Hour Probable Maximum Precipitation



FIGURES 16, 17, and 18

Figure 16 shows the highest mean rainfall recorded in outstanding Illinois storms from 1887 to 1965. Most of the values from which the envelope curves were derived came from two extremely heavy rainstorms. The majority of the values for the shorter durations of 6 to 24 hours were recorded in the southwestern Illinois storm of June 14 and 15, 1957; most of the longer duration values were recorded in another southwestern Illinois storm on August 12 through 16, 1946.

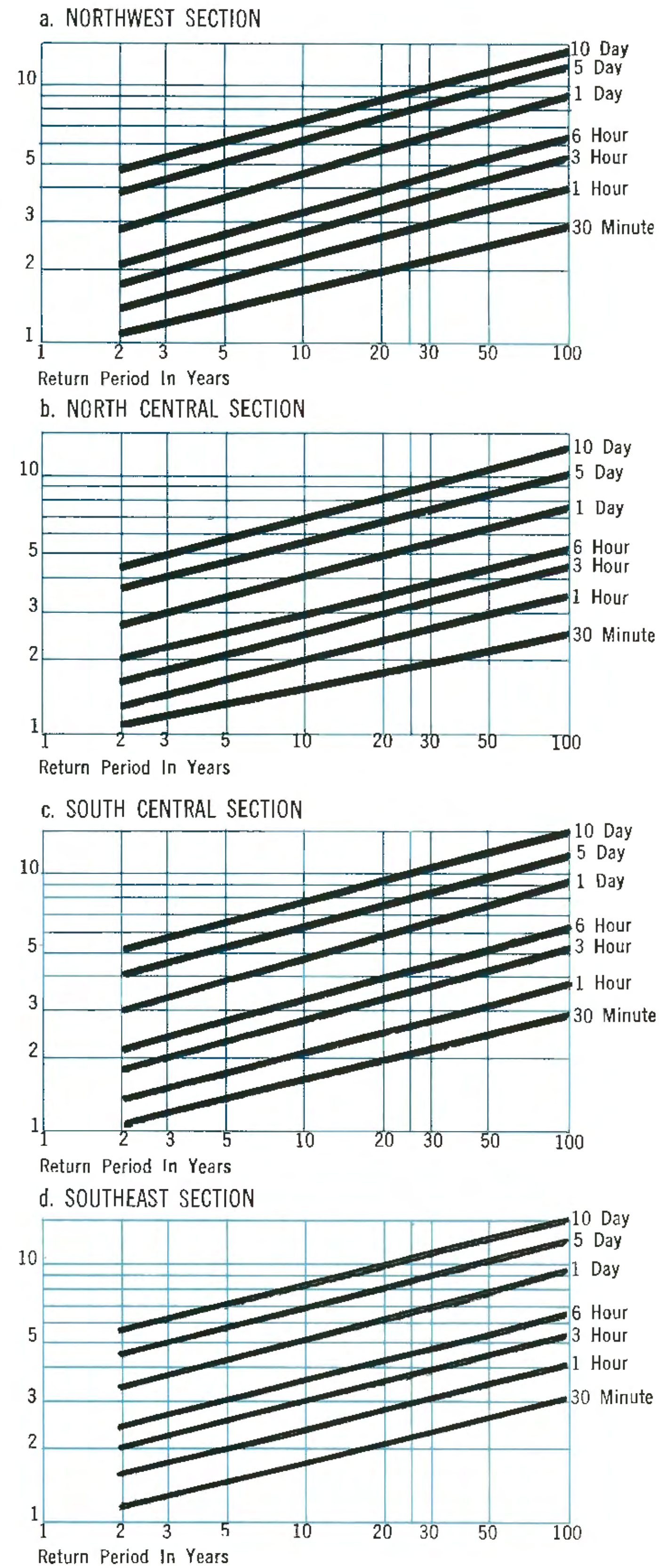
Interpretation of Figure 16 is illustrated by the following example. To find the heaviest average rainfall on record anywhere in Illinois over a contiguous area of 1000 square miles for a storm period of 24 hours, move upward from 1000 on the horizontal axis to the curve for 24 hours, then move horizontally to the vertical axis on the left which provides the desired value of 11 inches. Figure 17 can be used in conjunction with the graphs in Figure 18 to estimate precipitation for areas and durations in Zones 1 and 2 other than those shown. By definition, the probable maximum precipitation is the critical depth-duration-area relation which would result if conditions during an actual storm were increased to represent the most critical meteorological conditions considered probable. Comparison of the probable maximum estimates of Figures 17 and 18 with the maximum observed rainfall of Figure 16 shows that, in general, the observed values have been 50 to 60 percent of the probable maximum values. Source of data: Hydro-Meteorological Report Number 33, U. S. Weather Bureau.

FIGURE 19

To determine the average point rainfall for a storm period of six hours which will be equaled or exceeded on the average of once in 10 years at a location in the northwest section, move vertically from the 10-year point on the horizontal axis of the northwest curves to the 6-hour curve, then move horizontally to the vertical axis on the left to obtain the value of 3.1 inches. These data for point rainfall should not be confused with areal mean rainfall data, which are discussed in previous sections of this report. Source of data: Bulletin 46 and Technical Letters 1 and 2, State Water Survey.

FIGURE 19

AVERAGE POINT RAINFALL FREQUENCY RELATIONS



WEATHER MODIFICATION

Weather modification is still a limited and uncertain practice, but is potentially a method of controlling water resources. Since 1947 experiments have been conducted throughout the United States and in more than 40 other nations.* The experiments have been designed to dissipate clouds, disperse fog, increase rain and snowfalls, and inhibit hail and lightning. Attempts have also been made to modify the temperature and change the course of large-scale weather systems. Many techniques for weather modification, based upon partial understanding of the relevant atmospheric processes, have been developed.

Of all the possibilities in weather modification, cloud seeding to increase or decrease rainfall has received the most widespread attention. Cloud seeding with silver iodide is the most commonly used technique. Commercial seeders have made enthusiastic claims of success, but the reaction of research scientists has been much more guarded. Many difficulties arise in designing experiments to evaluate the effectiveness of cloud seeding; many experiments have been inconclusive or of unacceptable design. Strong controversy as to the effectiveness of cloud seeding still exists.

In a 1966 report, the Panel on Weather Modification of the National Academy of Sciences and National Research Council concluded: "There is increasing but still somewhat ambiguous statistical evidence that precipitation from some types of cloud and storm systems can be modestly increased or redistributed by seeding techniques." The Panel stressed the great need for basic research in cloud physics and for scientifically designed field experiments to define accurately the effects of cloud seeding. Nevertheless, the results of any seeding program undertaken at this time are unpredictable.

THE ECONOMIC POTENTIAL OF CLOUD SEEDING

If cloud seeding can successfully increase or decrease rainfall, its potential influence on the economy is tremendous. Many possible applications would benefit recreation, tourism, and military defense, but the greatest immediate potential appears to be for agriculture, municipal water supply, hydroelectric power, industry, and forestry.

* Part of the material presented here was abstracted from a recent Canadian report by Crozier and Holland, "Cloud Seeding to Influence Rainfall—Its Importance and Present Status."

Rainfall augmentation programs to benefit agriculture must be well managed. In some situations it would be helpful and in others it would be imprudent to undertake a rainfall augmentation program based on present knowledge and techniques. The usefulness of such a program in years when it is normally dry is questionable. A small amount of water might be added, but it would likely be much less than is needed. However, in areas where crop production is marginal because of water shortages, a rainfall augmentation program with adequate ground storage and distribution facilities could perhaps significantly increase the annual productive water supply, if it were operated during years of above-normal rainfall to supplement below-normal years.

Similarly, cloud seeding is not practical to relieve shortages in municipal water supplies during severe droughts. Occasionally, temporary disruptions of drought conditions may occur; seeding might produce positive results under these conditions. Routine seeding to augment water supplies during near-normal or above-normal periods of rainfall would be considerably more valuable. The possibility of detrimental effects—floods, increased soil erosion, and reservoir sedimentation—from intensification of natural rainfall rates has not been satisfactorily evaluated; therefore, any seeding program at this time risks these effects.

LEGAL ASPECTS OF CLOUD SEEDING

A number of states have recently passed laws that provide for governmental control of cloud seeding, and several have passed or considered laws prohibiting weather modification. Very little cloud seeding has been attempted in Illinois, so the need for legislation has not arisen. However, legislation may be needed in the future, if commercial cloud seeding activities should expand substantially in Illinois as the result of a severe drought or other extreme weather. Because weather modification creates both interstate and international problems, it is likely that Federal legislation to control weather modification will be passed—when and if the efficacy of weather control is satisfactorily proved.

STATUS OF RESEARCH

Most of the research on weather modification in the United States in recent years has been supported by funds from the National Science Foundation and the Bureau of Reclamation. Research is now concentrated west of the Mississippi River, primarily in the Mountain States and the Upper Great Plains. The U. S. Weather Bureau plans an extensive experiment in the near future to determine the efficacy of seeding in the eastern United States. Research on cloud seeding and hail suppression is also underway in Illinois. Two bills which provide for much larger commitment of Federal funds for weather modification research were introduced in the Senate in February 1966, but have not yet been acted upon.

STREAMFLOW

In order to predict how much water is available for use or for carrying away wastes, it is important to know how much water flows in Illinois streams at various times.

Streamflow is continuously recorded at about 150 locations along the streams of the State. Continuous streamflow records are available from 97 gaging stations for the 15-year period from 1950 through 1964. The gaging stations are operated by the U. S. Geological Survey; one-half of the cost is paid by State and local agencies.

The average runoff of streams is about 9 inches a year in most of central Illinois and about 15 inches in southern Illinois. Runoff is a major water resource because it can be taken directly from a stream and used, or it can be stored in a reservoir and used as needed. Another section of this report deals extensively with conservation of runoff water by storing it in impounding reservoirs.

In order to take water directly from a stream for use, the variability in the flow of the stream must be known. This variability is often expressed as the probability that a certain flow will be present in the stream—the more variable the streamflow, the less dependable the supply.

One indicator of the variability of flow in a particular stream is the amount of the median flow, or the flow which is present in the stream for half the days of the year. It is important to know how low the flow in the stream might be at certain times. The flow available 95 percent of the days is a meaningful measure that indicates either the tendency of a stream to go dry or to remain flowing during dry periods.

Obviously, if the flow on 95 percent of the days is large, a relatively large water supply can be taken directly from the stream. If the flow is small, an impounding reservoir to store the water for use in dry periods would be necessary.

FIGURE 20
LOCATION OF
STREAM GAGING STATIONS IN ILLINOIS

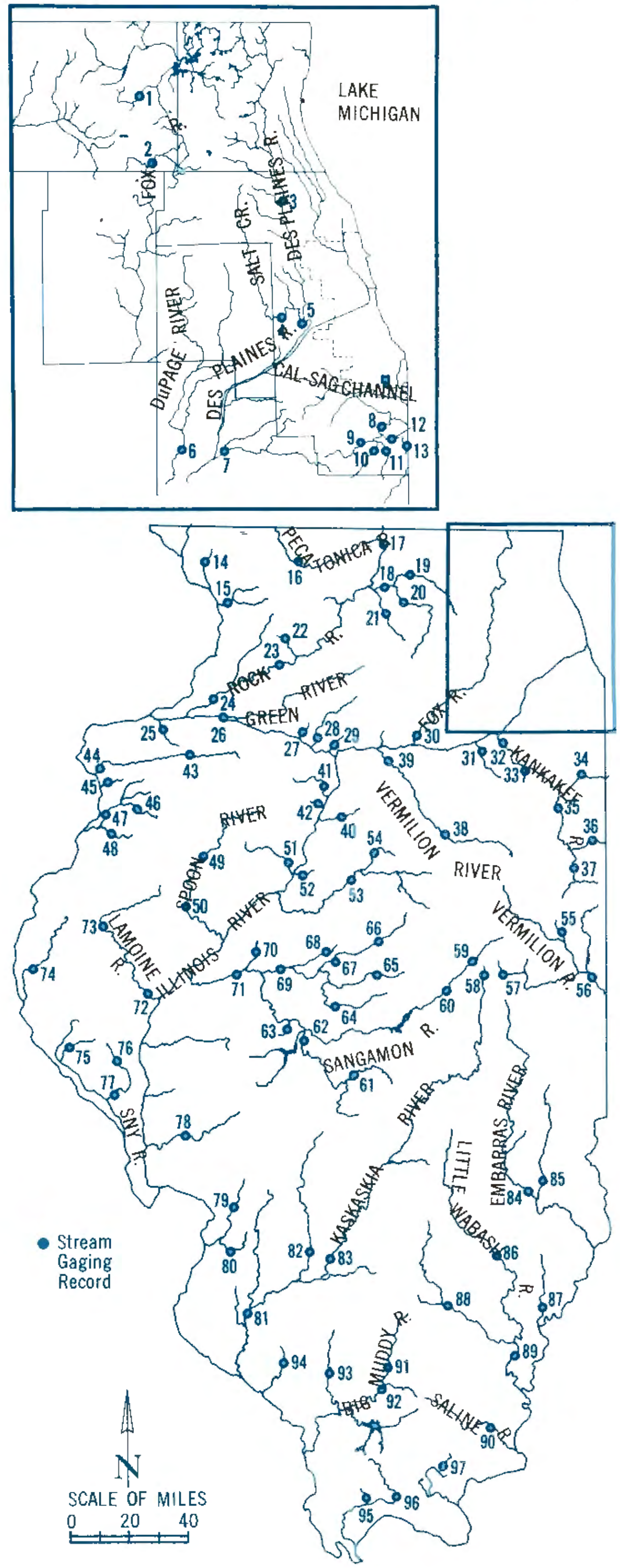


FIGURE 21

AVERAGE ANNUAL RUNOFF IN CFS PER SQUARE MILE

FIGURE 21

To obtain the average streamflow in cfs, multiply a value taken from the map by the drainage area in square miles at a particular location. Multiplying the flow rate in cfs by 0.646 gives million gallons per day.

Table 1 gives the flow distribution at 97 gaging locations which are shown on Figure 20. Figure 21 shows annual average runoff. Figure 22 is a sample of complete flow duration curves corresponding to the data in Table 1.

TABLE 1

FLOW DATA FOR ILLINOIS STREAMS BASED ON THE 15-YEAR PERIOD 1950 THROUGH 1964

Map No.	Station	Drainage Area sq mi	Flow cfs per sq mi 95 percent of days	50 percent of days	5 percent of days
14.	Apple River near Hanover	244	0.1066	0.258	2.30
77.	Bay Creek at Nebo	162	0.0006	0.068	1.46
76.	Bay Creek at Pittsfield	39.6	0.0028	0.038	1.34
74.	Bear Creek near Marcelline	348	0.0000	0.025	1.84
93.	Beaucoup Creek near Matthews	291	0.0003	0.079	4.26
95.	Big Creek near Wetaug	32.2	0.0077	0.177	4.84
91.	Big Muddy River near Benton	498	0.0024	0.088	4.04
92.	Big Muddy River at Plumfield	753	0.0033	0.100	4.56
55.	Bluegrass Creek at Potomac	34.8	0.0000	0.175	3.19
57.	Boneyard Creek at Urbana	4.64	0.2155	0.517	3.45
87.	Bonpas Creek at Browns	228	0.0000	0.061	5.57
1.	Boone Creek near McHenry	15.3	0.3007	0.536	1.63
28.	Bureau Creek at Princeton	186	0.0091	0.183	2.26
9.	Butterfield Creek at Flossmoor	23.4	0.0128	0.141	2.65
96.	Cache River at Forman	242	0.0015	0.169	5.58
80.	Canteen Creek at Caseyville	22.5	0.0122	0.156	2.27
46.	Cedar Creek at Little York	128	0.0508	0.258	2.02
70.	Crane Creek near Easton (Mason County)	28.7	0.0732	0.293	1.39
41.	Crow Creek (West) near Henry	55.3	0.0030	0.172	2.04
40.	Crow Creek near Washburn	123	0.0000	0.114	1.76
11.	Deer Creek near Chicago Heights	23.2	0.0216	0.129	2.41
3.	DesPlaines River near DesPlaines	359	0.0097	0.167	2.36
5.	DesPlaines River at Riverside	635	0.0252	0.233	2.30
6.	DuPage River at Troy (Will County)	325	0.0954	0.308	2.30
54.	E. Branch Panther Creek at El Paso	28.8	0.0000	0.073	2.47
29.	East Bureau Creek near Bureau	101	0.0000	0.097	1.80
44.	Edwards River near New Boston	434	0.0230	0.214	2.07
43.	Edwards River near Orion	163	0.0172	0.209	1.84
22.	Elkhorn Creek near Penrose	153	0.1176	0.281	1.33
84.	Embarras River at St. Marie	1513	0.0119	0.236	3.17
52.	Farm Creek at East Peoria	60.9	0.0148	0.107	2.18
61.	Flat Branch near Taylorville	279	0.0000	0.136	2.43
2.	Fox River at Algonquin	1364	0.0880	0.323	1.75

Map No.	Station	Drainage Area sq mi	Flow cfs per sq mi 95 percent of days	50 percent of days	5 percent of days
30.	Fox River at Dayton	2570	0.1089	0.378	1.86
42.	Gimlet Creek at Sparland	5.42	0.0000	0.111	2.40
26.	Green River near Geneseo	958	0.0605	0.270	1.84
75.	Hadley Creek at Kinderhook	72.7	0.0000	0.069	1.58
97.	Hayes Creek at Glendale	18.9	0.0000	0.122	5.40
47.	Henderson Creek near Oquawka	428	0.0234	0.208	1.96
7.	Hickory Creek at Joliet	107	0.0430	0.206	2.57
79.	Indian Creek at Wanda	37.0	0.0000	0.043	2.05
35.	Iroquois River near Chebanse	2120	0.0217	0.257	2.91
36.	Iroquois River at Iroquois	682	0.0249	0.287	2.96
34.	Kankakee River at Momence	2340	0.2184	0.624	2.06
32.	Kankakee River near Wilmington	5250	0.1128	0.452	2.25
58.	Kaskaskia River near Bondville	12.3	0.0083	0.228	2.68
83.	Kaskaskia River at Carlyle	2680	0.0138	0.235	2.82
81.	Kaskaskia River at New Athens	5220	0.0172	0.207	2.51
67.	Kickapoo Creek near Lincoln	306	0.0131	0.150	2.01
51.	Kickapoo Creek at Peoria	296	0.0135	0.149	1.69
66.	Kickapoo Creek at Waynesville	227	0.0062	0.150	1.94
21.	Killbuck Creek near Monroe Center	114	0.0395	0.175	1.74
19.	Kishwaukee River at Belvidere	525	0.0838	0.291	1.74
18.	Kishwaukee River near Perryville	1090	0.0780	0.268	1.84
64.	Lake Fork near Cornland	207	0.0164	0.150	2.36
73.	LaMoine River at Colmar	655	0.0047	0.116	2.15
72.	LaMoine River at Ripley	1310	0.0115	0.115	2.37
13.	Lansing Ditch near Lansing	8.7	0.0170	0.264	3.33
89.	Little Wabash River at Carmi	3111	0.0048	0.151	3.21
86.	Little Wabash River below Clay City	1134	0.0018	0.108	3.84
53.	Mackinaw River near Congerville	764	0.0054	0.134	2.23
78.	Macoupin Creek near Kane	875	0.0031	0.062	1.71
94.	Mary's River near Sparta	17.8	0.0000	0.011	2.87
31.	Mazon River near Coal City	470	0.0009	0.085	2.40
25.	Mill Creek at Milan	62.5	0.0048	0.160	1.89
12.	North Creek near Lansing	16.7	0.0130	0.204	3.47

Map No.	Station	Drainage Area sq mi	Flow cfs per sq mi 95 percent of days	50 percent of days	5 percent of days
85.	North Fork Embarras River near Oblong	319	0.0009	0.110	3.54
16.	Pecatonica River at Freeport	1330	0.1759	0.403	1.80
15.	Plum River below Carroll Creek near Savanna	231	0.0649	0.225	2.03
45.	Pope Creek near Keithsburg	171	0.0199	0.187	1.89
23.	Rock River at Como	8700	0.1414	0.383	1.54
24.	Rock River near Joslin	9520	0.1471	0.399	1.58
17.	Rock River at Rockton	6290	0.1528	0.388	1.59
90.	Saline River near Junction	1040	0.0048	0.135	5.77
69.	Salt Creek near Greenview	1800	0.0444	0.193	2.03
65.	Salt Creek near Rowell	334	0.0150	0.177	2.43
4.	Salt Creek at Western Springs	114	0.0482	0.307	2.92
59.	Sangamon River at Mahomet	356	0.0056	0.174	2.81
60.	Sangamon River at Monticello	550	0.0098	0.191	2.60
71.	Sangamon River near Oakford	5120	0.0447	0.225	2.27
82.	Shoal Creek near Breese	760	0.0059	0.099	2.92
88.	Skillet Fork at Wayne City	464	0.0006	0.069	4.94
49.	Spoon River at London Mills	1070	0.0196	0.205	1.99
50.	Spoon River at Seville	1600	0.0225	0.228	2.14
63.	Spring Creek near Springfield	107	0.0000	0.086	2.15
20.	S. Branch, Kishwaukee River near Fairdale	386	0.0337	0.189	2.28
62.	S. Fork Sangamon River near Rochester	872	0.0034	0.135	2.33
48.	S. Henderson Creek at Biggsville	81.4	0.0000	0.147	1.84
68.	Sugar Creek near Hartsburg	335	0.0338	0.173	1.93
37.	Sugar Creek at Milford	430	0.0163	0.209	3.21
33.	Terry Creek near Custer Park	12	0.0250	0.283	2.25
10.	Thorn Creek at Glenwood	24.6	0.4472	0.813	3.25
8.	Thorn Creek at Thornton	104	0.1442	0.337	3.37
56.	Vermilion River near Danville	1279	0.0305	0.262	2.91
39.	Vermilion River at Lowell	1230	0.0081	0.168	2.41
38.	Vermilion River at Pontiac	568	0.0046	0.125	2.46
27.	West Bureau Creek at Wyanet	83.3	0.0000	0.144	1.98

FIGURE 22 FLOW DURATION CURVES FOR ILLINOIS STREAMS

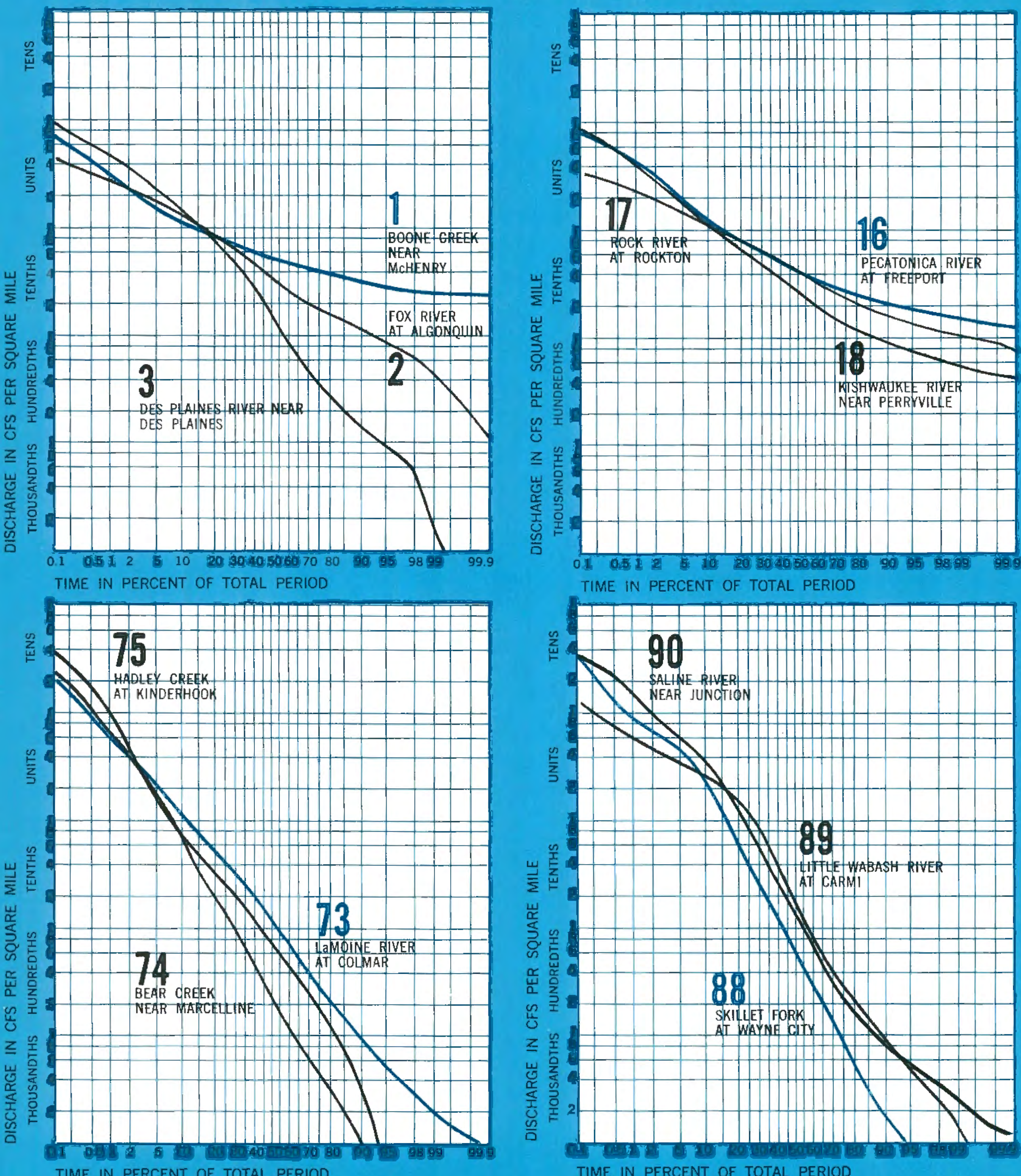


FIGURE 22 The flow duration curves are generally representative of Illinois conditions. Identification numbers refer to the stream gaging station numbers in Figure 20. To determine the flow in cfs which will be equaled or exceeded, multiply the discharge by the drainage area in square miles. These flow-duration curves were derived from records of daily discharges. From the flow-duration curve for each station, the flow values expected 95 percent, 50 percent, and 5 percent of the time are shown in Table 1. Information on flow duration for all the 97 stream gaging stations in Illinois is available from the State Water Survey.

EXISTING AND POTENTIAL RESERVOIRS

Illinois is bordered by three major rivers, the Mississippi on the west, the Ohio on the south, and the Wabash on the east. Internally the area is drained by the Rock, the Illinois, the Kaskaskia, the Big Muddy, the Embarras, and the Little Wabash Rivers, and by many smaller streams. Portions of the State are well supplied with ground water, but it is becoming increasingly clear that conservation methods of various kinds will be required, if we are to meet the demands of the future. One important means of conserving water is to capture flood runoff in a reservoir for use in dry seasons and droughts and to dilute wastes. Reservoir lakes can also be used for recreation and other purposes. Illinois has a number of large reservoirs and more are being planned or constructed; a large potential remains for the development of additional impoundments.

EXISTING RESERVOIRS, LAKES, AND FARM PONDS

Natural lakes in Illinois are confined to the northeastern portion of the State and are the result of juvenile drainage following the last glacial periods. Most of these are in the Fox Chain-O-Lakes region in Lake and McHenry Counties.

Man-made lakes or reservoirs have been developed throughout the State for various purposes. Some of the more notable are Crab Orchard Lake, Lake Springfield, Lake Decatur, Lake of Egypt, Horseshoe Lake, Lake Taylorville, CIPS Lake, Little Grassy, Raccoon Lake, Devils Kitchen Lake, New Mattoon Lake, and Lake Vermilion.

Illinois has 368 bodies of water of 40 acres or more with a total surface area of 138,317 acres (Table 2). The northern section of the State con-

TABLE 2 EXISTING RESERVOIR SITES OF 40 ACRES OR MORE

County	No. Sites	Pool Area (Acres)	Storage (Est.) (Ac-ft)
Northern			
Boone	0	—	—
Bureau	3	913	3,652
Carroll	1	3,550	14,200
Cook	15	3,367	21,012
DeKalb	0	—	—
DuPage	0	—	—
Grundy	0	—	—
Henry	3	193	1,505
Jo Daviess	6	626	4,046
Kane	1	42	168
Kendall	0	—	—
Lake	47	10,938	63,613
LaSalle	0	—	—
Lee	1	46	184
McHenry	13	1,892	11,734
Mercer	5	1,271	8,274
Ogle	1	44	176
Putnam	6	6,954	41,614
Rock Island	2	235	4,422
Stephenson	1	47	674
Whiteside	2	190	450
Will	9	759	3,503
Winnebago	1	162	2,326
Sub-Total	117	31,229	181,553
North-Central			
Adams	8	754	4,741
Brown	1	262	2,096
Cass	4	2,923	10,954
Champaign	0	—	—
Christian	4	1,612	*14,092
DeWitt	0	—	—
Ford	0	—	—
Fulton	12	*5,725	*18,975
Hancock	0	—	—
Henderson	2	293	1,758
Iroquois	1	130	780
Kankakee	1	45	180
Knox	3	362	5,040
Livingston	1	42	168
Logan	1	174	1,740
Macon	1	*2,805	*12,532
Marshall	4	4,785	15,985
Mason	27	12,781	50,763
McDonough	2	138	2,407
McLean	2	*645	*9,583
Menard	1	191	4,303
Morgan	4	*2,388	*13,337
Peoria	3	314	1,042
Piatt	0	—	—
Pike	14	2,132	13,170
Sangamon	3	4,337	*56,096
Schuyler	7	876	6,768
Scott	2	442	1,593
Stark	0	—	—
Tazewell	11	7,794	36,975
Vermilion	6	*995	*6,890
Warren	1	70	467
Woodford	2	3,540	11,900
Sub-Total	128	56,555	304,335
South-Central			
Bond	0	—	—
Calhoun	11	3,693	19,873
Clark	1	158	1,310
Clay	1	68	340
Clinton	1	12,500	233,000
Coles	3	1,788	*12,994
Crawford	0	—	—
Cumberland	0	—	—
Douglas	0	—	—
Edgar	2	*343	*2,980
Edwards	0	—	—
Effingham	1	586	13,810
Fayette	2	111	1,410
Greene	2	*92	*872
Jasper	0	—	—
Jersey	6	1,328	4,910
Lawrence	2	85	710
Macoupin	11	*979	*9,648
Madison	8	*3,374	*27,662
Marion	6	2,153	*17,141
Monroe	3	221	886
Montgomery	6	*2,943	*50,010
Moultrie	0	—	—
Richland	1	137	1,516
Shelby	0	—	—
St. Clair	1	197	591
Wabash	1	125	1,084
Washington	2	375	*3,672
Wayne	1	194	1,530
Sub-Total	72	31,450	405,949
Southern			
Alexander	1	2,400	4,800
Franklin	11	902	7,118
Gallatin	3	180	900
Hamilton	2	156	1,270
Hardin	1	135	945
Jackson	4	378	4,146
Jefferson	4	507	5,264
Johnson	1	74	740
Massac	1	690	2,760
Perry	3	540	4,282
Pope	1	79	632
Pulaski	0	—	—
Randolph	3	188	2,158
Saline	6	1,209	*9,449
Union	2	192	1,824
White	1	47	376
Williamson	10	11,406	*144,656
Sub-Total	51	*19,083	*191,320
State Total	368	138,317	1,083,157

* 1965 values

tains 117 such lakes; Lake County leads in this section with 47 lakes. In the north-central section there are 128 water bodies; Mason County has the largest number with 27 lakes. In the south-central section there are 72 lakes; Calhoun and Macoupin each has 11. There are 51 lakes in the southern section; Franklin and Williamson each has 9 lakes.

A small portion of the total water surface and storage consists of a large number of ponds, lakes, and reservoirs of less than 40 acres. About 82 percent of the total storage is in the 368 water bodies which are greater than 40 acres in surface area* (Table 3).

* Source of data: Illinois Department of Conservation, Division of Fisheries Special Report Number 1, plus recent additions.

TABLE 3 STORAGE VOLUMES IN IMPOUNDMENTS

Size Category (Acres)		Number	Acreage (Acres)	Estimated Storage (Ac-ft)	Percent of Total Storage
0.1 — 0.4		37,198	8,003	22,840	1.76
0.5 — 0.9		11,312	7,116	23,700	1.82
1.0 — 5.9		9,409	19,038	90,618	6.96
5.9 — 10.9		811	6,441	21,648	1.66
11.0 — 40.0		889	17,385	59,340	4.56
> 40.0		368	138,317	1,083,157	83.24
	Totals	59,988	196,300	1,301,303	100.00

Farm Ponds

Farm pond as used here is defined as a natural or artificial body of water with a surface area greater than 0.1 acre and less than 5.9 acres. These ponds were constructed or developed primarily by individuals, industries, and non-governmental agencies for water supply, livestock watering, dairy sanitation, fire protection, irrigation and gully stabilization on farms, and recreational use for swimming, fishing, boating, and winter sports.

Table 4 shows an inventory, by years, of the number of farm ponds constructed with technical assistance from the Soil Conservation Service and financial assistance from the Agricultural Stabilization and Conservation Service, both of which are agencies of the U. S. Department of Agriculture.

It is difficult to predict the future rate at which farm ponds will be added, but Table 4 indicates a rapid growth in the past ten years. If favorable support programs are available, the number could become very large. By 1980 the total number of farm ponds might reach an estimated 100,000. From 1980 to 2020 the rate of installing ponds should decrease as available sites decrease. The total will perhaps be no greater than 200,000 in 2020.

TABLE 4
FARM PONDS CONSTRUCTED WITH TECHNICAL AND FINANCIAL ASSISTANCE

Year	Ponds Constructed	Accumulated Number
1965	1633	25,992
1964	1699	24,359
1963	1361	22,660
1962	1191	21,299
1961	1244	20,108
1960	1151	18,864
1959	1196	17,713
1958	1527	16,517
1957	1657	14,990
1956	1776	13,333
1955	—	11,557
—	—	—
1950	—	361

Potential reservoir site.

LARGE RESERVOIRS UNDER DEVELOPMENT

Seven large reservoirs are under construction or being planned by the U. S. Army Corps of Engineers in Illinois (Table 5). Carlyle Reservoir on the Kaskaskia River near Carlyle in Clinton County is almost complete. Initial construction has begun on Shelbyville Reservoir on the Kaskaskia River near Shelbyville in Shelby County. It will be completed and filled in 1969. Initial construction of Rend Lake on the Big Muddy River in Franklin County is underway. It will be completed and filled in 1970.

Lincoln Reservoir on the Embarras River near the Coles-Cumberland County line has been authorized for construction. Oakley Reservoir on the Sangamon River in Macon and Piatt Counties is in the planning stage. Louisville Reservoir is being planned on the Little Wabash River near Louisville in Clay County. Helm Reservoir on Skillet Fork in Marion County is in the planning stage.

POTENTIAL RESERVOIRS

Although Illinois has a large potential for reservoir storage, distribution over the State is not ideal. Figures 23 through 26 and Table 6 show potential sites found in a recent study by the State Water Survey, with assistance from the State Geological Survey and the Soil Conservation Service. The sites are potential insofar as they have 1) the physical characteristics necessary to impound water; 2) run-off from the watershed in sufficient quantities to provide storage for beneficial use, plus anticipated losses; and 3) relative freedom from man-made or natural obstructions.

A complete evaluation of the potential reservoir sites for water resource development involves far more than the physical availability of sites, which is the criteria considered here. It is important to consider water developments in relation to other natural resources, the social and political environment, and the economy of a region. Cost of development must be balanced by benefits. The surface-water impoundment potential is dependent upon rainfall, topography, runoff, geology, and man's occupancy, as determined from an analysis of physiographic and hydrographic data.

This study was based on examination of topographic maps and field examination of the surface sites. The availability of potential reservoir sites in each of the counties was determined according to the following criteria: 1) the surface area should be larger than 40 acres; 2) maximum depth at dam not less than 20 feet; 3) average mean depth not less than 7 feet; 4) time to fill the reservoir should be neither greater nor less than the lines depicted on a graph showing the relationship of capacity to drainage area; 5) a maximum allowable storage loss of 2 percent per year by sedimentation; 6) maximum dam length of 0.5 mile, and 7) a maximum dam height of 90 feet.

TABLE 5 U. S. ARMY CORPS OF ENGINEERS RESERVOIRS

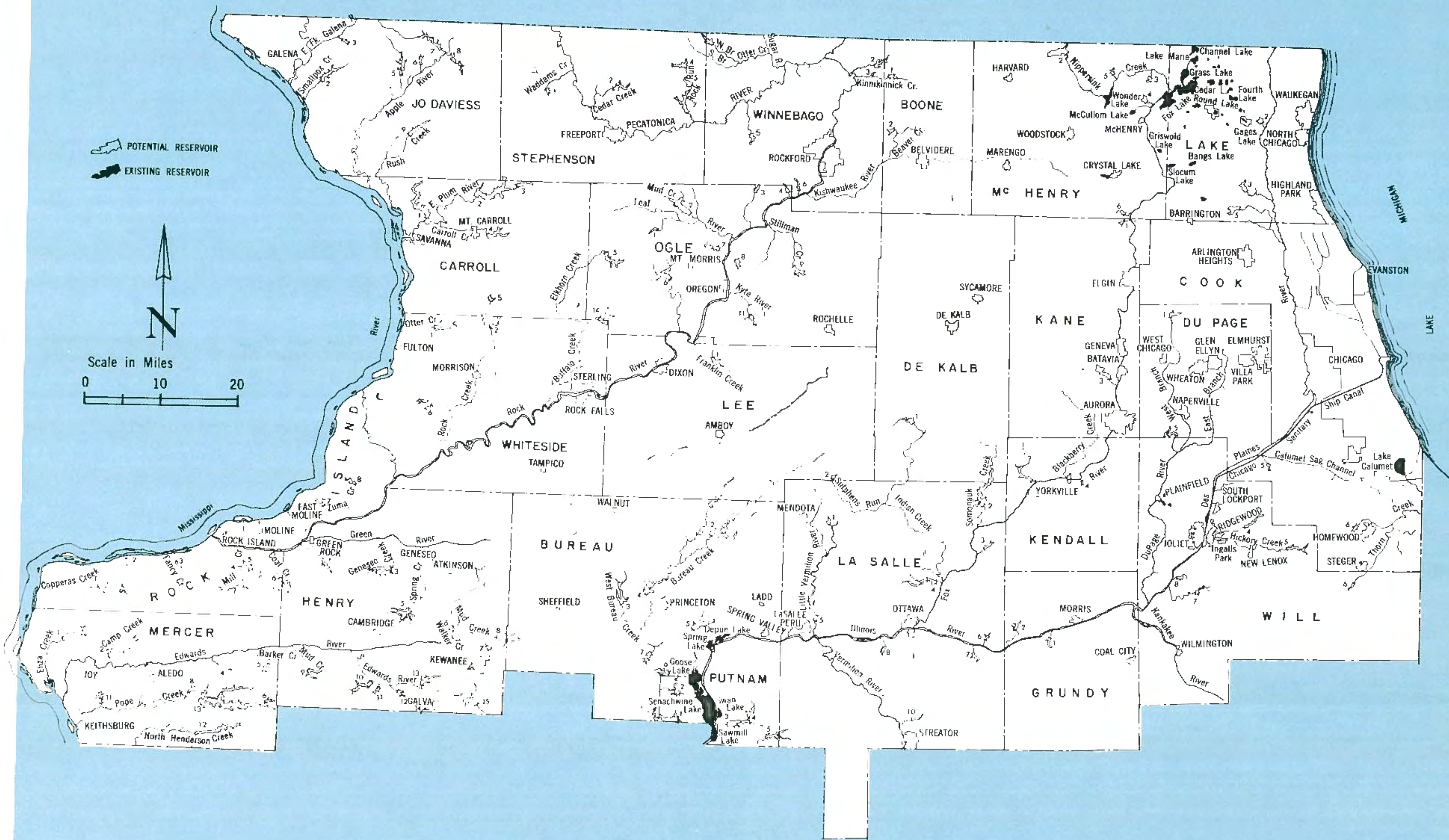
Reservoir	Carlyle	Shelbyville	Rend	Lincoln	Oakley	Louisville	Helm
Water Course	Kaskaskia River	Kaskaskia River	Big Muddy River	Embarras River	Sangamon River	Little Wabash River	Skillet Fork
Status	Under Construction	Under Construction	Under Construction	Authorized	Authorized	Planning	Planning
*Purposes	1, 2, 3, 4, 5, & 6	1, 2, 3, 4, 5, & 6	1, 2, 3, 4, 5, 6, & 7	1, 2, 3, & 6	1, 2, 3, & 6	1, 2, 3, & 6	1, 2, 3, & 6
Drainage Area (sq mi)	2,680	1,030	488	915	808	661	210
Shoreline at seasonal pool elevation (miles)	80	172	162	——	76	——	——
Storage Capacities							
Minimum (ac-ft)	50,000	30,000	25,000	55,015	12,000	38,000	12,000
Flood Control (ac-ft)	700,000	474,000	109,000	476,985	171,000	146,000	114,500
Total (ac-ft)	983,000	684,000	294,000	538,300	242,000	230,000	173,500
Conservation (ac-ft)	——	——	——	6,300	59,000	46,000	47,000
Seasonal (ac-ft)	233,000	180,000	160,000	65,450	——	35,000	15,300
Allocations							
Sedimentation (ac-ft)	50,000	30,000	25,000	55,015	12,000	38,000	12,000
Water Supply (ac-ft)	33,000	25,000	109,000	1,000	11,000	36,000	43,000
Low Flow Aug. (ac-ft)	200,000	155,000	51,000	5,300	48,000	10,000	4,000
Min. Low Flow (cfs)	50	10	30	25	50	——	——
Surface Areas of Pools							
Minimum (acres)	7,100	3,000	5,400	4,050	2,000	5,000	2,040
Conservation (acres)	——	——	——	4,310	6,100	7,500	5,300
Seasonal (acres)	26,000	11,100	18,900	6,760	——	9,400	6,000
Flood Control (acres)	57,500	25,300	24,800	21,250	13,500	13,500	10,000
Elevations of Pools							
Minimum (ft msl)	429.5	573.0	391.3	582.4	621	469	453.0
Conservation (ft msl)	——	——	——	584.0	636	476	466.0
Seasonal (ft msl)	445.0	599.7	405.0	596.0	——	480	468.5
Flood Control (ft msl)	462.5	626.5	410.0	629.0	654	490	481.0

* Purposes

1. Flood Control
2. Water Supply
3. Recreation
4. Navigation
5. Fish & Wildlife Conservation
6. Water Quality Control
7. Area Redevelopment

Carlyle Reservoir.

FIGURE 23 SURFACE-WATER RESOURCES OF NORTHERN ILLINOIS



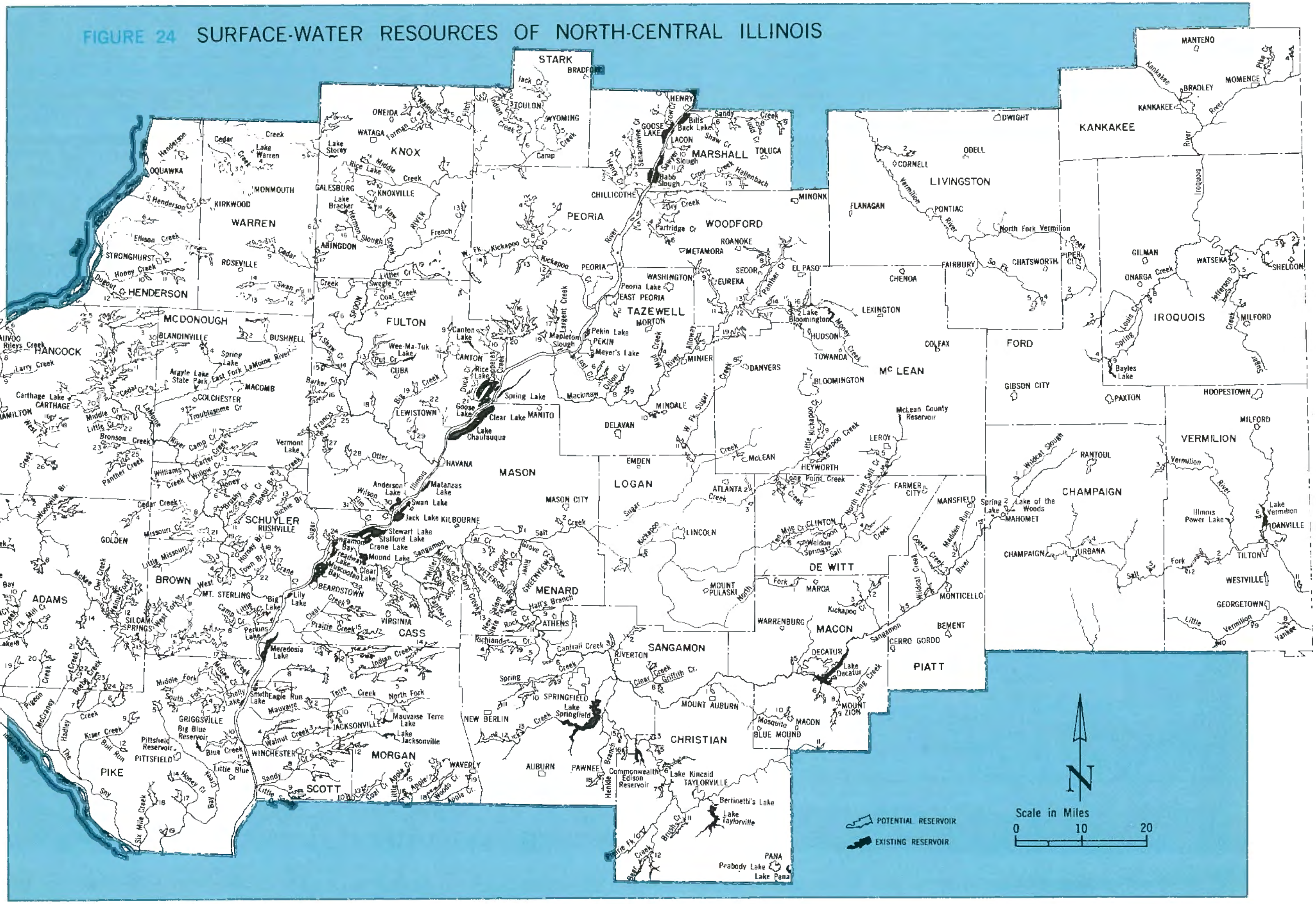


FIGURE 24 SURFACE-WATER RESOURCES OF NORTH-CENTRAL ILLINOIS

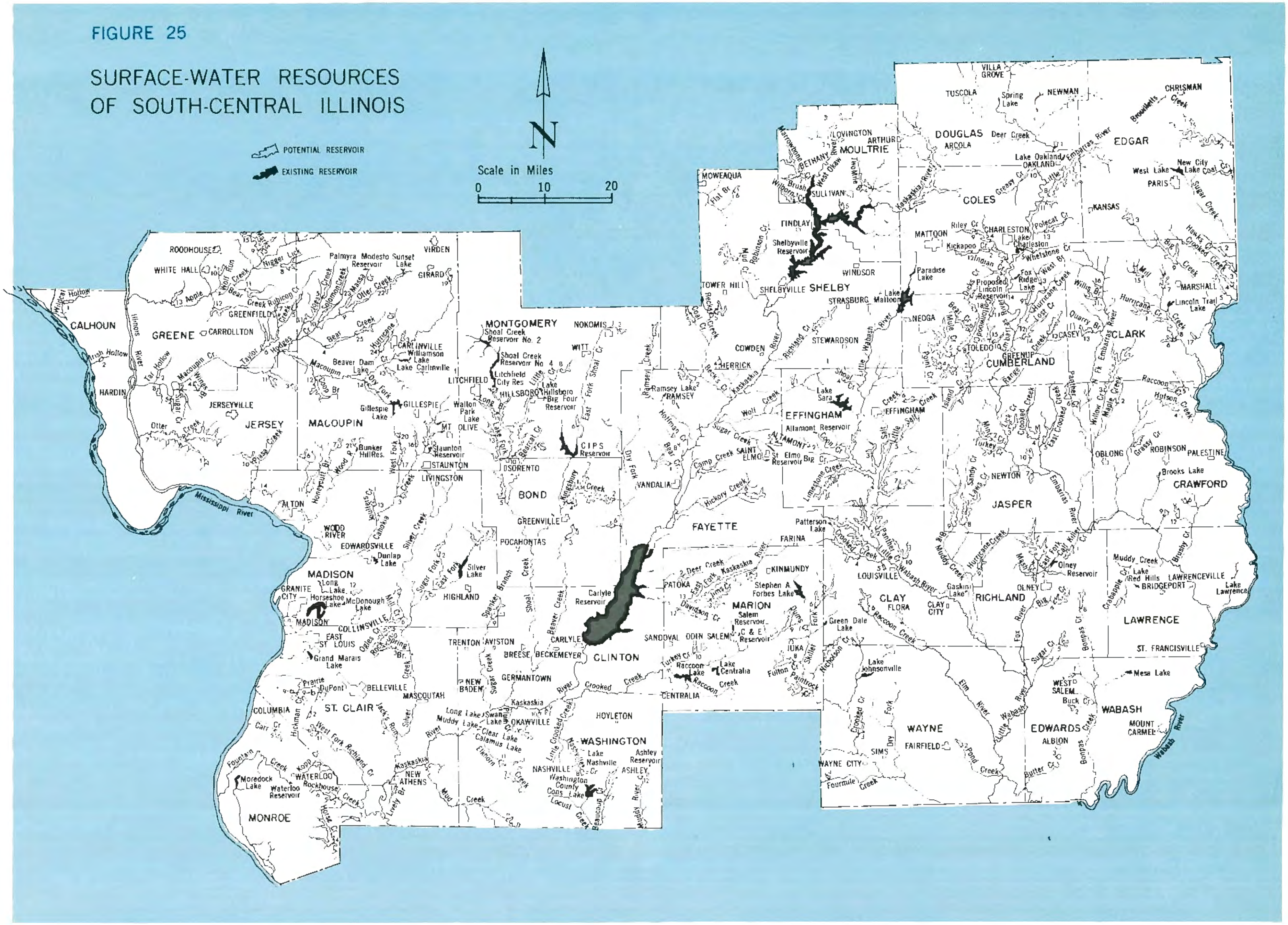


FIGURE 25

SURFACE-WATER RESOURCES OF SOUTH-CENTRAL ILLINOIS

FIGURE 26

SURFACE-WATER RESOURCES OF SOUTHERN ILLINOIS

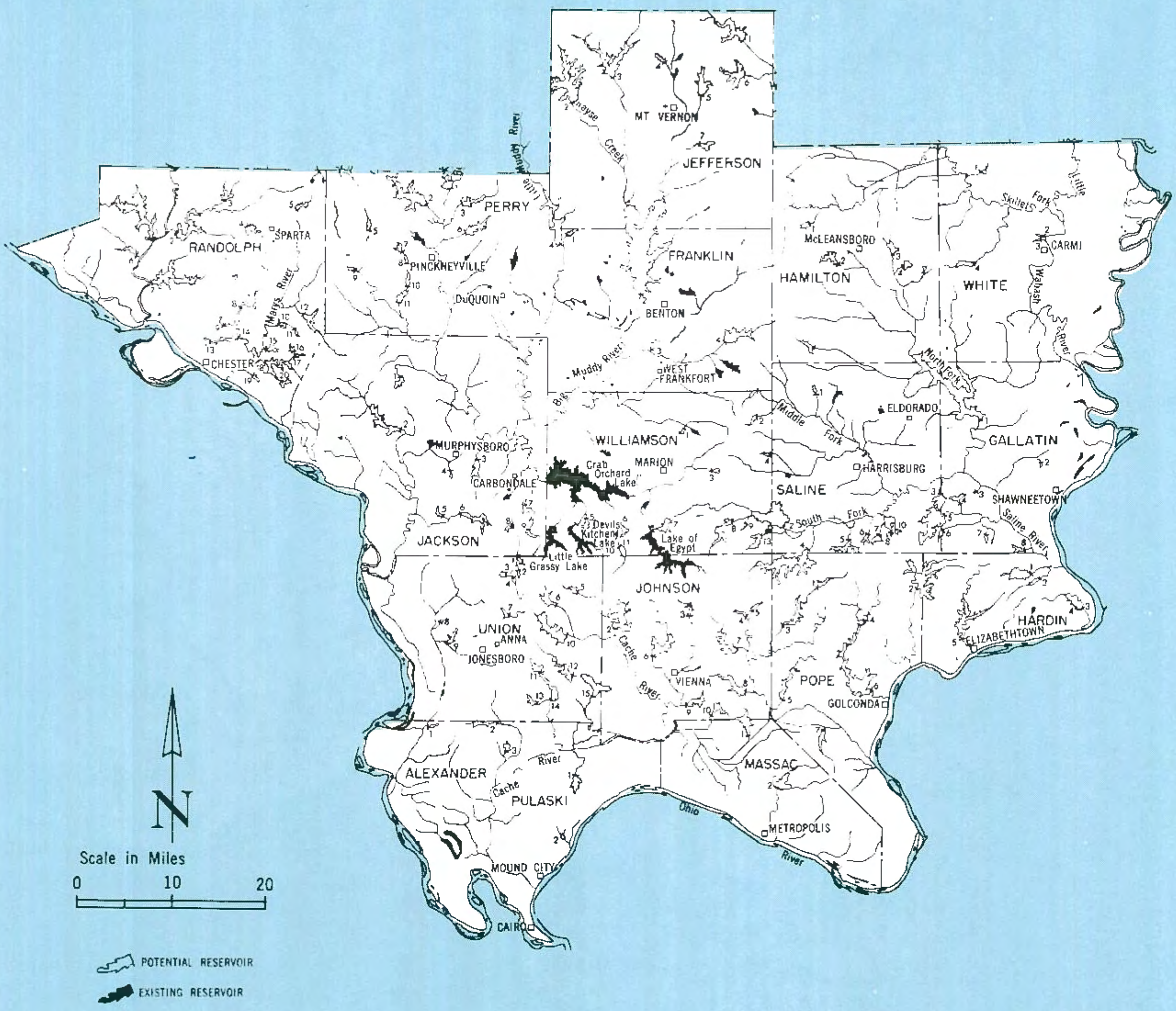


TABLE 6

POTENTIAL RESERVOIR SITES OF 40 ACRES OR MORE

County	No. Sites	Pool Area (Acres)	Storage (mg)	Yield (mgd)
Northern				
Boone	2	349	1,400	2.7
Bureau	7	6,630	44,600	60.9
Carroll	5	5,709	41,234	32.4
Cook	2	172	373	0.6
DeKalb	1	493	2,500	2.2
DuPage	2	1,265	3,933	3.8
Grundy	2	310	1,573	2.3
Henry	13	6,476	25,810	28.4
Jo Daviess	7	3,856	31,650	31.5
Kane	2	628	1,772	1.9
Kendall	2	395	2,038	6.0
Lake	3	1,195	3,984	3.1
LaSalle	9	3,126	22,888	23.1
Lee	2	776	3,804	4.8
McHenry	5	1,599	4,481	10.6
Mercer	9	10,122	67,494	66.6
Ogle	11	3,923	18,655	26.3
Putnam	5	3,302	24,700	27.4
Rock Island	8	3,778	19,514	22.1
Stephenson	5	3,155	12,250	30.1
Whiteside	3	1,236	5,200	8.1
Will	5	1,452	4,784	16.1
Winnebago	5	1,394	6,100	9.6
Sub-Total	115	61,341	350,737	420.6

County	No. Sites	Pool Area (Acres)	Storage (mg)	Yield (mgd)
North-Central				
Adams	19	13,305	79,600	58.1
Brown	12	9,976	75,600	64.7
Cass	13	3,808	19,500	13.5
Champaign	5	473	898	1.6
Christian	8	2,752	9,033	4.9
DeWitt	6	4,492	24,800	29.3
Ford	3	397	900	0.8
Fulton	22	9,526	55,300	52.5
Hancock	23	17,847	95,600	85.4
Henderson	9	4,433	26,400	22.9
Iroquois	8	1,029	2,500	3.6
Kankakee	2	1,286	4,000	6.4
Knox	13	4,748	18,900	21.0
Livingston	4	1,165	3,300	3.3
Logan	5	826	2,300	2.1
Macon	10	2,527	8,600	9.1
Marshall	9	1,548	8,700	7.3
Mason	2	173	600	0.6
McDonough	7	3,572	17,400	15.9
McLean	8	4,090	20,000	15.0
Menard	9	3,262	18,000	13.3
Morgan	18	9,097	50,600	28.8
Peoria	15	8,215	62,100	47.8
Piatt	5	1,496	4,900	5.3
Pike	16	11,432	84,100	48.8
Sangamon	17	6,121	23,400	10.9
Schuyler	19	11,173	69,800	53.5
Scott	10	5,895	38,800	19.7
Stark	6	5,255	28,100	27.5
Tazewell	7	1,715	8,900	8.5
Vermilion	7	3,093	16,400	29.7
Warren	11	4,339	21,100	26.3
Woodford	12	16,274	92,100	68.7
Sub-Total	340	175,340	992,231	806.8

County	No. Sites	Pool Area (Acres)	Storage (mg)	Yield (mgd)
South-Central				
Bond	7	4,060	17,752	10.2
Calhoun	2	370	2,900	0.9
Clark	14	9,097	47,022	27.4
Clay	9	18,045	75,307	63.4
Clinton	0	—	—	—
Coles	13	10,896	48,629	56.7
Crawford	8	4,177	16,170	9.0
Cumberland	17	17,375	74,411	83.1
Douglas	1	59	219	0.3
Edgar	3	2,740	19,647	16.3
Edwards	3	311	862	0.3
Effingham	8	2,497	11,732	7.9
Fayette	6	3,117	14,290	9.1
Greene	12	5,342	25,615	14.6
Jasper	10	8,422	39,151	27.3
Jersey	9	6,210	49,124	23.5
Lawrence	1	210	456	0.2
Macoupin	21	11,937	49,008	30.8
Madison	11	3,673	14,750	11.1
Marion	10	10,229	45,001	32.0
Monroe	6	2,915	13,870	9.8
Montgomery	8	21,789	126,212	61.7
Moultrie	5	2,364	7,764	3.9
Richland	7	5,191	16,975	10.5
Shelby	6	2,855	13,644	8.3
St. Clair	9	2,205	11,165	7.8
Wabash	0	—	—	—
Washington	8	4,414	13,548	7.9
Wayne	4	1,660	6,391	3.8
Sub-Total	218	162,160	761,615	537.8

County	No. Sites	Pool Area (Acres)	Storage (mg)	Yield (mgd)
Southern				
Alexander	3	1,412	10,354	6.1
Franklin	4	20,690	171,351	53.2
Gallatin	8	9,310	31,615	27.2
Hamilton	5	1,725	6,905	5.9
Hardin	5	3,930	24,230	21.4
Jackson	9	4,900	31,755	19.9
Jefferson	7	12,079	59,636	44.4
Johnson	10	9,530	38,997	38.7
Massac	2	1,800	7,488	7.6
Perry	11	7,247	22,638	22.4
Pope	7	9,130	76,558	68.2
Pulaski	2	660	2,704	3.1
Randolph	20	11,401	47,194	57.9
Saline	10	8,758	60,074	38.8
Union	15	6,752	36,053	41.9
White	4	740	2,584	0.8
Williamson	13	5,014	39,239	16.2
Sub-Total	135	115,078	669,375	473.7
State Total	808	513,919	2,773,958	2,238.9

EXISTING, PLANNED, AND POTENTIAL STORAGE

The total storage in existing lakes in Illinois would cover the State with 0.44 inches of water. Of this amount, only 0.05 inches is in the many farm ponds of under 5.9 acres. Corps of Engineers reservoirs under construction, authorized, and in the planning stage would cover the State with 0.36 inches of water. The potential storage of 808 potential reservoirs, if fully developed, would add an equivalent of 2.85 inches of water over the State, or about six times the existing storage.

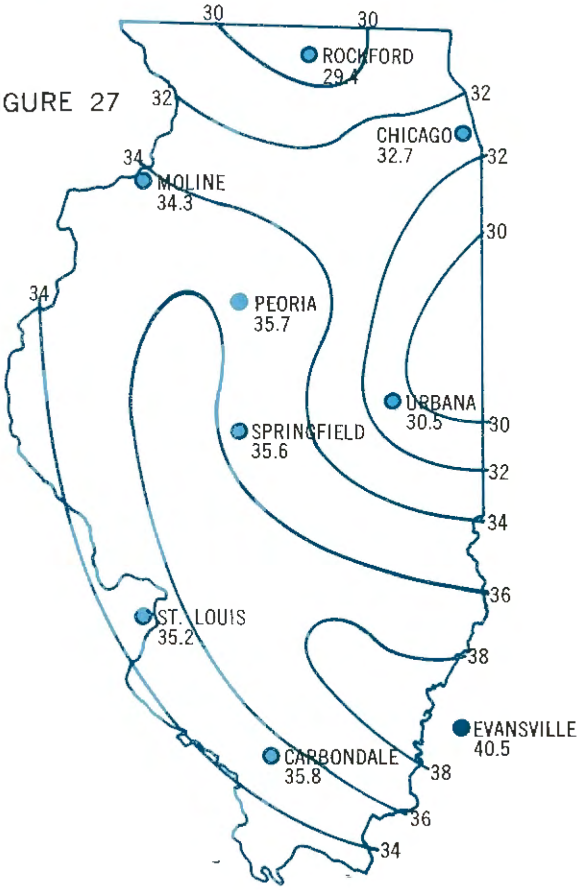
The grand total of surface-water storage (existing artificial and natural reservoirs; Corps of Engineers reservoirs under construction, authorized and in planning; and the potential reservoirs) amounts to an equivalent of 3.65 inches of water over all of Illinois, or 10,353,000 acre-feet.

EVAPORATION FROM LAKES

The average annual evaporation from a lake surface varies from 30 inches near Rockford to 38 inches near Evansville, Indiana (Figure 27).

AVERAGE ANNUAL EVAPORATION FROM A LAKE SURFACE IN INCHES

FIGURE 27



RESERVOIR SEDIMENTATION

Any reservoir constructed to impound the waters of a flowing stream may fill with sediment. In Illinois most of the drainage area land is cultivated and subject to soil erosion; consequently, the streams carry a variable but considerable load of soil or sediment particles. The water invariably flows faster in the stream than in the reservoir; when the water enters the reservoir, the soil particles settle.

For about 30 years, comprehensive research has measured sediment in Illinois reservoirs and the characteristics of watersheds that affect sedimentation. Sedimentation surveys have been made on 101 reservoirs in Illinois by the State Water Survey, the Illinois Agricultural Experiment Station, and the U. S. Department of Agriculture.

The rate of soil erosion on many watersheds in Illinois is excessive for the long-term protection of the land resource base. Soil loss from erosion can be drastically reduced by soil conservation practices. In many cases a conservation program on a watershed has significantly reduced the rate of reservoir sedimentation. An intensive watershed conservation program to prevent soil erosion and reduce sedimentation should be considered a necessary part of reservoir development.

A soil conservation program on the watersheds shown in Table 7 could reduce soil loss in amounts varying from 43 to 92 percent. The rates of reservoir sedimentation could be expected to be similarly reduced. In a nationwide study, soil conservation programs effectively reduced reservoir sedimentation rates in amounts from 28 to 93 percent in seventeen example cases.

TABLE 7

POSSIBLE REDUCTION OF SOIL EROSION ON NINE ILLINOIS RESERVOIR WATERSHEDS

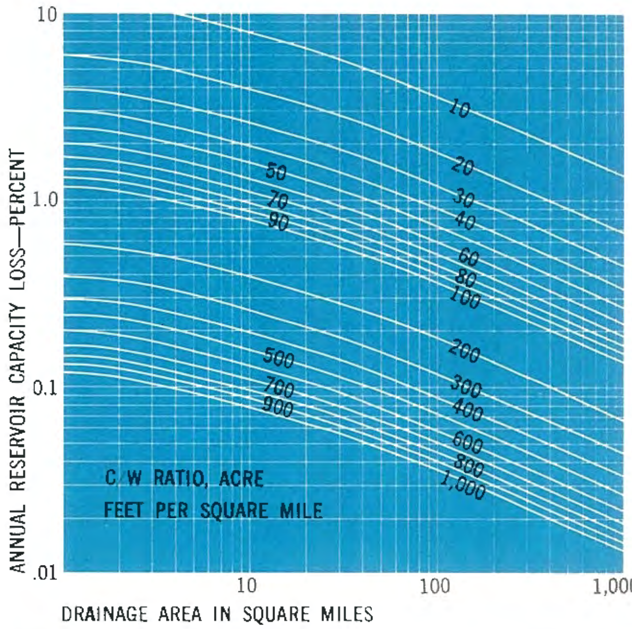
Reservoir	Watershed Area (Square Miles)	Sediment Deposition Rate (Tons per Acre per Year)	Computed Soil Loss from Watershed		Estimated Reduction of Soil Loss by Conservation (Percent)
			Present Condition (Tons per Acre per Year)	After Conservation Program (Tons per Acre per Year)	
Ridge Lake	1.41	4.36	4.36	1.87	43
Lake Carthage	2.90	2.50	3.80	1.03	73
Carbondale Reservoir	3.10	7.68	11.60	.95	92
West Frankfort Reservoir	4.03	4.00	4.36	.65	85
Lake Bracken	9.14	3.37	7.02	.78	89
Lake Calhoun	13.10	2.00	8.27	.91	89
Spring Lake	20.20	1.44	4.55	.88	81
Crab Orchard Lake	196.00	2.80	5.37	.51	91
Lake Springfield	258.00	1.03	3.26	.72	78

Sedimentation Rates

Two important effects on reservoir sedimentation rates in Illinois are the size of the lake with respect to the drainage area (capacity/watershed ratio) and the size of the drainage area of a watershed. Figure 28 which shows these effects is based on surveys of 101 lakes. It may be used to estimate annual capacity loss for a particular proposed reservoir. A large capacity/watershed (c/w) ratio indicates a large space for storage of sediment in a reservoir, as compared to the possible yield of sediment from the surrounding land. In other words, it would take proportionately longer for a large reservoir to fill with silt. Reservoirs with low proportionate c/w ratios collect sediment proportionately more rapidly.

As the size of a watershed increases, the unit rate of sediment production per square mile decreases. For any particular region in Illinois, it can be assumed that the average overall rate of soil loss from erosion would be uniform for large and small drainage basins. For a relatively small drainage area, most of this sediment is transported the short distance downstream to the reservoir. The larger the drainage area, the greater the tendency is for much of this sediment to be transported only a short distance, where it is deposited at a fence, along ditches, streams, or on bottom lands along a major stream. Thus, a smaller percentage of the total watershed soil loss is actually carried all the way downstream to be deposited in the reservoir.

FIGURE 28 RESERVOIR CAPACITY LOSS FROM SEDIMENTATION



Valuable storage space intended for water now holds only deposited sediment.

GEOLOGY OF GROUND WATER

Many aspects of water resources in Illinois are related to the State's geology. The topography and the nature of surface earth materials influence the pattern in which precipitation infiltrates the ground or runs off. The permeable formations that serve as aquifers, storing water and allowing it to flow into wells, control the amount of ground water available (Table 8). Fortunately for some areas and unfortunately for others, aquifers are distributed unevenly in Illinois. Relatively impermeable beds such as shale act as barriers to ground-water movement and maintain pressure differences or water quality differences between aquifers. In some areas, creviced limestone formations at land surface allow ground-water pollution. The geologic structure of the bedrock—its configuration or deformation—commonly influences ground-water movement.

The geologic framework of the State also localizes mineral industries, with their special water problems. For example, virtually all of Illinois' oil production and a substantial part of the coal production come from the southern third of the State. Both operations require large quantities of water and also can impair water quality, unless properly controlled.

Knowledge of the distribution of aquifers in Illinois is perhaps the most fundamental factor in delineating the State's ground-water resources. Ground water in Illinois is usually obtained from unconsolidated deposits of sand and gravel, mainly in the glacial drift or from limestone or sandstone formations of the underlying bedrock.

The most favorable ground-water conditions are

TABLE 8 CLASSIFICATION, NATURE, DISTRIBUTION, AND WATER-YIELDING CHARACTERISTICS OF ILLINOIS ROCKS COMMONLY DRILLED FOR WATER

System	Series	Megagroup	Group (G) or Stage (S)	Formation	Remarks
Quaternary	Pleistocene		Recent S.		Soils, recent sediments, widespread.
			Wisconsinan S. Sangamonian S. Illinoian S. Yarmouthian S. Kansan S. Aftonian S. Nebraskan S.	Sankoty Sand	Glacial deposits: ice-laid till, water-laid sand and gravel, wind-blown silt. A few feet to over 500 feet thick. Cover most of State. Sand and gravel important sources of water, especially in bedrock valleys.
Tertiary		Embayment		"Lafayette" Gr. Wilcox Porters Creek Clayton	Clays, fine sands, silts, and some gravel. Aggregate maximum thickness of 900 ft. Restricted to southern tip of State. McNairy and Tuscaloosa best aquifers; yield up to 1000 gallons per minute.
Cretaceous				Owl Creek McNairy Tuscaloosa	
Pennsylvanian			McLeansboro G.	Mattoon Bond Modesto	Mainly shale, with siltstone, sandstone, limestone and coal. Maximum thickness 2500 feet in Illinois Basin. Widespread. Sandstones yield small water supplies. Water highly mineralized with depth.
			Kewanee G.	Carbondale Spoon	
			McCormick G.	Abbott Caseyville	
Mississippian	Chesterian	Pope		Grove Church Sh. Kinkaid Ls. Degonia Ss. Clore Palestine Ss.* Menard Ls. Waltersburg Ss.* Vienna Ls. Tar Springs Ss.* Glen Dean Ls. Hardinsburg Ss. Haney Ls. Fraileys Sh. Beech Creek Ls. Cypress Ss.* Ridenhower Bethel Ss.* Downeys Bluff Ls. Yankeetown Ss. Renault Ls.	Shale, 50 percent; sandstone, 25 percent; limestone, 25 percent. Maximum thickness 1500 feet. Limited to southern third of State. *Sandstones, especially those starred, are main aquifers, though of low permeability. Yield potable water only near outcrop area. Sandstones, especially Tar Springs and Cypress, in Illinois Basin yield large quantities of brine for oil field water-flooding.
	Valmeyeran	Mammoth Cave		Aux Vases Ss.* Ste. Genevieve Ls. St. Louis Ls. Salem Ls. Sonora Ss. Warsaw Sh. Keokuk Ls. Burlington Ls.	Limestones and siltstones, maximum thickness 2000 feet. Occurs in southern two-thirds of State. Limestones yield water from crevices. Potable water limited to near outcrop areas in west and south. Contains brine in Illinois Basin.
				Fern Glen Sedalia Ls. Borden Sts.	
	Kinderhookian	Knobs		Chouteau Ls. Hannibal Sh. "Glen Park"	
Devonian	Upper			Louisiana Ls. Saverton Sh. Grassy Creek Sh. Sylamore Ss.	Mainly shale. Average thickness 200 feet. Limited to western and southern parts of State. Rocks "tight", generally unfavorable as sources of water.
	Middle	Hunton		Cedar Valley Ls. Wapsipinicon Ls.	Limestones and dolomites. Thickness 200-400 feet in north. Devonian absent in northeastern Illinois. Water obtained from crevices and solution channels in the rocks; usually best yields from upper Silurian. Thick Devonian limestone and chert good aquifer in southern tip of state.
	Lower			Clear Creek Ch. Backbone Ls. Bailey Ls.	
Silurian	Niagaran			Racine Waukesha Joliet	
	Alexandrian			Kankakee Dol. Edgewood Dol.	
Ordovician	Cincinnatian		Maquoketa G.		Mainly shale. Average 200 feet thick. Unfavorable for water; some available from interbedded dolomites.
	Champlainian	Ottawa	Galena G.	Dubuque Wise Lake Dunleith Guttenberg Kings Lake Spechts Ferry	Dolomites, some shales. Average thickness 350 feet in north. Present in most of State. Yields water from crevices and solution channels, especially from upper part if not overlain by Maquoketa Group. Used as water source only in northern part of State.
			Platteville G.	Quimbys Mill Nachusa Grand Detour Mifflin Pecatonica	
			Ancell G.	Glenwood St. Peter Ss.	Sandstone, shaly above. Maximum thickness 600 feet. Extensive. Highly permeable aquifer.
	Canadian	Knox	Prairie du Chien G.	Shakopee Dol. New Richmond Ss. Oneota Dol. Gunter Ss.	Dolomites, some sandstones, shale. Maximum thickness 2500 feet. Present throughout State. Sandstones locally useful aquifers. Creviced dolomites yield supplementary water in some deep wells. Drinkable water only in north.
Cambrian	Croixan		Trempealeauan S.	Eminence Dol. Jordan Ss. Potosi Dol.	
			Franconian S.	Franconia Ironton Ss.	Sandstone. Up to 175 feet. Permeable aquifer, north.
		Potsdam	Dresbachian S.	Galesville Ss. Eau Claire Mt. Simon Ss.	Shale, 400 feet, extensive. Sandstone. Up to 2500 feet. Large ground-water reservoir, containing potable water in upper part, only in north.
PRECAMBRIAN CRYSTALLINE ROCKS					

found in the northern third of the State, where there are dependable sandstone and limestone aquifers in the bedrock and extensive sand and gravel aquifers in the glacial drift (Figure 29). Somewhat similar conditions prevail at the southern tip of the State.

In the remainder of Illinois, the only aquifers of high potential yield are sand and gravel deposits of the Mississippi, Illinois, buried Mahomet, Wabash, Ohio, Kaskaskia, and Embarras valleys.

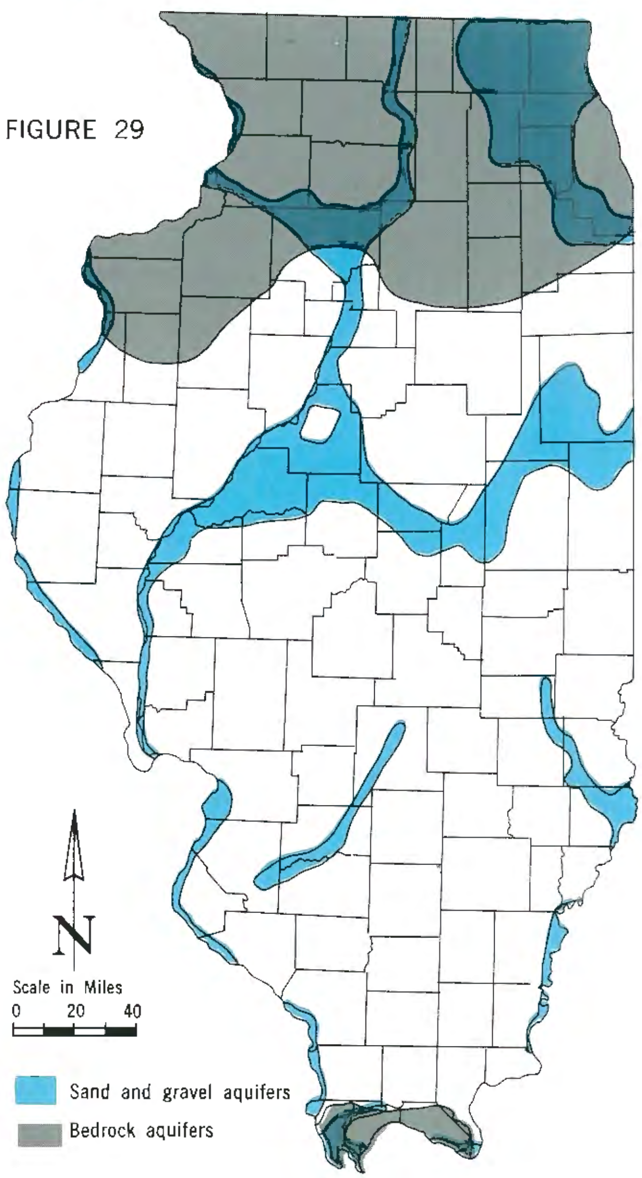
SAND AND GRAVEL AQUIFERS

Occurrence and Distribution — Most of the unconsolidated, or sand and gravel, aquifers of Illinois were deposited by meltwater from the various continental glaciers which entered the State. The sand and gravel were deposited mainly as outwash plains that are broad expanses of sand and gravel at the front of melting ice, or as valley trains that are long narrow deposits within valleys draining meltwater away from the ice. The finer-grained sediment such as silt and clay was carried farther downstream and deposited in quieter water.

The sand and gravel are present as surface deposits, or as layers interbedded between ice-laid deposits of pebbly silt or clay (till). In some places, layers of sand and gravel are connected, and locally sand and gravel are continuous to bedrock. The distribution of sand and gravel aquifers and their thickness is shown in Figure 30.

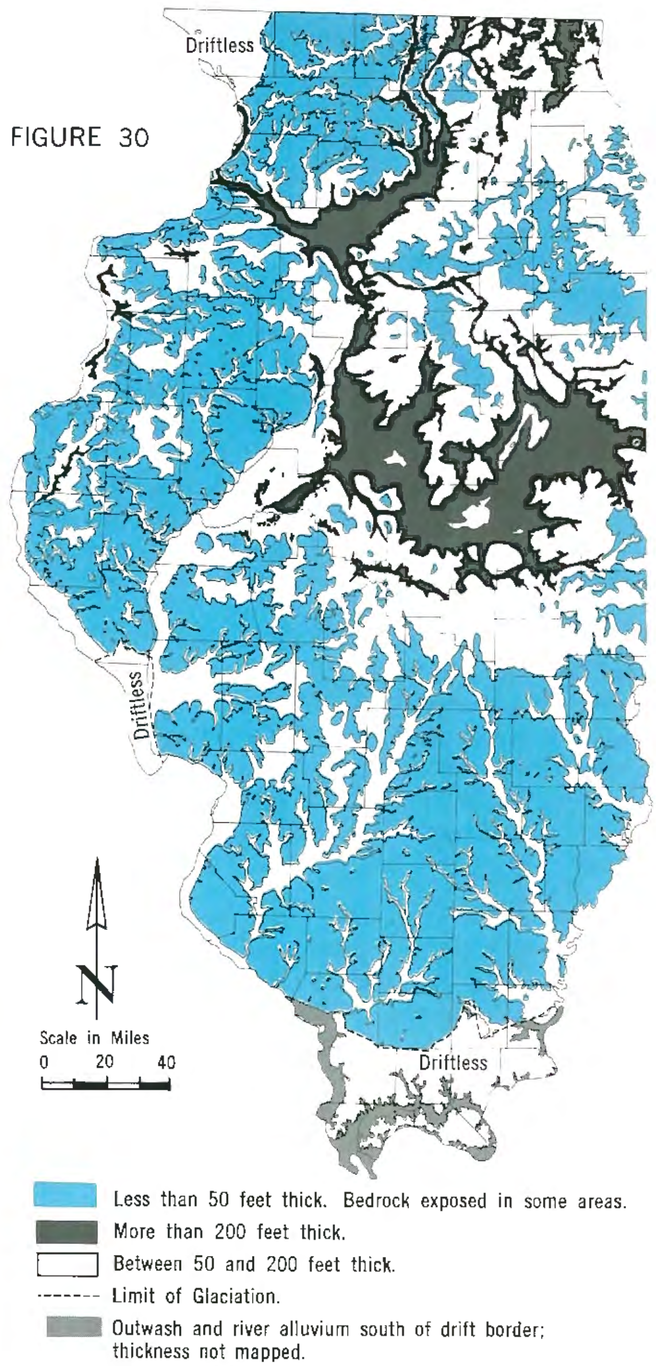
AREAS OF MOST FAVORABLE GROUND-WATER CONDITIONS

FIGURE 29



GLACIAL DRIFT THICKNESS

FIGURE 30



Gravel deposits transported by glacial meltwater in Shelby County.

BEDROCK AQUIFERS

Bedrock formations (Cambrian through Silurian) are favorable aquifers in the northern third of Illinois, where drinkable water supplies are obtained to depths of 1500 feet or more (Figures 31 and 32). The Silurian age dolomite occurs just below the drift or within a few hundred feet below the surface of the bedrock and yields water for thousands of private, municipal, and industrial supplies. Ordovician and Cambrian formations, especially the Galena-Platteville Dolomite, the Glenwood-St. Peter Sandstone, the Ironton-Galesville Sandstone, and the Mt. Simon Sandstone (Table 8 and Figure 33) are other aquifers which are extensively developed.

The Galena-Platteville Dolomite is a common source of small ground-water supplies where it occurs just below the drift. The Glenwood-St. Peter Sandstone is a source of small to moderately large supplies where it is the sole source of supply, and it contributes water to wells drilled to deeper aquifers, such as the Ironton-Galesville and Mt. Simon Sandstone.

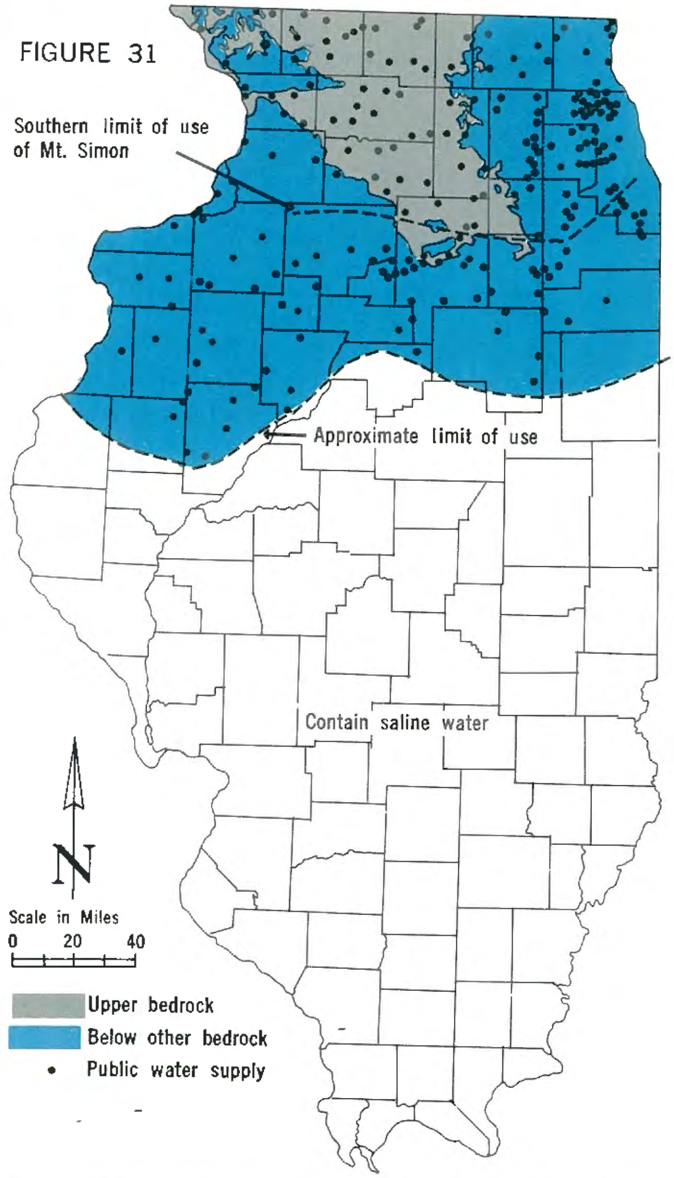
Many hundreds of wells have been drilled to the deeper aquifers and yield water from many formations. Some are uncased from the Silurian age dolomite downward, and some are uncased from the Galena-Platteville downward. Many industrial and municipal wells are open to the Galena-Platteville through Ironton-Galesville formation, inclusive, a section of rocks called the Cambrian-Ordovician aquifer in parts of this and other reports.

The Ironton-Galesville Sandstone is the most consistently permeable of the bedrock formations and for more than 75 years has been the prime target for high-capacity municipal and industrial wells. The Mt. Simon Sandstone, which occurs some 400 feet below the base of the Ironton-Galesville Sandstone, is also an important aquifer, but is less permeable than the Ironton-Galesville. Because of its greater depth, it contains drinkable water in a somewhat smaller area of Illinois than the Ironton-Galesville.

The southward and southeastward dip of the bedrock formations brings the Mt. Simon Sandstone to a depth at which it contains water too brackish for use south of a line about 10 miles north of the Illinois River (Figure 31). The Glenwood-St. Peter Sandstone—at least 1400 feet shallower than the

DISTRIBUTION AND USE OF ORDOVICIAN AND CAMBRIAN AQUIFERS

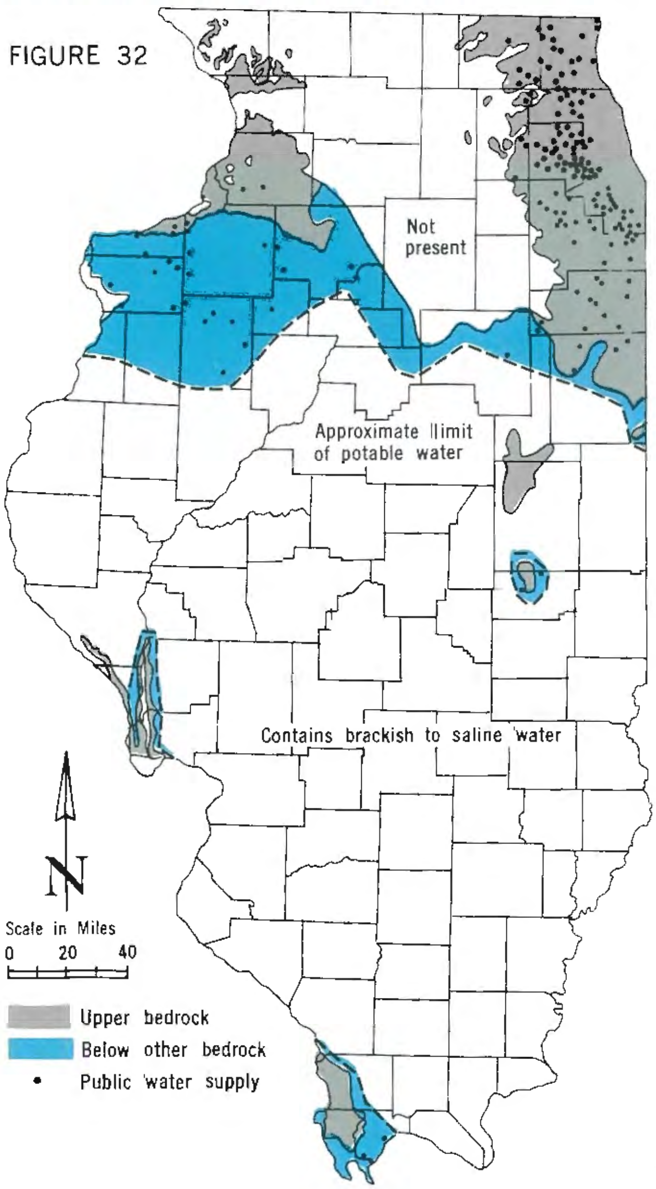
FIGURE 31



Rocks consist in downward order of Galena-Platteville Dolomite, Glenwood-St. Peter Sandstone, Shakopee Dolomite, New Richmond Sandstone, Oneota Dolomite, Eminence-Potosi Dolomite, Franconia Formation, Ironton-Galesville Sandstone, Eau Claire Formation, and Mt. Simon Sandstone. Sandstones, especially Glenwood-St. Peter, Ironton-Galesville, and Mt. Simon are main water yielding units.

DISTRIBUTION AND USE OF HUNTON (DEVONIAN-SILURIAN) AQUIFER

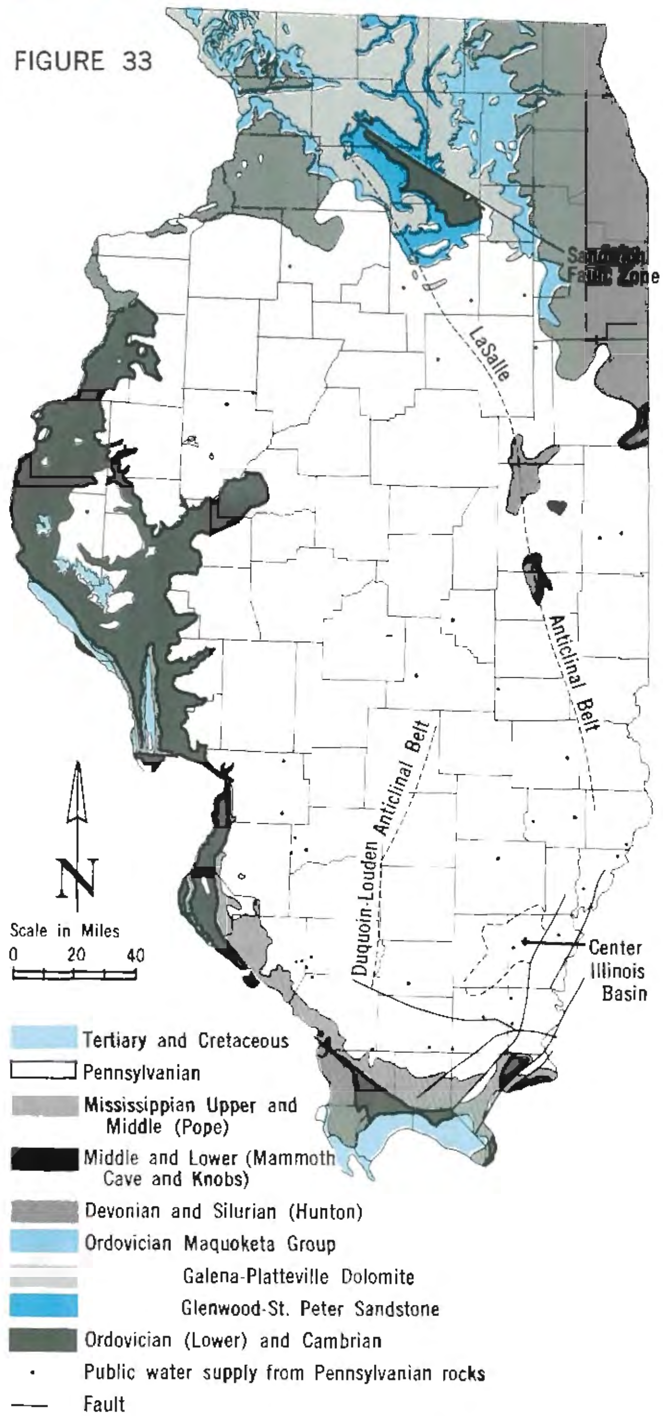
FIGURE 32



Aquifer is dolomite and limestone which is creviced, especially in upper part.

GROUND-WATER GEOLOGY OF THE UPPER BEDROCK

FIGURE 33



Bedrock units mapped and described here are at land surface or are overlain by unconsolidated glacial, river, or windblown deposits of variable thickness. Tertiary and Cretaceous—some water-yielding sands and gravels, with clay and silt beds. Pennsylvanian—mainly shale, not water-yielding; some sandstones and limestones yield small to moderate supplies of water. Mississippian, Upper and Middle (Pope)—sandstones and limestones, some of which yield small supplies of water; Middle and Lower (Mammoth Cave and Knobs)—limestones and siltstones; limestones yield small to moderate supplies of water. Devonian and Silurian (Hunton)—limestone and dolomite; water yields from solution channels variable, higher in Silurian than Devonian. Ordovician, Maquoketa Group—generally does not yield water; some dolomite beds yield small quantities; Galena-Platteville Dolomite—yields water from solution channels, especially in upper part; Glenwood-St. Peter Sandstone—yields water; a major aquifer. Ordovician (Lower) and Cambrian—dolomite and sandstone; water yields variable, generally low.

Mt. Simon—contains useable water to a line about 50 miles farther south, which marks the southern limit of use of the Ordovician and Cambrian aquifers of northern Illinois. The Ironton-Galesville Sandstone continues as a useable aquifer some 15 miles farther south of the line where water in the Mt. Simon becomes brackish.

Along the steep west flank of the LaSalle Anticlinal Belt in LaSalle and Lee Counties, rocks dip sharply to great depths (Figure 33), and water quality deteriorates markedly. However, along the crest of the Anticlinal Belt, older rocks such as Devonian and Mississippian are brought up to shallower depth, and in some areas are sources of ground water.

In the two-thirds of Illinois south of the area using Ordovician and Cambrian aquifers (Figure 32), ground water is obtained from limestone and dolomite of the Hunton (Devonian-Silurian) Megagroup in three small areas in the southern, western, and east-central part (Figure 32), from Pennsylvanian and Mississippian rocks (Figures 34 and 35) in wells a few hundred to about a thousand feet deep. Wells a few hundred feet deep are more common. The older rocks, Ordovician and Cambrian, and in most of the area the Devonian and Silurian, are brought to considerable depth by the dip of the formations in the Illinois Basin. These formations contain highly mineralized water.

Rocks of Pennsylvanian age are the uppermost bedrock in most of the area (Figure 33). Shale is predominant in the Pennsylvanian System; sandstone is subordinate; and limestone and coal are present in lesser amounts. Sandstones, which are the chief aquifers, are thickest and coarsest in the McCormick Group (Table 8), but occur as somewhat coarser channel deposits or somewhat finer sheet deposits at many horizons and in many areas.

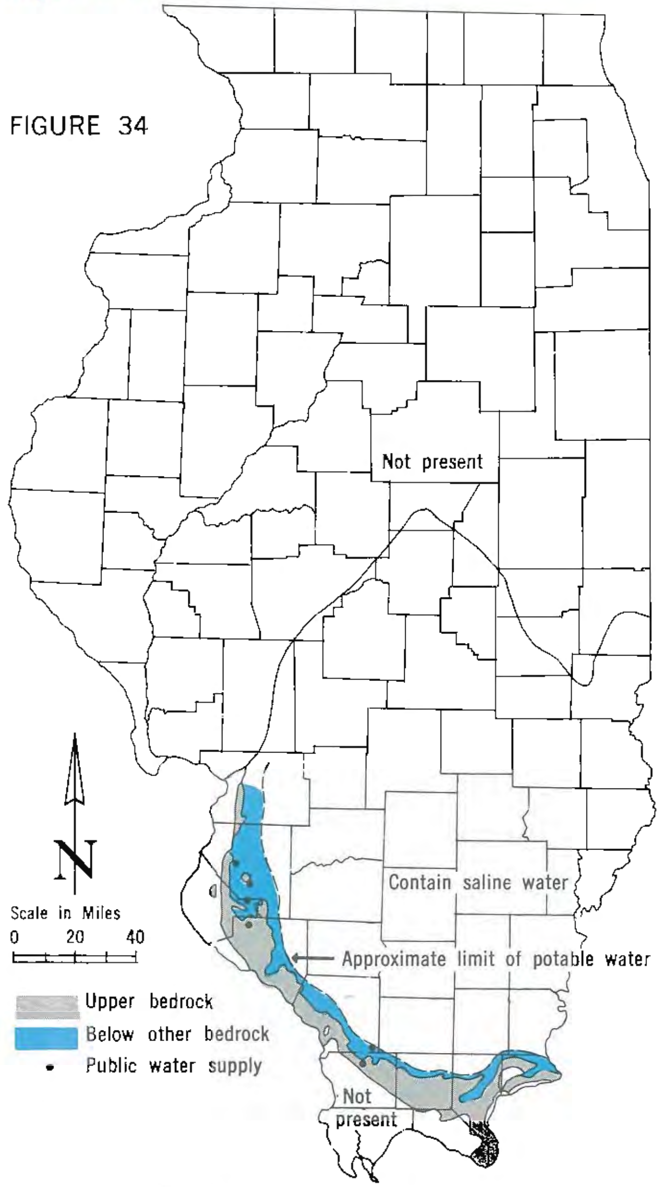
Data on the water-yielding properties and water quality of the Pennsylvanian aquifers come both from fresh water wells and from oil field wells and tests. In addition to the shallower fresh water wells, many wells are drilled to Pennsylvanian sandstones to secure brine for water-flooding of oil fields. Yields of these wells generally range from 10 to 100 gallons per minute. Determinations of porosities and permeabilities of sandstone cores from oil wells show that porosities are relatively uniform and low, averaging 17 to 20 percent. Permeabilities have a wider range, but are also relatively low compared to clean sand and gravel aquifers. The McCormick Group sandstones are more permeable than the higher sandstones.

Pennsylvanian sandstones are severely limited as aquifers because they contain highly mineralized water at fairly shallow depths. Public water supplies, mainly municipal wells, get water from Pennsylvanian rocks as deep as 950 feet, but most of them are less than 300 feet deep.

Mississippian rocks, the principal sources of oil in Illinois, underlie the drift along the western and southern borders. Mississippian rocks yield drinkable water to wells in the outcrop area and from below the Pennsylvanian rocks in a narrow belt east of the outcrop area (Figures 34 and 35). The Pope rocks consist of shales, sandstones, and limestones. The sandstones are the principal aquifers, yielding

DISTRIBUTION AND USE OF POPE (UPPER AND MIDDLE MISSISSIPPIAN) AQUIFERS

FIGURE 34



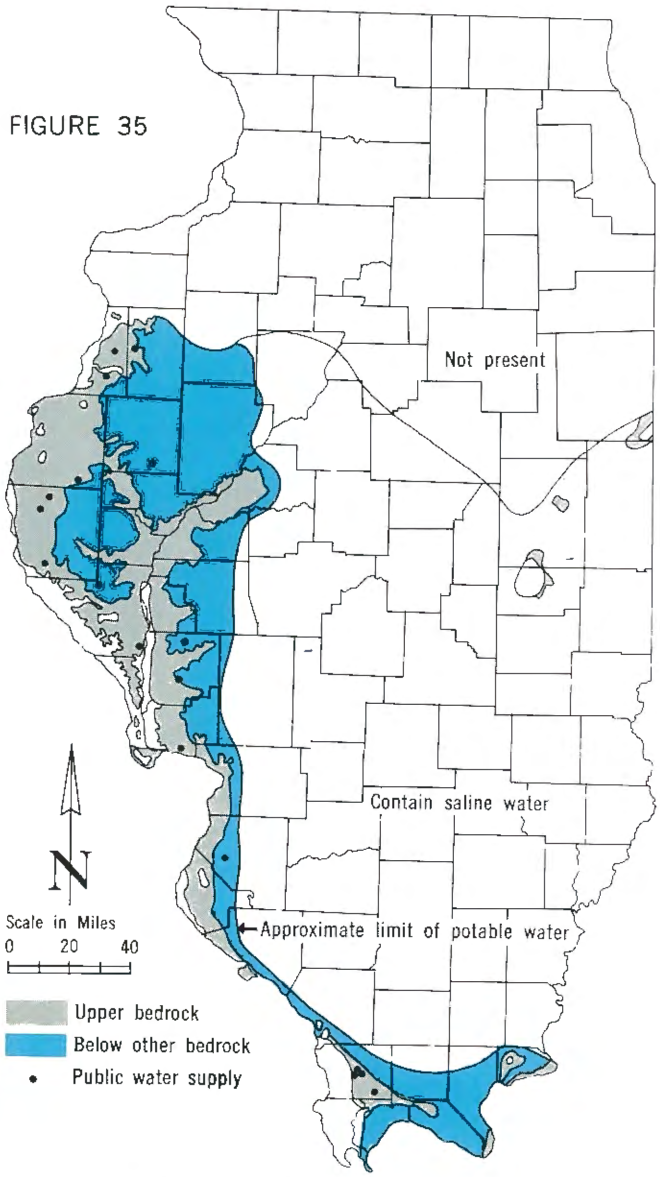
The rocks are alternating shale, sandstone, and limestone. Sandstones, chiefly Palestine, Waltersburg, Tar Springs, Cypress, Bethel, and Aux Vases, are main aquifers, with widely varying yields. Potable waters are obtained only along and near outcrop. Brines, widely used in water flooding of oil fields, occur in most of the area.

low but variable supplies of ground water. The Tar Springs and Cypress Sandstones (Table 8), both of which can be more than 100 feet thick, are the chief sources of brine for water-flooding oil fields.

Like the Pennsylvanian sandstones, the Pope sandstones have both sheet and channel phases, with maximum thicknesses of about 20 and 140 feet, respectively. They are generally finer grained than the Pennsylvanian, especially the lower Pennsylvanian, sandstones. The porosities are relatively low, averaging 16 to 18 percent. The permeabilities of the Waltersburg, Hardinsburg, and Clore Sandstones

DISTRIBUTION AND USE OF MAMMOTH CAVE (MIDDLE AND LOWER MISSISSIPPIAN) LIMESTONE AQUIFERS

FIGURE 35



The Ste. Genevieve, St. Louis, Salem, Keokuk, and Burlington are main aquifers, with variable yields from cracks, solution channels and oolitic zones. In southern Illinois potable waters are obtained only along and near outcrop. The limestones contain brines in the Illinois Basin and are sources of water for flooding of oil fields.

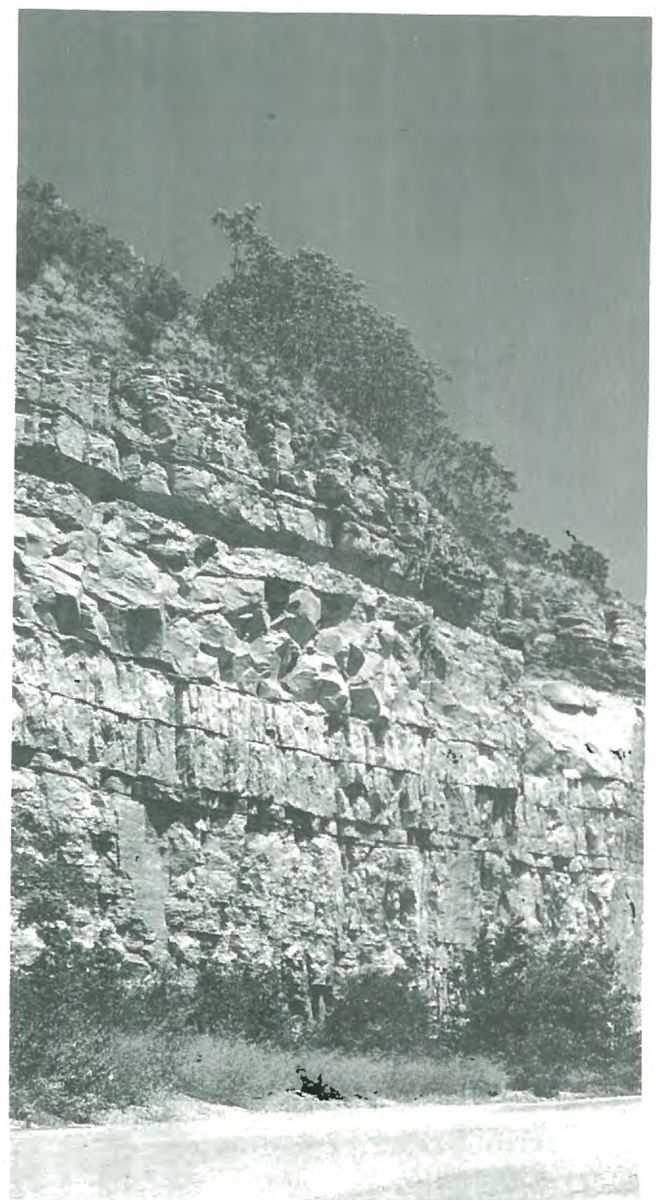
are the highest of the Pope rocks, but are generally lower than those of the Pennsylvanian sandstones.

The Mammoth Cave rocks (Figure 35) are chiefly limestones that crop out in the Shawnee Hills and along the Mississippi and lower Illinois Rivers. They yield modest supplies of water to wells from joints, solution channels, and zones of oolitic, or grainy, rocks. They also discharge water as springs along the river bluffs. Among the Mammoth Cave limestones the Ste. Genevieve Limestone, which includes the Ohara, Rosiclare, and McClosky zones, is a large source of brine for water-flooding.

In general the sandstones and limestones of Mississippian age contain more concentrated brine as their depth increases in the Illinois Basin.

Parts of extreme southern Illinois have bedrock aquifers of good ground-water potential, in addition to the sand and gravel aquifers. The McNairy Formation and the Tuscaloosa Gravel are the coarsest beds in the Cretaceous System and are favorable sources of ground water. They are more than 100 feet thick in most of the area of Tertiary-Cretaceous rocks and yield small to large supplies.

Limestones and dolomites of Devonian age (Hunton), especially the Clear Creek Chert and Bailey Limestone are more than 1500 feet thick in southern Illinois and locally give high yields of ground water in wells up to 1000 feet deep.



Outcrop of Ste. Genevieve and St. Louis Limestones (Mississippian) near Alton.

HYDROLOGY OF GROUND WATER

POTENTIAL YIELDS OF PRINCIPAL SAND AND GRAVEL AQUIFERS

The potential yields of principal sand and gravel and bedrock aquifers in Illinois are estimated to be 4.8 and 2.5 billion gallons per day (bgd), respectively. The total ground-water potential in Illinois, based on full development of either sand and gravel or bedrock aquifers whichever has the higher recharge rate, is estimated to be 7.0 bgd.

The potential yield, expressed in gallons per day per square mile (gpd per sq mi), is defined as the maximum amount of ground water that can be continuously withdrawn from a reasonable number of wells and well fields without creating critically low water levels or exceeding recharge.

The major sources of recharge to sand and gravel aquifers in Illinois are direct precipitation on intake areas and downward percolation of stream runoff (induced infiltration). Potential yield calculations (Figure 36) are based partly upon the assumption of full development of the principal sand and gravel aquifers. Pumping from the sand and gravel aquifers reduces recharge to the underlying bedrock aquifers and, therefore, reduces the potential yield of the aquifers. This assumption should be given special consideration when ground-water resources development is contemplated in the northern third of the State, where important bedrock aquifers are located.

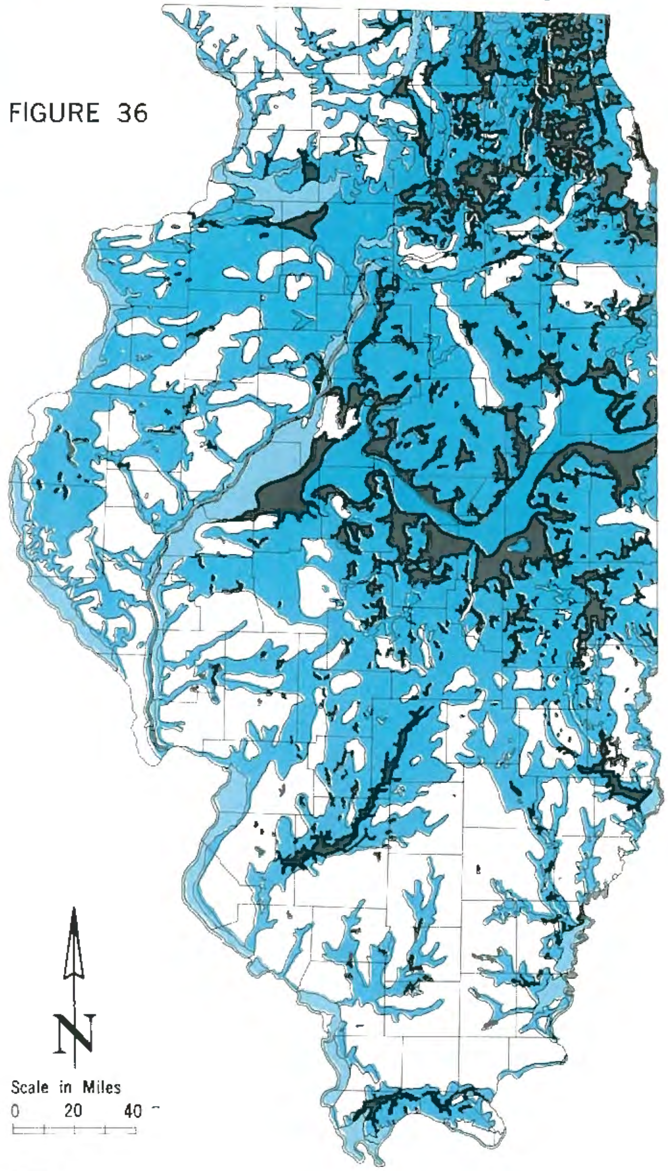
Of the total estimated potential yield of 4.8 bgd from sand and gravel aquifers in the State, about 2.8 bgd is from direct precipitation and 2.0 bgd is from induced infiltration along major rivers in Illinois.

Because the occurrence of ground water is principally determined by geologic features, ground-water supplies are not uniformly distributed throughout Illinois. Principal sand and gravel aquifers underlie only about 25 percent of the total land area in Illinois. Moreover, the most important water-bearing sand and gravel aquifers are located along major bedrock valleys and along major rivers in Illinois (Figure 30).

About 3.1 bgd, or about 65 percent, of the total potential yield of the principal sand and gravel

ESTIMATED POTENTIAL YIELDS OF PRINCIPAL SAND AND GRAVEL AQUIFERS.

FIGURE 36



Areas where municipal and industrial water supplies are usually developed from other sources.

Areas where small industrial and small municipal water well development in thin sand and gravel aquifers may be possible.

Estimated potential yields in gallons per day per square mile.

- Less than 50,000
- 100,000—150,000
- 150,000—200,000
- 200,000—300,000
- 300,000—400,000
- 1,000,000—3,000,000
- 3,000,000—5,000,000

aquifers in the State is concentrated in less than 6 percent of the total land area in Illinois and is located in alluvial deposits that lie directly adjacent to major rivers such as the Mississippi, Illinois, Ohio, and Wabash. About 0.5 bgd, or about 10 percent, of the total potential yield is from the principal sand and gravel aquifers in the major bedrock valleys of the buried Mahomet valley in east-central Illinois and in the river valleys of the Kaskaskia, Little Wabash, and Embarras Rivers in southern Illinois. The remaining 1.2 bgd, or about 25 percent of the potential, is scattered throughout most of the glaciated portions of central and northeastern Illinois.

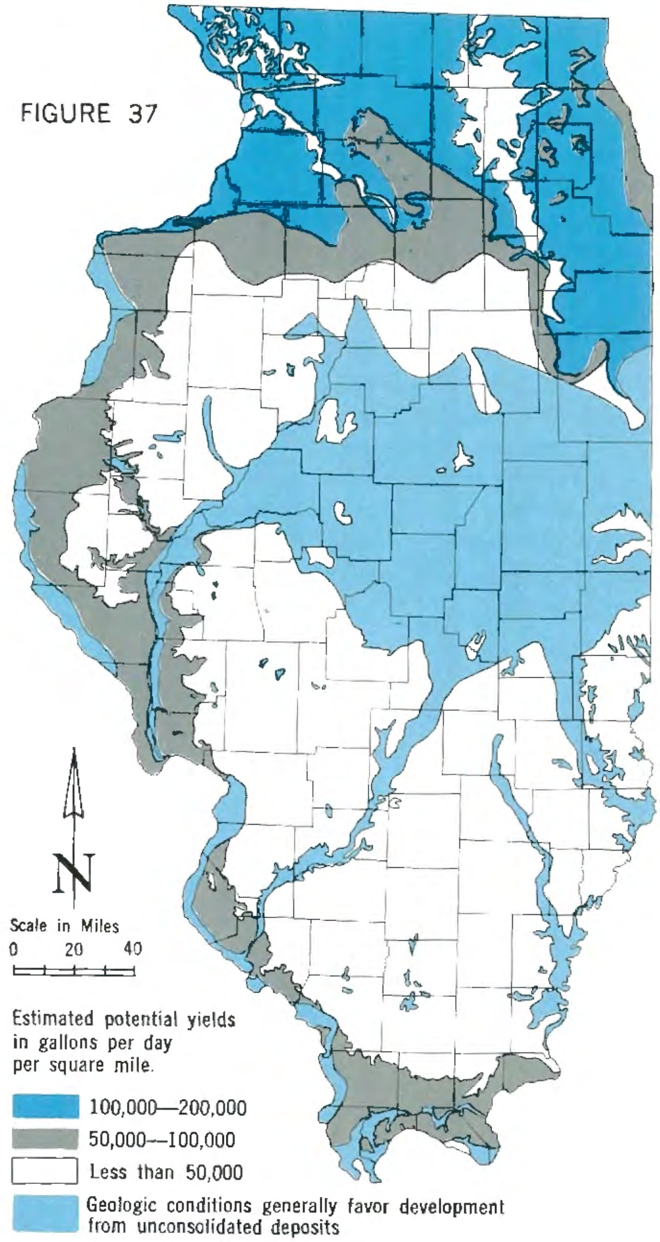
In portions of the State that are not underlain by the principal sand and gravel aquifers, small yields are available from minor or thin sand and gravel aquifers (Figure 36). Generally, however, they may be adequate only for domestic and livestock purposes and for supplying small quantities of water to small municipalities and light industry. Extensive test drilling and geophysical exploration are recommended in the areas categorized as possible locations of thin sand and gravel aquifers.

Cumulatively large ground-water supplies from a given aquifer may occur over a relatively large geographic area, but transporting the water to an area of concentrated demand may be too costly to be feasible. Heavy, concentrated withdrawals in a small geographic area may cause substantial drawdown, increased pumping pressures, and decreases in individual well production, although the aquifer elsewhere may retain further production potential. Notable examples of this situation occurred in the early 1940s at Peoria and Champaign, in the mid-1950s at Granite City, and in the early 1960s at Woodstock and at Joliet in the Hadley valley area. In all of the above cases, highly concentrated municipal and industrial withdrawals lowered water levels from near the surface to below critical stages, resulting in increased pumping pressures and decreased well production. Meanwhile, additional potential for development from wells was possible from the same aquifers in areas distant from the immediate pumping centers. Therefore, caution must be exercised when planning large ground-water supplies within small geographic areas, even though cumulative potential yield figures might indicate a large available resource.

The estimates of potential yields are not highly accurate, but merely indicate the order of magnitude of available ground-water resources. They should be used only for preliminary planning. Descriptions of local conditions are outside the scope of this report and may be obtained from publications dealing with specific areas or by communicating directly with the State Water Survey. In most areas shown in Figure 36, the available data are inadequate to assure supplies at specific locations. For this reason, and because of the sudden lateral variations in permeability of most glacial deposits, test drilling and aquifer test programs must precede development in any area.

ESTIMATED POTENTIAL YIELDS OF PRINCIPAL BEDROCK AQUIFERS.

FIGURE 37

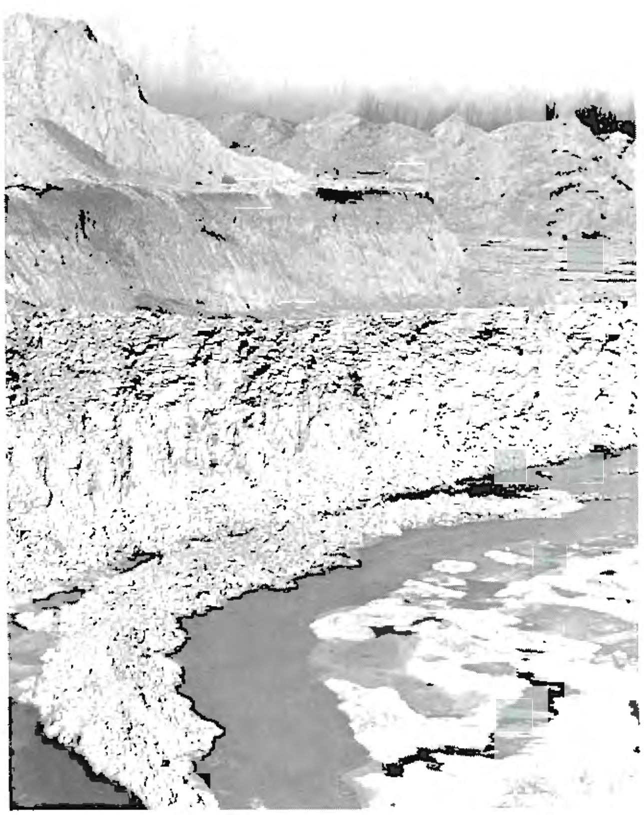


POTENTIAL YIELDS OF THE BEDROCK AQUIFERS

The ranges in potential yields of the principal bedrock aquifers in Illinois, estimated from aquifer recharge rates, are shown in Figure 37. Recharge to the bedrock aquifers is primarily from vertical leakage occurring locally through the glacial drift or overlying bedrock formations. The glacial drift is in turn recharged by precipitation.

Large areas in northeastern Illinois have sand and gravel aquifers overlying and connected with shallow bedrock aquifers. In such areas, pumpage from sand and gravel aquifers reduces the amount of water available to the bedrock as recharge and, therefore, reduces the potential yield of the shallow bedrock aquifers. The potential yield estimates for bedrock aquifers assumed full development of the bedrock.

Of the total estimated potential yield of bedrock aquifers in the State, 1.7 billion gallons per day, or 68 percent, is available from the shallow bedrock aquifers, mainly dolomites, in the northern third of the State. The potential yield of the shallow dolomites varies. In areas where the more permeable shallow dolomites lie directly beneath the glacial drift, the potential yield ranges from 100 to 200 thousand gpd per square mile. In areas where less permeable dolomites lie directly beneath the drift or are overlain by thin beds of less permeable rocks of Pennsylvanian age, the potential yield ranges from 50 to 100 thousand gpd per square mile. Where the overlying Pennsylvanian rocks are thick, the potential yield is less than 50,000 gpd per square mile.



Millersville Limestone (Pennsylvanian) in lower part of quarry, overlain by glacial drift.

The Cambrian-Ordovician aquifer, the uppermost of the two deep bedrock aquifer systems, in northeastern and parts of northwestern Illinois is directly overlain by the Maquoketa Group, mainly shale, which greatly retards the vertical movement of water, and thus reduces the potential yield of the Cambrian-Ordovician aquifer in these areas. Development of the Cambrian-Ordovician aquifer in northeastern Illinois has been possible because sufficient drawdown is available for pumpage to create large cones of depression and divert water from recharge areas in north-central Illinois, where the upper layers of the Cambrian-Ordovician aquifer lie directly beneath the glacial drift. Diversion of recharge in the recharge area to other pumping centers would limit the potential yield of the Cambrian-Ordovician aquifer in northeastern Illinois to the maximum amount of water that can move vertically downward through the Maquoketa Group and upward through the Eau Claire Formation, about 15 mgd, or less than 5000 gpd per square mile.

In western, southwestern, and extreme southern Illinois the principal bedrock aquifers are limestones and sandstones of Mississippian age. The total potential yield of Mississippian aquifers was estimated to be 0.5 bgd. The potential yield of Mississippian aquifers ranges from 50 to 100 thousand gpd per square mile, where they lie directly beneath the glacial drift, and to less than 50,000 gpd per square mile, where they lie beneath less permeable rocks of Pennsylvanian age. In extreme southern Illinois potential yields of the Mississippian aquifers may be as high as 100 to 200 thousand gpd per square mile.

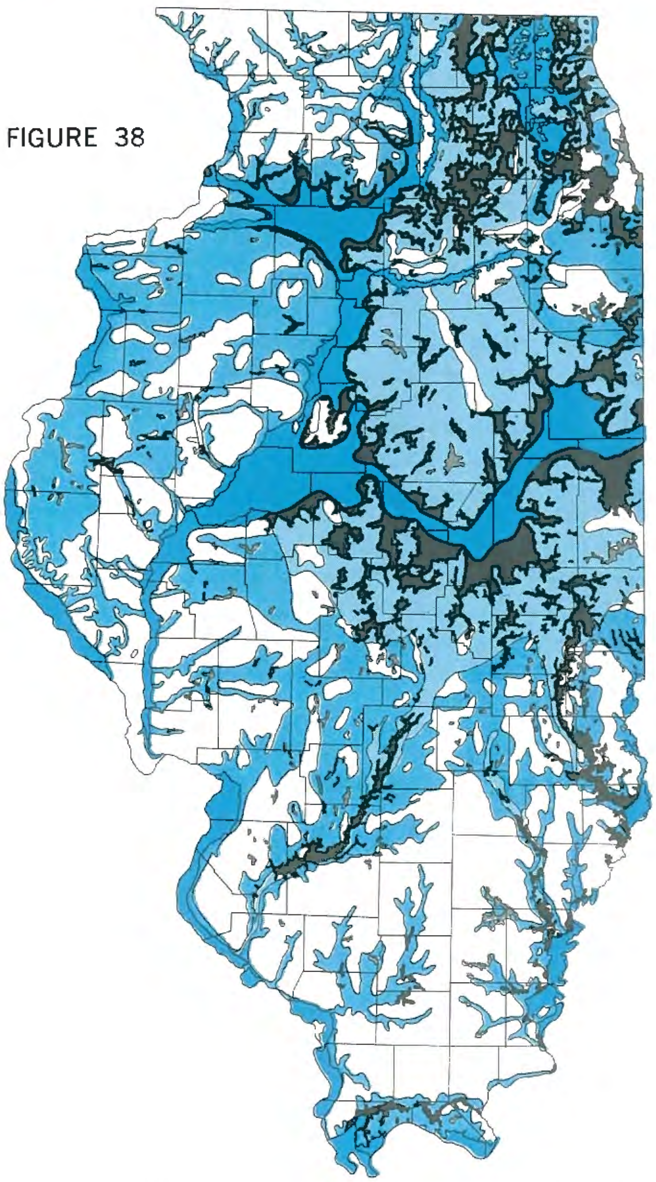
In central and southern Illinois the principal bedrock aquifers are thin beds of sandstone and limestone in Pennsylvanian rocks. The total potential yield of Pennsylvanian aquifers was estimated to be 0.3 bgd. The potential yield of Pennsylvanian aquifers is low, less than 50,000 gpd per square mile.

Development of large supplies of ground water from Pennsylvanian and Mississippian rocks (except from Mississippian rocks in extreme southern Illinois) has not proved feasible. Permeabilities of the rocks are low, and allowable drawdown is not sufficient to develop the large cones of depression necessary to divert large quantities of ground water to pumping centers.

Along the major river valleys and in a large part of central Illinois, the development of ground-water supplies for industrial and municipal use in sand and gravel aquifers is considerably more favorable than development of supplies in the bedrock. The potential yield for the bedrock aquifers in these areas (Figure 37) was not computed.

ESTIMATED YIELDS OF WELLS IN SAND AND GRAVEL AQUIFERS.

FIGURE 38



Areas where municipal and industrial water supplies are usually developed from other sources (E).

Areas underlain by principal sand and gravel aquifer at least 15 feet thick, where chances of obtaining wells with yields of:

- 20 GPM or more are good (D_2)
- 100 GPM or more are good (C, D_1)
- 500 GPM or more are good (A, AB, B_1, B_2, B_3, B_4)

Location of other possible sand and gravel aquifers, where small industrial and municipal well development may be possible and chances of obtaining wells with yields of:

- 20 GPM or more are possible (D_2)
- 100 GPM or more are possible (D_1)

Letters in parentheses refer to sources of water by geographic areas and possible well yields defined in a later section of the chapter.

YIELDS OF SAND AND GRAVEL WELLS

Figure 38 shows estimated yields of sand and gravel wells. The map should not be used to locate specific wells. It indicates general areas where conditions are especially favorable for drilling wells with large yields. Test drilling is required to locate specific wells, because data for most of the areas shown are inadequate or conditions variable from place to place. The map should be used with caution, and preferably only in conjunction with the potential yield map in Figure 36, when planning long-term ground-water development in sand and gravel aquifers in Illinois.

The areas in which conditions are favorable for the development of wells with moderate to high yields are generally associated with the principal sand and gravel aquifers. Most of the areas in which conditions are favorable for obtaining sand and gravel wells with yields in excess of 500 gallons per minute (gpm) are in deposits that are within major bedrock valley systems. These systems include the present Mississippi, Illinois, Ohio, and Wabash River valleys; the buried Mahomet valley in east-central Illinois; and areas within several buried and surface valley systems in the northern third of the State.

Most of the areas in which conditions are favorable for obtaining sand and gravel wells with yields in excess of 100 gpm are in areas underlain by principal sand and gravel aquifers. In many of these areas the deposits are associated with bedrock uplands, minor bedrock valleys, or deposits with moderate-to-high permeability. Sand and gravel wells with lower yields in excess of 20 gpm are probable in areas with similar conditions, but with deposits with only low to moderate permeabilities.

The yields of sand and gravel wells are generally great enough in Illinois to allow water to be withdrawn from aquifers faster than nature can replace the water by recharge. Depths of individual wells vary greatly and are dependent upon the geologic environment which governs the occurrence of the water-bearing deposits that they penetrate. However, large quantities of water are available from relatively shallow wells that are usually drilled to depths of less than 300 feet.

Static water levels in sand and gravel wells in Illinois vary considerably and are generally dependent upon many geohydrologic factors, some of which may be related to depth of deposits penetrated, location of natural recharge and discharge areas in relation to the well, hydraulic transmission and storage properties of the water-bearing deposits, and possible interference effects of nearby pumpage from other wells. No simple rule can be formulated to predict the exact position of the static water level in a sand and gravel well before it is actually drilled. Generally, wells in deposits very close to the land surface encounter unconfined water so

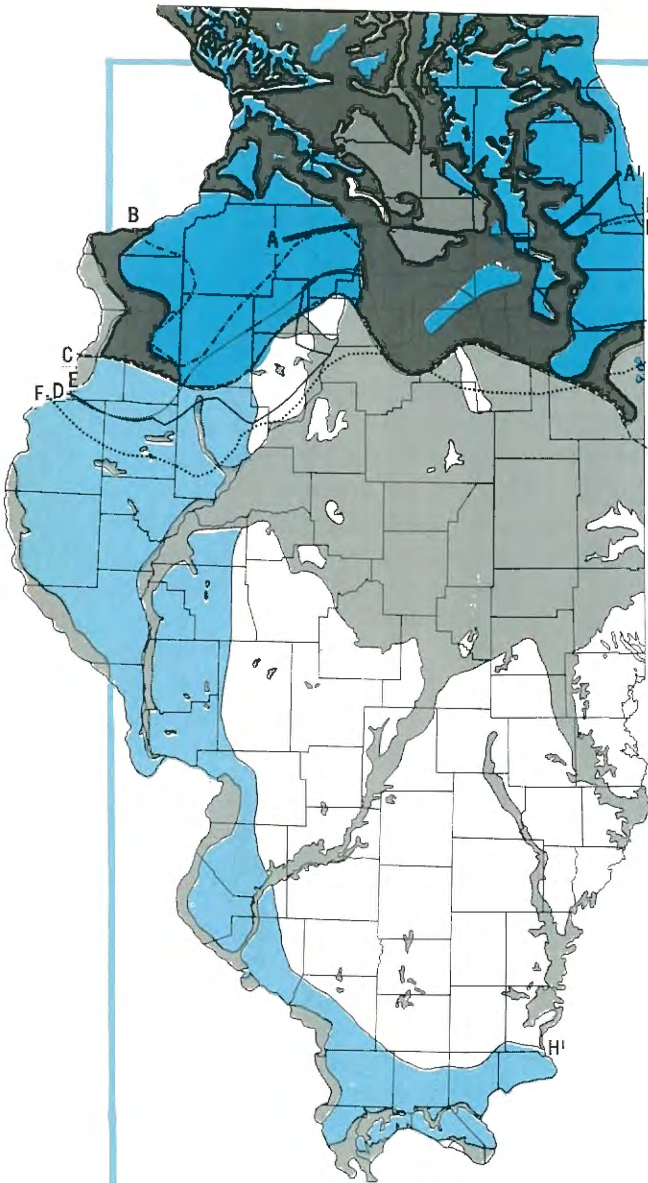


FIGURE 39

ESTIMATED YIELDS OF WELLS IN BEDROCK AQUIFERS

Yields of Wells in Deep Sandstone Aquifers.

North of line B---B' deep sandstone wells will normally yield 500 gpm or more (P)

Between lines E—E' and B---B' deep sandstone wells will normally yield between 100 to 500 gpm (Q)

Between lines F····F' and E—E' deep sandstone wells will normally yield less than 100 gpm (R)

A— A' Southern limit of use of Mt. Simon Sandstone Aquifer

D---- D' Southern limit of potable waters (1500 ppm total solids) from deep sandstones

F····· F' Southern limit of use of water from deep sandstones

Yields of Wells in Shallow Dolomites and Mississippian and Pennsylvanian Aquifers

Chances of obtaining a well with a yield of:

- 500 gpm or more from shallow dolomites are good (H)
- 100 gpm or more from shallow dolomites are good (I)
- 100 gpm or more from shallow dolomites are poor (J)
- Areas where shallow dolomites are missing (L)

C--- C' Southern limit of potable waters (1500 ppm total solids) from shallow dolomites

- 20 gpm or more from Mississippian limestones and sandstones are poor (K)
- 10 gpm or more from Pennsylvanian sandstone and limestones are poor (L)
- Geologic conditions generally favor development of unconsolidated deposits (L)

Limestones in Massac County in southern Illinois may yield 100 to 500 gpm or more.

Letters in parentheses refer to sources of water by geographic area and well yields defined in a later section of the chapter.

that static water levels are high and rise to the level of the water table. In the case of deeply buried deposits where confined water is obtained, static water levels are independent of and are usually lower than the water table.

YIELDS OF BEDROCK WELLS

In the northern third of the State, large quantities of ground water for industrial and municipal use are withdrawn from wells in the deep sandstone aquifers of Cambrian and Ordovician age and from the shallow dolomite aquifers of Silurian and Ordovician age (Figure 39). In the southern two-thirds of the State, where the glacial drift is thin or relatively impermeable, small water supplies are developed from thin beds of sandstone and limestone in rocks of Pennsylvanian and Mississippian age. In the extreme south, in the southern half of Alexander, Pulaski, Massac, and Pope Counties, moderate supplies of ground water may be withdrawn from wells in creviced limestones of Mississippian, Devonian, and Silurian age.

In general, bedrock wells are capable of yielding more water by heavy pumpage than will be recharged. Thus, water can be withdrawn faster than it is naturally replaced. Careful planning should precede any large long-term ground-water development.

Deep Sandstone Wells in Northern Illinois

Several hundred industrial and municipal wells in the northern third of Illinois take large quantities of ground water from deep sandstone aquifers. The Ironton-Galesville Sandstone is the main source of ground water for many public and industrial supplies and is considered the best bedrock aquifer in Illinois because of its consistently high yield. Part of the yield of many high-capacity deep sandstone wells is also from the Glenwood-St. Peter and Mt. Simon Sandstones. Deep sandstone wells often have yields exceeding 700 gallons per minute (gpm) and have been prolific sources of water for nearly 100 years. Deep sandstone wells average about 1300 feet in depth; wells of recent design are often finished 16 to 20 inches in diameter.

Most high-capacity deep sandstone wells in the northern part of the State tap several units and are multi-unit wells. The Galena-Platteville Dolomite, Glenwood-St. Peter Sandstone, and Prairie du Chien Group of Ordovician age and the Trempealeau Dolomite, Franconia Formation, Ironton-Galesville Sandstone, and Mt. Simon Sandstone of Cambrian age yield appreciable quantities of water. Yields of the 1) Galena-Platteville Dolomite and Glenwood-St. Peter Sandstone, 2) Prairie du Chien Group, Trempealeau Dolomite, and Franconia Formation, and 3) Ironton-Galesville Sandstone constitute about 15, 35, and 50 percent, respectively, of the total yield of the rocks above the Mt. Simon Sandstone.

The yields of multi-unit deep sandstone wells above the Mt. Simon Sandstone are shown in Figure 39. Water from the deep sandstones is highly mineralized south of the Illinois River. The line D-D' in Figure 39 is approximately the southern limit of drinkable water (less than 1500 parts per million total dissolved solids) in the deep sandstones. For lack of more suitable water supplies, wells are drilled locally to the sandstones a short distance south of this line (to F-F').

In parts of northern Illinois, yields of deep sandstone wells are increased by penetrating into the Mt. Simon aquifer (lower sandstones of the Eau Claire Formation and upper beds of the Mt. Simon Sandstone). The average permeability of the Mt. Simon aquifer is comparable to the average permeability of the Glenwood-St. Peter Sandstone. The average depth of penetration of wells into the Mt. Simon aquifer is about 350 feet in northeastern Illinois and about 590 feet in northwestern Illinois. No wells drilled for water have penetrated the entire thickness of the Mt. Simon aquifer in Illinois. This is because adequate yields are obtained with penetration of the upper beds only, or because water encountered in the Mt. Simon aquifer below an elevation of about 1300 feet below sea level is commonly too salty for municipal use. Line A-A' in Figure 39 indicates the southern limit of use of the Mt. Simon aquifer.

Shallow Dolomite Wells in Northern Illinois

Shallow dolomite aquifers of Silurian age and the Galena-Platteville Dolomite of Ordovician age are the main source of ground water for many moderate-to-large public and industrial supplies in the northern third of Illinois. Silurian and Ordovician rocks are encountered at depths ranging from a few to several hundred feet; the rocks above the Glenwood-St. Peter Sandstone which function as aquifers consist largely of dolomite.

Silurian rocks are usually encountered at depths between 10 and 300 feet in northeastern Illinois and between 30 and 880 feet in northwestern Illinois. Silurian rocks range in thickness from a few to more than 450 feet; the maximum known thickness of the Galena-Platteville Dolomite exceeds 350 feet. The Silurian rocks are major aquifers in northeastern and northwestern Illinois, and the Galena-Platteville Dolomite is a major aquifer in the central portion of northern Illinois.

Despite the fact that these shallow dolomite aquifers are inconsistent in productivity and the yields of wells vary greatly from place to place, shallow dolomite wells have been prolific sources of water for nearly 75 years. Small quantities of water also are obtained from dolomite beds of the Maquoketa Group and limestone beds of Devonian age. The average depth of shallow dolomite wells is about 140 feet, and most wells of recent design are finished 12 to 16 inches in diameter.

Pennsylvanian and Mississippian Aquifers

In the southern two-thirds of Illinois, thin sandstone and limestone beds of Pennsylvanian age and sandstone and limestone formations of Mississippian age yield small quantities of ground water. Although wells in these rocks commonly yield less than 25 gpm, they are the only source of water for several thousand farms and homes and several hundred small municipalities and industries. These rocks are also an important source of water for water-flooding operations in oil fields. The average depths of wells in Pennsylvanian-Mississippian rocks are 170 and 250 feet, respectively. Wells are often finished 6 to 12 inches in diameter.

In a small area in extreme southern Illinois, wells which penetrate rocks of Mississippian, Devonian, and Silurian age have yields in excess of 100 and 500 gpm. The area shown in Figure 39 in Massac County may be expanded after more records of well yields become available.

GROUND-WATER LEVELS

No long-term continuing trends of general rise or decline of the water table in Illinois can be detected. In general, the water table in Illinois under natural conditions declines in the late spring, summer, and early fall; water levels generally begin to recover in the fall. The rise of water levels is especially pronounced in the wet spring months.

Water levels are at low stages during dry periods, but as precipitation increases, water levels return to higher stages. The effects of the 1952 through 1956 drought are illustrated by the hydrograph of well STC2N9W-26.8f near East St. Louis. Water levels declined persistently during the drought, then rose to near normal stages in 1957 when precipitation was above normal. A 23-year water-level record for a shallow well in Bureau County showed no long-term rise or decline of the water table.

In some instances, large developments of ground water have caused pronounced and serious declines of water levels. The water-level declines in the Cambrian-Ordovician aquifer in the Chicago region are the best example. The declines of water levels are illustrated by water-level measurements made in well COK39N12E-12.3e in a western suburb of Chicago (Figure 40). Water levels in the well declined a total of 335 feet from 1931 to 1965. Since 1864, water-level declines of more than 700 feet have been estimated in the Cambrian-Ordovician aquifer in the Chicago region in areas of heavy pumpage at Summit, southwest of Chicago, and at Joliet.

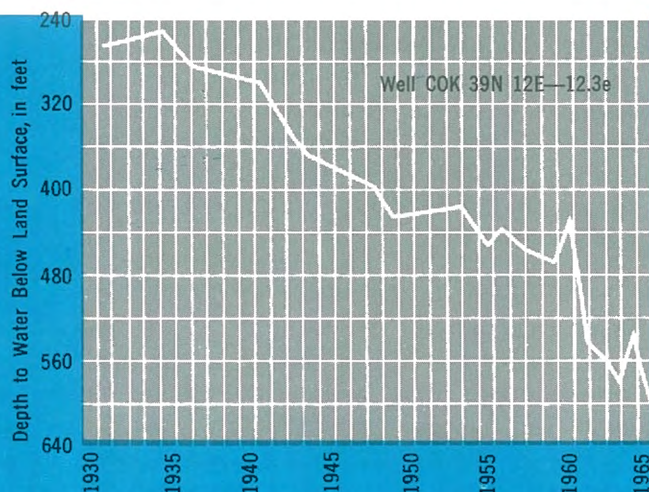
Water levels in the sand and gravel aquifer in the Peoria area reached critical stages in the 1940s. Water levels in the area recovered because of decreased ground-water pumpage, more favorable recharge conditions, and artificial recharge of river water through open pits.

During the 1950s, water levels in the sand and gravel aquifer in the Granite City area were at critical levels because of extreme, heavily concentrated ground-water pumpage. Water levels recovered to above critical stages when ground-water pumpage in the area was greatly reduced.

Heavy pumping does not always cause serious declines. Water levels have stabilized in the East St. Louis area, although pumpage in 1965 was about 110 mgd. Water levels are not critical at the present in other heavily pumped areas such as in the Peoria-Pekin, Rockford, and Champaign-Urbana areas.

FIGURE 40

WATER LEVELS

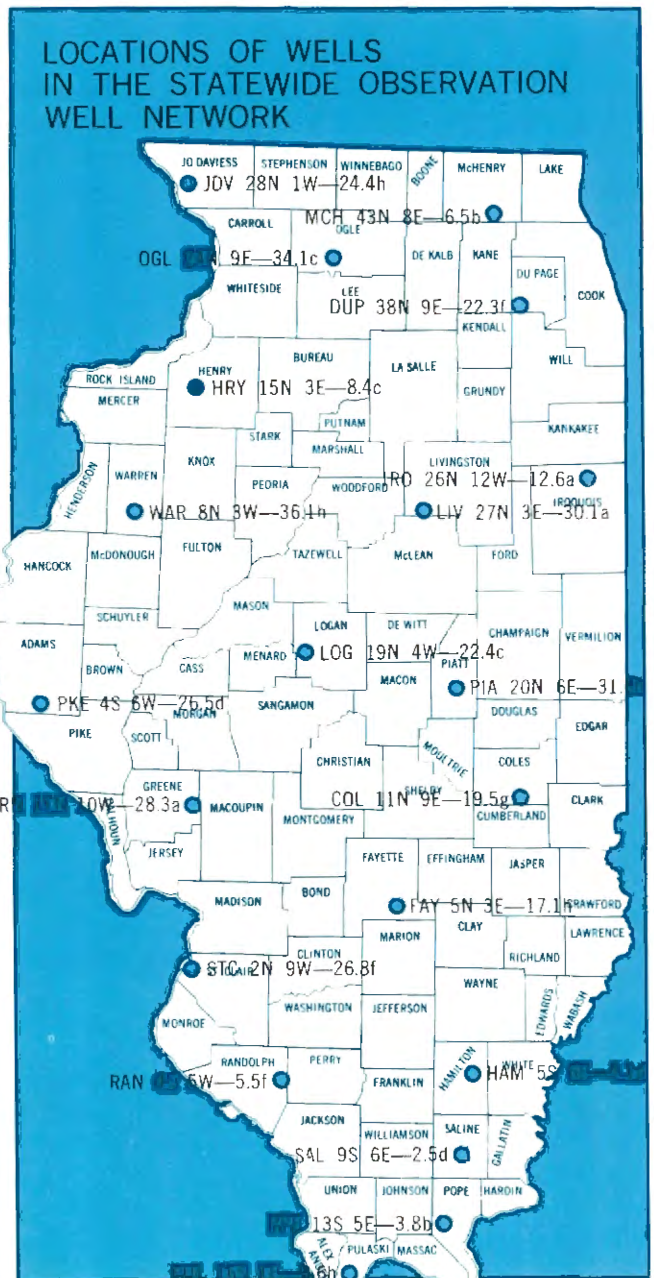


Water-Level Measurements

Ground-water levels in Illinois are monitored by a statewide network of observation wells. Systematic measurements of water levels are made in heavily pumped aquifers in northeastern Illinois and the East St. Louis, Peoria, and Champaign-Urbana areas.

To detect continuing long-term trends in fluctuations of water levels, a statewide network of representative shallow observation wells in areas remote from centers of ground-water withdrawals was started in 1958 (Figure 41). Hydrographs of water levels in six observation wells established prior to 1958 that were incorporated into the network are shown in Figure 42.

FIGURE 41

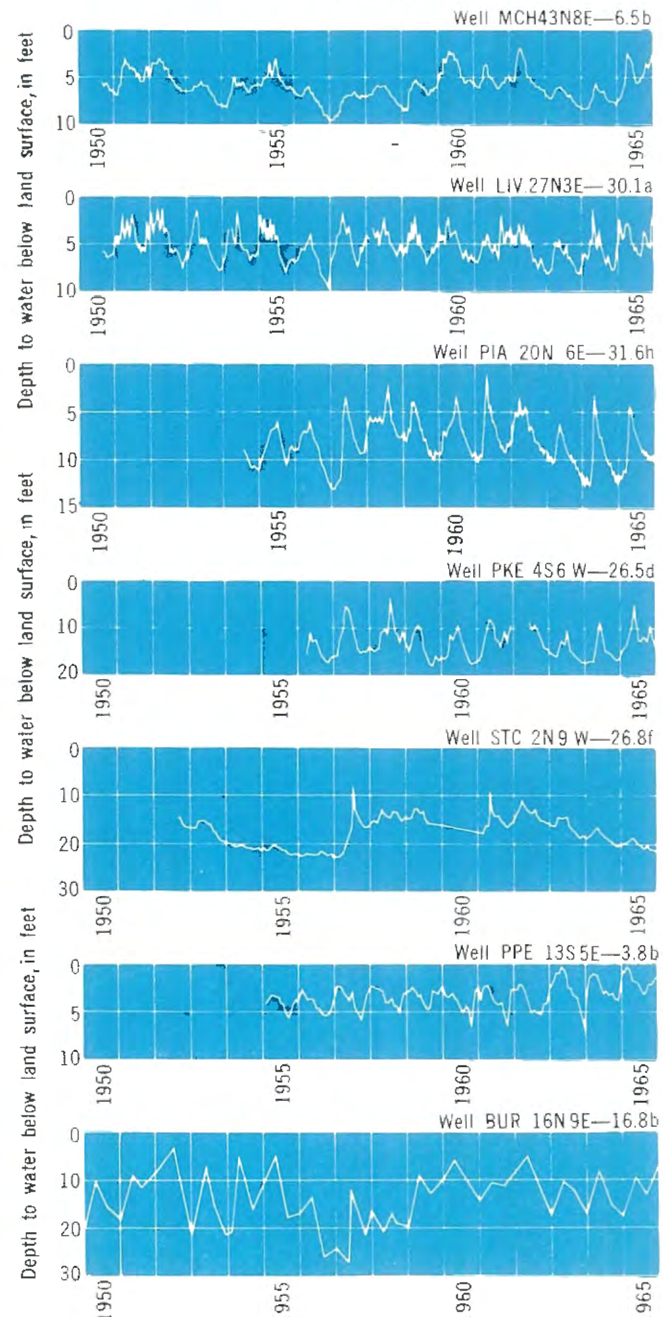


ARTIFICIAL RECHARGE POTENTIAL

The potential exists in limited areas of the State to augment the natural capabilities of the ground water by the artificial recharge from surface waters. Figure 43 shows the major areas of these possibilities based on a survey of sand and gravel formations existing in proximity to surface water which is adequate in quality and quantity. Recharge of sand and gravel formations is based upon successful operations at Peoria over the past fifteen years. There is no experience at this time for assuming that rock formations can be recharged, but future research may reveal these additional possibilities.

Areas identified on Figure 43 are those capable of

FIGURE 42 WATER LEVELS IN WELLS



producing at least 500,000 gallons per day for six months without recharge. The quantity of flow available for recharge is sufficient so that the stream discharge will not be diminished below that needed for dilution of upstream effluents. Also, reasonable limits of water quality have been established including turbidity, temperature, hardness, total dissolved minerals, nitrates, radioactivity, and other parameters.

No quantitative estimate has been made of the total artificial recharge potential of the State. Should the need for such recharge arise in a particular location, further detailed site investigations of the surface-water quality and discharge, as well as aquifer characteristics of the site, would be desirable.

MAJOR AREAS WHERE ARTIFICIAL RECHARGE MAY BE POSSIBLE USING THE PIT METHOD

FIGURE 43

WATER QUALITY

When planning a water supply for municipal, agricultural, industrial, or other uses, it is not always sufficient to know that the supply is drinkable. The amount and the kind of minerals the water contains are also important, so that an estimate of the cost of water treatment can be made.

One of the properties of water is its ability to dissolve minerals and other substances. The degree to which minerals are dissolved depends upon the type of mineral with which the water comes in contact, the time of contact, and in some cases, the presence or absence of dissolved oxygen. For example, Illinois surface waters in rivers and lakes seldom contain dissolved iron because of the presence of dissolved oxygen. Iron may be present as suspended iron oxide or in suspended silt, but not dissolved. On the other hand, well waters seldom contain dissolved oxygen, but iron is present in the water of about three of every four wells in a concentration of more than 0.3 milligrams per liter (mg/l) sufficient to cause staining.

The contact minerals in ground water are related to the geologic formation. The minerals in surface water are generally those of the surface soil, although many streams are occasionally fed by ground water. Other minerals are added through public, industrial, and agricultural use of water.

Water Quality Sampling.

Generally, for most subsurface waters, chemical analysis of a single sample is sufficient to give an accurate evaluation of the quality of the water which is obtained from a given well. However, the quality of the water in a stream varies almost continuously. Hence, an evaluation must be based upon a series of analyses obtained by a regulated sampling program, rather than upon any single analysis.

Ground water from sources of the same depth is fairly consistent in mineral quality for local areas, but the quality can vary widely with a change in depth-source locally. Sources of the same depth may also vary from one geographic area to another.

Most waters in Illinois are suitable for agricultural use, if the mineral content is satisfactory for municipal use, and if the sodium adsorption ratio (the total dissolved minerals minus the hardness, and divided by 5 times the square root of the hardness) does not exceed 10. A ratio of more than 20 to 25 is generally unsatisfactory.

The parameters selected for defining mineral quality in this report were chosen because of their effect on general municipal and industrial use. No assessment is made here of the sanitary quality of the water.

MINERAL QUALITY

The following discussion indicates the significance of each of the chemical determinations of mineral quality of ground or surface water. Fluoride has not been included, because its concentration is significant in only 1.2 percent of the public ground-water supplies in Illinois.

Data on color and odor are not included. Odor, when present in ground water, is normally caused by hydrogen sulfide; only a very few water supplies have any appreciable color. Taste, color, and odor are significant in that they are objectionable to the user.

Turbidity is an empirical measure of particles of clay, silt, or microscopic organisms suspended in water, which interfere with light transmission. Generally, in the absence of iron, the turbidity of ground-water supplies is negligible.

The Public Health Service Drinking Water Standards state that the turbidity of water shall not exceed 10 units. One or two units may be detected by eye in a glass of water. All public water supplies in Illinois from rivers or reservoirs are filtered to clarify the water and improve the effectiveness of disinfection by removing matter that would use up the disinfectant. Turbid water may be used for industrial cooling without prior treatment.

Total Dissolved Minerals — The total mineral content includes all the mineral ingredients in the water. Water with a high mineral content may have a salty or brackish taste of an intensity that depends on the concentration and kind of minerals in solution.

The Public Health Service Drinking Water Standards (1962) recommend that water should not contain more than 500 parts per million (ppm) total dissolved minerals. Mineralization of more than 500 ppm has a faint taste. Several municipalities in Illinois use waters of 1500 to 2000 ppm mineral content. Waters of 3000 and 4000 ppm can hardly be called palatable. At 5000 or 6000 ppm, even livestock do not do very well. At about 15,000 ppm, the water is injurious and would cause death if used continuously.

Equipment that can de-mineralize limited quantities of water is available, but the process is costly, compared with ordinary zeolite softening. The cost of chemicals to de-mineralize 100 gallons of water containing 5000 ppm total dissolved minerals would be about one to two dollars. This would be expensive water for lawn sprinkling, but the water for sixteen cups of coffee would cost one or two cents.

Hardness — Calcium and magnesium in water cause it to be hard. The distinction between hard and soft water is relative. Cities accustomed to water of 250 ppm hardness consider Lake Michigan water (130 ppm) soft; those supplied by softened water of 50 to 75 ppm hardness consider Lake Michigan water hard. In turn, anyone who is accustomed to water softened in a home zeolite system (0 to 10 ppm hardness), or to rain water, considers water of 50 to 75 ppm to be hard.

Hard water has a number of effects, very few of them good. Hard water causes scale to form in boilers or hot water heaters, because the solubility of calcium carbonate and sulfate salts and magnesium hydroxide is lower at increased temperatures, and fuel costs are increased. Chemical treatment of water used in boilers that produce steam and power is common and, in most cases, is an economic necessity.

Soap and soap products do not clean properly in hard water. The insoluble calcium and magnesium soaps which are formed with hard water leave a film on laundry and a white deposit on dishes.

In 88.5 percent of the public ground-water supplies in Illinois, hardness is greater than 200 ppm; in 58.3 percent, it is greater than 300 ppm; and in 26.2 percent, greater than 400 ppm. Of the 770 supplies, 155 serving 27 percent of the population have treatment plants that produce water with 100 ppm hardness or less.

Iron — Iron, as it exists in natural ground water, is in the soluble (ferrous) state and gives the water a faint green tinge. When exposed to air, it is converted to the insoluble ferric state and separates from the water to form fine-to-fluffy reddish brown particles and causes "red water." If allowed to stand long enough, these particles will gather together and settle to the bottom of a container. Such water causes red stains on laundry and may clog pipes in distribution systems, in service lines to homes, and in the household appliances.

The U. S. Public Health Service Drinking Water Standards recommend a limit of 0.3 ppm iron to avoid staining of laundry and porcelain ware. Three of every four public ground-water supplies in Illinois contain more than 0.3 ppm iron. Of these, 38.8 percent, or 227 supplies serving a population of 640,600, treat the water to remove iron. Thus, 60 percent of the population has iron-free water, including supplies that are naturally iron-free. However, 47 percent of the ground-water supplies used by the other 40 percent of the population still has an undesirable iron content.

Manganese — Manganese in water can cause brownish or black stains on laundry. Even very low concentrations can eventually cause black deposits that clog water mains and household service lines. To avoid such problems, the U. S. Public Health Service Drinking Water Standards recommend a limit of 0.05 ppm.

The available data for 726 public ground-water supplies show that 223 supplies, or 30.7 percent, contain 0.1 ppm manganese, or twice as much as is recommended. Of these, 55 percent serving a population of 514,600 are treated supplies. A remaining population of 329,000 is served by 100 supplies that still require treatment to reduce the manganese content to less than 0.1 ppm, of which 37 supplies provide water of 0.2 ppm or more manganese.

Nitrate — Excessive nitrate concentrations in water may cause a condition in infants called methemoglobinemia, which is one form of what is often called "blue babies," when such water is used to mix their formulas. The Public Health Service recommends that the nitrate content of drinking water not exceed 45 ppm (as NO_3).

Four of the present public ground-water supplies in Illinois contain more than 45 ppm nitrate. These have been in use for a number of years with no reported difficulty. However, there have been a great number of cases of blue babies associated with shallow rural supplies where this concentration has been exceeded. Fifty-three percent of 754 public ground-water supplies contain 1.0 ppm NO_3 or less.

Alkalinity — In most ground waters in Illinois, the alkalinity is within the range of 200 to 400 ppm and is generally associated with 20 to 50 ppm free carbon dioxide. Only a few waters contain a free carbon dioxide content greater than 50 ppm. In such cases the waters have a tendency to be excessively corrosive to pumping equipment and to hot water facilities.

Methane — Methane gas is present in a number of ground-water supplies and on several occasions has caused severe explosions. This gas is colorless, odorless, and tasteless; it is lighter than air and inflammable. When released from the water and mixed in concentrations of 5 to 15 percent, with air, the mixture is highly explosive when ignited. Methane gas can readily be removed from water by standard aeration procedures.

Water Treatment

Any of the water sources described in this report can be treated for any purpose; the cost and amortization are the controlling economic factors. Limits and treatments for various uses will not be discussed here because the range is wide within each particular field or industry.

SURFACE-WATER QUALITY IN ILLINOIS

Table 9 is an attempt to characterize surface-water quality for the entire State. Location and physiography influence water quality; water quality differs in the northern, central, and southern regions of the State.

The physiography of northern Illinois is such that variability of streamflow is low, as is variability of mineral content of the water. Underground storage conditions are generally good, and much of the streamflow is from stored ground water. Largely because of this interchange of water between the ground and the streams, the surface water is harder.

Continuing southward through the State, changes in physiography lead to progressively greater variability in streamflows, decreasing hardness, and a generally greater variability in mineral composition. Surface waters in the southern parts of the State can be expected to have slightly higher temperatures than those in the north.

TABLE 9 HIGHEST CONCENTRATION IN MG L, OR HIGHEST MEASURED VALUE, FOR INDICATED PERCENT OF SURFACE-WATER SAMPLES ANALYZED

Watershed	Sampling Station Location	& No.	Alkalinity 10%	50%	90%	Hardness 10%	50%	90%	Total Dissolved Minerals 10%	50%	90%	Nitrate 10%	50%	90%	Turbidity 10%	50%	90%	Temperature Degrees F 10%	50%	90%	Sampling Period and No. Samples	Watershed Area Square Miles	Instantaneous Flow CFS/Square Mile 10%	50%	90%
WISCONSIN DRIFTLESS REGION																									
Apple R.	Hanover	14	195	285	315	240	325	345	285	345	370	2	5.5	8.5	7	2	0.4	32	54	75.5	1957-1961 — 46	244	1.2	0.3	0.12
ROCK RIVER HILLS																									
Rock R.°	Como	23	175	240	270	225	290	330	280	340	390	2	6.5	12	7	3	0.6	32	56	78	1957-1961 — 59	8,700	1.0	0.39	0.15
WHEATON MORAINAL REGION																									
Fox R.	Algonquin	2	200	230	280	275	315	380	340	385	450	3	6	11	5	2	0.5	33	55	77	1957-1961 — 60	1,364	1.45	0.35	0.11
DuPage R.°	Troy	6	160	240	285	330	400	470	420	530	630	2.5	10.5	17	10	3	0.2	33	56	79	1945-1950 — 51	325	1.3	0.31	0.10
GREEN RIVER LOWLAND																									
Green R.	Geneseo	26	165	235	255	255	350	385	315	405	445	0.5	4	12	20	4	0.5	32	60	74	1945-1950 — 53	958	1.5	0.32	0.12
BLOOMINGTON RIDGED PLAIN-NORTH																									
Fox R.°	Dayton	30	185	230	290	275	320	375	350	400	480	3.5	7.5	13.5	7	3	0.7	32.5	60	78	1956-1961 — 60	2,570	1.2	0.41	0.027
KANKAKEE PLAIN																									
Vermilion R.	Pontiac	38	170	220	255	265	350	455	340	415	530	2	9	28	25	4	0.7	33	56	80.5	1957-1961 — 51	568	1.1	0.2	0.015
Vermilion R.	Lowell	39	155	220	260	250	355	460	310	445	685	3	11	28	10	2	0.4	32	57.5	78.5	1957-1961 — 54	1,230	1.4	0.22	0.019
Iroquois R.	Iroquois	36	95	200	225	140	305	355	220	375	420	2	10	17	10	4	0.1	32	49.5	78	1950-1956 — 51	682	2.1	0.34	0.052
Kankakee R.	Wilmington	32	145	190	210	255	315	345	330	390	435	1.5	6	19	20	2	0.4	32.5	56	78	1956-1961 — 52	5,250	1.9	0.6	0.18
GALESBURG PLAIN																									
LaMoine R.	Colmar	73	80	205	250	105	255	285	190	320	380	1.5	3.5	10	100	4	0.8	32	57	74	1957-1961 — 50	655	1.3	0.15	0.023
LaMoine R.	Ripley	72	70	165	220	110	225	290	150	270	350	1.5	5	10.5	90	10	2	33	57	76	1945-1950 — 49	1,310	3	0.18	0.045
Spoon R.	London Mills	49	110	230	270	175	315	375	210	385	495	0.5	6.5	13.5	55	7	2	32	55	80	1945-1950 — 47	1,070	1.4	0.15	0.032
Spoon R.	London Mills	49	160	260	310	230	350	440	315	440	625	1.5	6.5	14.5	45	4	0.7	32.5	59	78	1957-1961 — 48	1,070	1.8	0.2	0.032
INTERSECTIONAL																									
Illinois R.	Meredosia	104	125	155	180	195	245	300	295	360	415	4.5	17	27.5	25	8	4	33	56	81	1955-1960 — 60	25,300	1.4	0.54	0.25
Illinois R.	Peoria	102	120	150	180	200	250	300	255	330	400	5.5	9.5	16	100	31	10	34	59	80	1945-1949 — 48	——	—	n.r.	—
Illinois R.	Peoria	102	135	160	180	225	260	320	330	385	450	3.4	10	18	70	37	13	32	54	81	1957-1961 — 50	——	—	n.r.	—
LINCOLN HILLS																									
Hadley Cr.	Barry	75	80	160	190	110	180	215	165	230	260	0.5	2	6	25	2	0.5	34.5	61	85	1956-1961 — 59	40.6	0.44	0.047	0.0025
SPRINGFIELD PLAIN																									
Embarras R.°	Ste. Marie	84	145	210	270	200	280	310	255	330	385	1	5.5	16	25	3	0.5	33	59.5	79	1956-1961 — 60	1,513	1.8	0.23	0.022
Kaskaskia R.°	Vandalia	106	105	210	265	130	275	315	170	345	445	1	3.5	12.5	25	3	0.5	34	54	81	1950-1956 — 50	1,980	0.95	0.12	0.011
Kaskaskia R.°	New Athens	81	40	125	215	75	185	305	130	285	435	2	5	10	50	10	2	34	59	78	1945-1950 — 55	5,220	3.5	0.45	0.07
Kaskaskia R.°	New Athens	81	50	135	215	80	210	300	150	315	500	1.5	4.5	9	55	9	2	34	57	78	1957-1961 — 48	——	—	n.r.	—
Sangamon R.°	Oakford	71	155	235	265	205	305	330	265	380	430	1.5	5	13.5	25	2	0.5	34	60.5	75.5	1957-1961 — 60	5,120	1.2	0.26	0.065
Little Wabash R.	Wilcox	86	50	105	190	85	175	275	165	285	435	0.5	2	5.5	20	3	0.9	33.5	53	80	1950-1955 — 60	1,130	1.7	0.08	0.002
Indian Cr.	Wanda	79	125	210	250	175	305	355	245	385	440	1.5	4	8	30	5	1	34	55	77	1945-1950 — 58	37	0.7	0.15	0.01
Macoupin Cr.	Kane	78	75	200	250	125	265	345	160	330	440	1	4	8	70	7	1	34	56	78.5	1945-1950 — 60	875	2.5	0.17	0.015
BLOOMINGTON RIDGED PLAIN-SOUTH																									
Kaskaskia R.	Shelbyville	105	80	200	255	125	320	625	170	405	1080	0.5	8	23.5	10	2	0.2	33	60	78	1956-1961 — 60	1,030	1.6	0.24	0.015
Sangamon R.	Monticello	60	165	235	300	225	320	350	270	375	485	2.5	8.5	27	8	2	0.3	33	51.5	74.5	1956-1961 — 60	550	1.4	0.28	0.026
Salt Cr.	Rowell	65	140	260	315	180	305	335	230	355	460	3	7	17.5	20	2	0.3	33.5	54	76	1950-1956 — 59	334	1.5	0.14	0.022
Mackinaw R.	Green Valley	103	150	250	320	195	320	350	260	350	390	1.5	6.5	18.5	25	2	0.5	35	50	80	1950-1956 — 60	1,100	1.2	0.23	0.052
Vermilion R.	Catlin	101	170	230	300	225	290	340	285	390	560	4	13.5	20.5	7	1	0.4	34	52	78	1950-1956 — 60	959	1.7	0.22	0.024
MT. VERNON HILLS																									
Skillet Fork	Wayne City	88	15	60	105	60	170	260	115	295	435	0.5	2	3.5	30	6	2	33	56.5	76.5	1945-1950 — 54	475	5	0.12	0.0072
Skillet Fork	Wayne City	88	25	55	115	60	135	295	125	260	530	1	2.5	4.5	25	5	2	33	60	78	1957-1961 — 51	475	4.6	0.11	0.0025
Big Muddy R.	Plumfield	92	10	30	70	60	145	335	110	295	675	1	2.5	6.5	20	10	2	35	57	79.5	1945-1950 — 58	753	5.8	0.26	0.014
Big Muddy R.	Murphysboro	107	25	50	100	100	200	440	205	425	795	1.5	3.5	5	30	5	2	36	58.5	77	1956-1961 — 55	2,170		0.39	
Crab Orchard Lk.	Wolf Creek	109	20	40	60	100	120	140	175	210	240	—	—	—	5	3	1	37	58	82.5	1951-1956 — 55	——	2.5	n.r.	0.014
Crab Orchard Lk.	Station 5	108	20	35	50	85	100	120	150	165	220	0.5	1	2.5	5	1	0.5	37	56.5	83	1951-1956 — 55	——	—	n.r.	
Little Wabash R.	Carmi	89	30	75	150	65	150	240	140	280	470	1.5	3	5.5	35	5	2	33.5	61	78	1957-1961 — 50	3,111	2.5	0.3	0.014
Saline R.°	Junction	90	20	75	165	65	265	655	120	460	1010	1.5	2.5	3.5	20	5	1	35	60	79	1945-1950 — 41	1,040	4.0	0.28	0.02
SHAWNEE HILLS																									
Cache R.	Forman	96	30	55	95	40	70	110	75	120	165	1	2	3.5	40	6	2	34	59	77	1957-1961 — 60	243	5.4	0.25	0.0062
INTERSECTIONAL																									
Wabash R.	Riverton, Ind.	117	110	180	220	165	260	325	225	340	405	3.5	12	26	45	9	2	38	59.5	82	1955-1960 — 60	13,100	2.2	0.56	0.17
Wabash R.	Mt. Carmel	116	115	180	225	165	250	310	215	305	395	2	6	10.5	25	3	1	—	—	—	1950-1956 — 56	28,600	2.0	0.5	0.14
Ohio R.	Metropolis	115	45	70	90	85	120	150	125	170	215	1.5	3.5	6	9	3	0.5	34	59	77	1950-1956 — 52	203,000	3.0	0.89	0.32
Ohio R.	Cairo	114	60	75	95	100	135	165	150	205	255	1.5	4	6.5	10	4	0.9	34.5	66	83	1958-1961 — 42	——	—	n.r.	—
Mississippi R.	Keokuk, Iowa	110	100	135	160	125	170	190	165	200	230	0.5	3	6.5	30	3	0.7	32.5	54	81	1950-1955 — 56	119,000	0.95	0.50	0.22
Mississippi R.	E. St. Louis	111	120	150	180	155	205	245	210	280	300	2.5	6	11	60	8	1	34	62	82.5	1958-1961 — 41	——	—	n.r.	—
Mississippi R.	Chester	112	110	135	190	160	200	250	230	290	360	1.5	7	18	75	20	6	33	56.5	82	1955-1960 — 60	712,600	0.38	0.16	0.081
Mississippi R.	Thebes	113	115	150	175	160	200	240	235	300	370	2	4.5	7.5	75	20	5	—	—	—	1951-1956 — 59	717,200	0.5	0.18	0.1

SURFACE-WATER QUALITY SAMPLING STATIONS

FIGURE 44

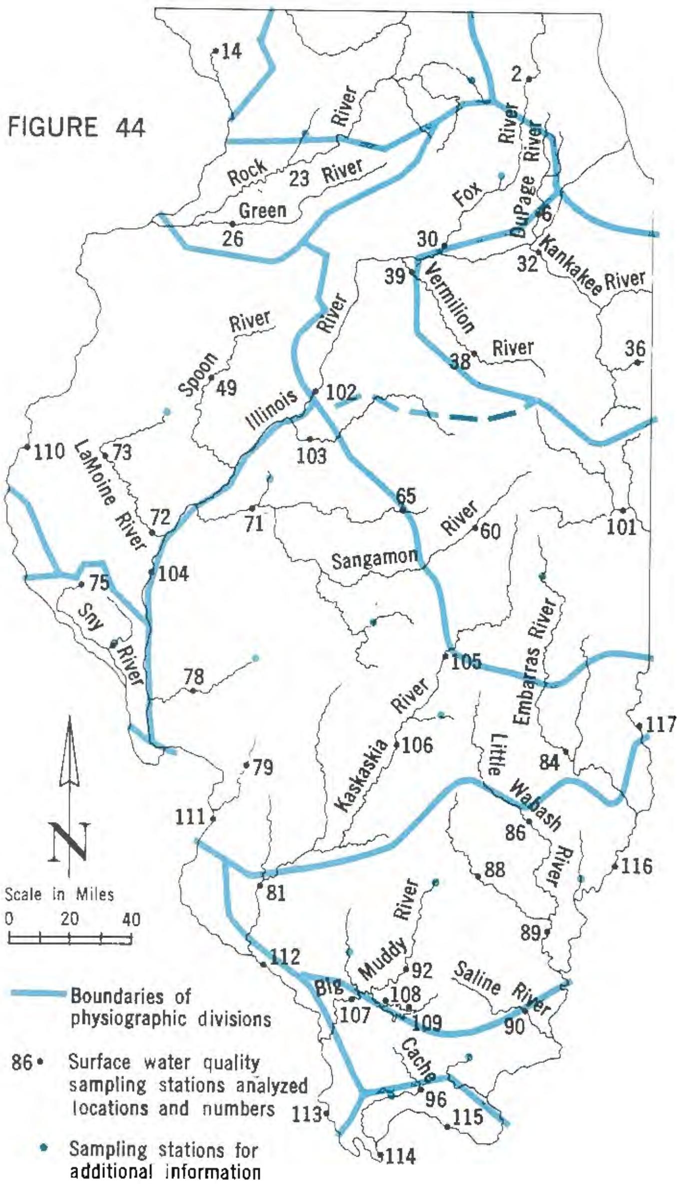


Table 9 summarizes data analyzed from samples collected in 29 watersheds from 44 sampling locations. Generally, samples were collected monthly for a period of four to five years at any one sampling station. Locations of the sampling stations, grouped according to physiographic divisions of the State, are shown in Figure 44. Using the data for different sampling periods at the same location, changes in quality can be compared with time.

GROUND-WATER QUALITY

More than 16,000 ground-water samples, collected from the statewide area between 1896 and 1965, were analyzed in an attempt to characterize ground-water quality in Illinois (Tables 10, 11, 12, and 13). Elimination of duplicate or incomplete data reduced this total to approximately 11,000 analyses which were of use in this study.

Identification of the four sources of ground water and the geographic areas related to the possible yields within which the sources are located are defined as follows:

Sand and Gravel Wells

A — Alluvial areas along the Mississippi, Ohio, and Wabash Rivers, exclusive of the so-called American Bottoms in Madison and St. Clair Counties. Areas where the chances are good of obtaining municipal and industrial wells with yields of 500 gpm or more are indicated in Figure 38.

AB — Alluvial areas along the Mississippi River in the American Bottoms, where chances are good of obtaining municipal and industrial wells with yields of 500 gpm or more.

B_1 — Areas along the Illinois River and the ancient buried Mississippi River valley, where chances are good of obtaining municipal and industrial wells with yields of 500 gpm or more.

B_2 — Areas along the ancient, buried Mahomet bedrock valley, where chances are good of obtaining municipal and industrial wells with yields of 500 gpm or more.

B_3 — Areas along the ancient, buried Rock and Troy River valleys, where chances are good of obtaining municipal and industrial wells with yields of 500 gpm or more.

B_4 — Areas along the ancient, buried Ticona bedrock valley, where chances are good of obtaining municipal and industrial wells with yields of 500 gpm or more.

C — Alluvial areas along the Fox, Spoon, Sangamon, Kaskaskia, Embarras, Little Wabash, and Cache Rivers, where the map in Figure 38 shows chances are good of obtaining municipal and industrial wells with yields of 100 gpm or more.

D_1 — Scattered sand and gravel aquifers located in areas of the Wisconsinan drift, where chances are good of obtaining municipal and industrial wells with yields of 100 gpm or more.

D_2 — Scattered sand and gravel aquifers located outside the limits of the Wisconsinan drift, where chances are fair of obtaining municipal and industrial wells with yields of 20 gpm.

E — Rarely-occurring sand and gravel aquifers located outside the limits of the Wisconsinan drift,

HIGHEST CONCENTRATIONS OF GROUND-WATER SAMPLES ANALYZED

TABLE 10 — IN AREAS WHERE WELLS ARE POTENTIALLY CAPABLE OF YIELDS OVER 500 GPM (For Wells More than 50 Feet Deep)

Ground-water Source		NO_3			Cl			Alkalinity			Hardness			Total Dissolved Minerals			Fe			Mn			Depth-ft		
	Area	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%
Drift	A	tr	1.8	23.0	2	8	55	144	256	496	155	272	533	220	324	594	0.1	1.3	22.2	0	0.2	1.8	55	85	225
Drift	AB	tr	0.9	9.9	3	11	73	160	284	352	207	399	727	262	455	1056	0.3	5.5	16.8	0	0.4	1.4	60	100	121
Drift	B_1	0	2.9	42.0	1	10	85	176	316	476	186	347	589	248	438	855	0	1.0	6.0	0	0	0.8	58	108	336
Drift	B_2	0	1.2	10.6	1	3	37	280	352	536	216	326	624	316	416	965	0.3	2.0	10.0	0	0	0.2	73	137	302
Drift	B_3	0.1	1.4	28.7	1	3	30	220	310	384	118	322	432	244	349	552	tr	1.2	3.0	0	0	0.4	90	170	335
Drift	B_4	0	0.9	6.2	1	4	30	126	308	404	194	361	738	290	397	1083	0.1	1.0	4.4	0	0	0.1	63	111	226
Limestone	H	0	1.1	9.6	1	8	172	130	332	484	69	420	949	293	564	1422	tr	0.8	7.2	0	0	0.2	90	237	655
Sandstone	P	0	1.2	11.5	1	19	320	204	280	380	168	316	643	292	478	1499	tr	0.4	5.0	0	0	0.2	175	1357	2125

TABLE 11 — IN AREAS WHERE WELLS ARE POTENTIALLY CAPABLE OF YIELDS OF 100 TO 500 GPM (For Wells More than 50 Feet Deep)

Ground-water Source	Area	NO_3 5%	50%	95%	Cl 5%	50%	95%	Alkalinity 5%	50%	95%	Hardness 5%	50%	95%	Total Dissolved Minerals 5%	50%	95%	Fe 5%	50%	95%	Mn 5%	50%	95%	Depth-ft 5%	50%	95%
Drift	C	0	1.5	32.0	2	12	445	134	344	688	108	364	565	306	519	1818	0.1	2.0	16.4	0	tr	0.4	54	88	162
	D_1	0	1.2	11.3	1	8	127	168	362	624	120	312	612	310	447	1100	0.2	1.8	12.0	0	0	0.2	58	110	218
Limestone	I	0	1.4	46.7	1	8	175	118	312	460	124	336	612	298	446	1172	tr	0.6	6.9	0	0	0.2	63	187	713
	J	0	1.2	6.7	1	10	52	128	294	516	60	251	448	208	374	790	0	0.5	6.8	0	0	0.1	100	215	641
Sandstone	Q	0	0.8	5.7	6	275	3179	202	324	1192	28	228	1224	480	1323	5844	tr	0.8	7.4	0	0	0.9	98	1009	2445
	R	0	1.3	53.8	6	130	2620	136	368	1000	32	252	1088	427	1282	4845	tr	0.9	12.3	0	0	0.9	65	190	1850
Limestone-Sandstone	X	0	1.2	14.2	2	33	810	180	272	372	160	323	670	292	555	2197	0	0.4	4.3	0	0	0.1	315	1400	2262

TABLE 12 — IN AREAS WHERE WELLS ARE POTENTIALLY CAPABLE OF YIELDS OF LESS THAN 100 GPM

Ground-water Source	Area	NO_3 5%	50%	95%	Cl 5%	50%	95%	Alkalinity 5%	50%	95%	Hardness 5%	50%	95%	Total Dissolved Minerals 5%	50%	95%	Fe 5%	50%	95%	Mn 5%	50%	95%	Depth-ft 5%	50%	95%
Drift	D_2	0.1	3.1	158.6	2	16	220	125	316	542	151	352	1090	253	504	1788	0	1.0	12.2	0	tr	0.7	15	41	141
	E	0.2	6.6	177.0	3	17	178	96	300	510	102	381	939	237	498	1542	0	0.5	10.1	0	0	1.1	16	35	140
Limestone	K	tr	1.9	66.4	2	21	1225	160	352	704	40	292	740	253	484	2755	0	0.8	18.0	0	0	0.8	60	226	981
	L	tr	1.2	54.9	1	28	2149	196	372	712	30	275	800	344	619	4426	0	1.2	31.0	0	0	0.4	72	240	1525
Sandstone	S_1	0	1.4	31.0	1	15	1940	72	316	648	25	303	1430	230	477	5870	tr	1.2	56.7	0	0	2.0	51	187	1520
	S_2	0	1.6	132.8	2	65	2450	140	408	772	16	286	2605	327	871	5772	tr	1.1	33.3	0	0	1.8	25	150	900
Limestone-Sandstone	Y	0	1.2	8.6	4	550	1875	128	322	1012	26	348	2003	300	2520	7007	0	0.6	37.5	0	0	1.0	122	610	2243
	Z	0	0.7	17.5	1	451	5700	201	350	708	24	264	730	495	1781	13600	0	0.9	18.0	0	0	0.1	159	1000	3070

TABLE 13 — FOR WELLS OF LESS THAN 50 FEET DEEP AND PROBABLY CAPABLE OF YIELDS LESS THAN 100 GPM, BUT LOCATED IN AREAS CAPABLE OF YIELDS OVER 100 GPM FROM DEEPER WELLS

Ground-water Source	Area	NO_3 5%	50%	95%	Cl 5%	50%	95%	Alkalinity 5%	50%	95%	Hardness 5%	50%	95%	Total Dissolved Minerals 5%	50%	95%	Fe 5%	50%	95%	Mn 5%	50%	95%	Depth-ft 5%	50%	95%
Drift	A	0.5	10.2	120.4	3	12	147	30	240	390	91	308	446	145	389	583	0	0.2	37.0	0	0.1	12.0	16	32	50
	AB	—	—	—	3	13	274	114	290	520	158	452	1920	246	518	3049	0	1.3	49.3	—	—	—	23	35	50
	B_1	0.8	18.3	135.0	4	15	94	152	282	436	220	398	780	273	478	1056	0	0.1	4.3	0	0	1.6	16	30	46
	B_2	0.2	9.8	141.7	1	16	220	168	328	508	239	438	1120	263	532	1556	tr	0.4	7.3	—	—	—	12	35	50
	B_3	—	—	—	4	20	36	114	204	384	205	347	1592	257	537	2270	0	0.3	15.0	—	—	—	11	30	48
	B_4	0.3	2.5	43.0	3	16	86	132	318	568	268	447	900	324	532	1372	0	0.4	3.6	0	0	0.2	10	25	49
	C	0	3.4	203.7	6	18	145	52	278	452	146	368	856	256	475	1235	0	0.5	6.0	0	0	0.8	14	35	47
	D_1	0.2	4.8	150.0	2	17	176	176	304	528	238	405	1050	314	519	1580	tr	0.7	9.4	0	tr	0.7	14	32	50

tr — means trace quantity
Blank < 12 determinations

In milligrams per liter for indicated percent of samples analyzed.

where chances are remote of obtaining wells for industrial and municipal use.

Limestone and Dolomite Wells

H — Areas of shallow dolomites, where the map in Figure 39 shows chances are good of obtaining wells with yields of 500 gpm or more.

I — Areas of shallow dolomites, where chances are good of obtaining municipal and industrial wells with yields of 100 gpm or more.

J — Areas of shallow dolomites, where chances are poor of obtaining wells with yields of 100 gpm or more.

K — Areas of shallow limestones, where chances are poor of obtaining wells with yields of 20 gpm or more.

L — Areas of shallow limestones, where chances are poor of obtaining wells with yields of 10 gpm or more, or where shallow dolomites are missing.

Sandstone Wells

P — Areas north of the line B-B' in Figure 39, where deep sandstone wells will normally yield 500 gpm or more.

Q — Areas between the lines E-E' and B-B' of Figure 39, where deep sandstone wells will normally yield 100 to 500 gpm.

R — Areas between the lines F-F' and E-E' of Figure 39, where deep sandstone wells may yield 100 gpm or less.

S_1 — Areas corresponding to those called K, where chances are poor of obtaining wells with yields of 20 gpm or more from the sandstone.

S_2 — Areas corresponding to those called L, where chances are poor of obtaining wells with yields of 10 gpm or more from the sandstone (Pennsylvanian).

Limestone-Sandstone Wells

X — Area north of line C-C' (northern Illinois) in Figure 39, where chances of wells with yields of 100-500 gpm are probably good.

Y — Area south of line C-C' and west of line H-H' (western and extreme southern Illinois) in Figure 39, where chances of wells with yields of 20 gpm or more are poor.

Z — Area south of line C-C' and east of line H-H' (middle and eastern Illinois) of Figure 39, where chances of wells with yields of 10 gpm or more are poor.

In this attempt to characterize ground-water quality within rather broad categories, defined by source and potential well yields, it was impossible to derive specific values of parameters for wells within a particular group or category. Instead, the 5, 50, and 95 percent values of probability of occurrence have been shown as a guide to the ranges within which these parameters of quality can be expected to occur. Extreme variability, or a wide range in quality, is to be expected in some categories, particularly those for wells widely separated in broad areas of the State, for those located where geologic conditions are such that the possibilities of ground-water withdrawals from multiple aquifers exist, and for wells varying greatly in depth within a given area. Data are available for greater definition of quality by depth, if a specific location within an area is considered for well development.

Few conclusions can be drawn from the broad classifications of water sources and potential availability. However, it is evident that water from drift wells is more likely to contain higher concentrations of iron than water from the bedrock. On the other hand, water from the bedrock is more likely to have greater mineralization, particularly in the Q, R, Y, and Z categories. Shallow wells of less than 50 feet in depth are more likely to contain higher nitrate concentrations. Water of exceptionally high hardness may be found occasionally in waters from all categories, and only a few have a possibility of yielding waters of hardness less than 100 mg/l.

CONCLUSIONS AND RECOMMENDATIONS

Information on streamflow and ground water which is summarized in this chapter suggests that Illinois has large water resources. These resources can be conserved and their availability increased by reservoir storage and by artificial recharge of aquifers. Studies still in the research stage on weather modification, desalination, transpiration reduction, and other subjects hold promise that our natural water resources may be increased substantially in the future.

However, whether water resources are adequate or not is primarily determined by the future demands which will be placed upon them. This matter is discussed in the following chapter on water supply and use, and recommendations are made there for conserving and maximizing the usefulness of the water resource. The chapter also makes recommendations with respect to hydrologic and geologic data and research programs to refine our knowledge of the resource in the ways and to the extent this will be needed in the future.

I. The Illinois stream gaging program has been nearly constant for 15 years, with increased budgets about adequate to offset rising costs. This program at about 150 gaging locations is designed to merely sample the runoff of Illinois streams. Such a program assumes that streamflow data can be transferred to other unmeasured places with reasonable accuracy. With the increased storage of runoff in streams and the anticipated diversions, this design will no longer prove adequate; increasingly the flow must be measured at sites where this information is needed.

It is also apparent that information is required on more of the smaller streams than have previously been gaged in order to manage waste dilution.

A. It is recommended that the Illinois stream gaging program be strengthened gradually over a ten-year period so that direct measurements will be available on all streams draining 100 square miles or more.

B. It is recommended that the data agencies survey the low-flow characteristics of all streams draining more than 25 square miles. This should be by a program of temporary gages which will establish the low-flow characteristics for waste dilution.

C. It is recommended that a program of generalized research into the hydraulic geometry of streams be accelerated with existing data. This will guide the design of the needed expansion of the gaging network and allow maximum interpretation of its results.

II. Ground-water data accumulated over the past 70 years has been fully utilized in the preparation of this chapter. This has made possible the estimates of potential yield of aquifers. These estimates are not highly accurate, but were adequate for preliminary planning purposes.

Ground-water data collected over the years has been furnished voluntarily by engineers, well drillers, and others. Obviously, a great deal of information exists which has not been made available to the State agencies for evaluation and study.

The network of water-level measurements has indicated no general decline which can be ascribed to climatic causes. Declines which have been observed are related to heavy local or regional pumpage. The present network is primarily concentrated in areas of heavy pumpage and should be extended so that at least one regular observation well is established in each county.

A. It is recommended that the State agencies institute a program of deliberate hydrologic and geologic data collection at a cost of about $100,000 per biennium. Such a program will insure that all available information is being obtained and will insure that needed refinements in present estimates of the capability of the ground-water resources can be made as needed.

III. The ultimate and long-term adequacy of Illinois water resources will probably not be determined by development of reservoir storage or the diversion of water from one river basin to another. These are relatively short-term means. It may be possible through research findings to literally increase what now appears to be a fixed but variable resource. Such increases could come through weather modification, reduction of evaporation and transpiration, or by other means.

In addition to increasing the size of the resource, it will also be necessary in the long term to re-use our water resource several or many times. This would also have the effect of greatly increasing the resource. The ability to re-use water will largely be a function of maintaining good quality in our streams and underground supplies. This will, most immediately, be a matter of applying known technology as described in the chapter on pollution and pollution control. However, it is recognized that present technology will fall short of the knowledge which will eventually be needed to make repeated use of our water.

A. It is recommended that the present strong program of research in the State agencies and universities related to improving the quality and quantity of our water resources be continued.

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chapter three
water supply and use

illinois technical advisory committee on water resources

"Without water, a man dies. Without water, a community faces the same fate."

Leonard A. Scheele

SUMMARY

Nature made no provision in our body for storing water. Thus, man must live near a never-ending source of water, if he or the community in which he lives is to survive and thrive.

Water's use as a domestic supply may have first priority, but it is only one of the multi-purpose uses of this vital natural resource. A stream can support fish, be a source of water for agricultural crops and animals, and a vital natural raw material for the development and very existence of industry, water transportation, and water-related recreation. A stream must often carry away the community's treated domestic and industrial wastes.

The bases for a successful community supply are adequacy in quantity, safety, and desirable physical qualities. Means of achieving satisfactory public water supplies are illustrated by a series of case studies for the following locations: Bellwood, Bloomington-Normal, Carbondale, Chicago, Joliet, the Kaskaskia River Basin, the Rend Lake area, and St. Clair and Madison Counties.

Municipal water use totaled 1.76 billion gallons per day (bgd) in 1965, and is expected to increase to 2.65 bgd by 1980 and 3.7 bgd in 2020. Rural water use, exclusive of irrigation, is expected to increase from 0.11 bgd in 1965 to 0.13 in 1980 and 0.18 in 2020.

Industrial pumpage, exclusive of cooling water used for power production, was 1.44 bgd in 1965. This is expected to grow to 2.2 bgd by 1980 and 3.0 bgd by 2020.

Water requirements for cooling in steam power generating plants are very large, amounting to 13.0 bgd in 1965. This is far greater than the above named uses. Further, large increases are projected for power cooling water in the future. This use is expected to be 31.1 bgd in 1980 and 162.8 bgd in 2020, which will clearly require that some waters of the State be re-used several times.

A preliminary analysis of supply and demand for 1980 and 2020 is carried out for each county of the State. Virtually all counties will have increased demands at these future dates. The State as a whole will enjoy a surplus during the study period. A few areas of the State will require water transfers, but good alternate sources exist. Continued dependence upon Lake Michigan will be required in northeastern Illinois.

INTRODUCTION

Whatever its source—wells, lakes, springs, or rivers—all water originates as some form of precipitation—as rainfall, snow, dew, or hail. From the earth it returns to the atmosphere by evaporation from seas, lakes, and rivers and by transpiration from plants, only to return to the earth—an endless cycle which has repeated itself for centuries. Water is neither manufactured nor destroyed. In its various forms as a liquid, vapor, or solid, there is no more water now than there was a thousand years ago, and a thousand years from now there will be no more water than at present. Thus, water is a limited resource. As the demands made on quantity and quality approach the limits of the resource, it becomes necessary to evaluate the limits and the demands and to plan control measures which reconcile the greatest practical use with adequate protection of the resource.

Major demands are made on Illinois' water resources by municipalities, by industry, agriculture, and recreation, and for electrical power generation, shipping, and waste treatment. Municipal use includes water used by incorporated areas, cities, towns, and villages; unincorporated non-farm rural and suburban areas; and industries located within and supplied from such areas. Industrial use includes that which is self-supplied from private wells or is taken directly from rivers, lakes, or canals. Usually, it excludes that supplied to industry by municipalities. Cooling water required by steam-generating electrical power plants quite often is considered as a category of use excluded from industrial use.

More water is used for agriculture than for all other uses combined. Water from the soil moisture reservoir and wells, rivers, streams, and farm ponds is needed for growth of vegetation, for irrigation, for livestock watering, and for domestic use in rural areas. Illinois waters provide recreational facilities for fishing, boating, swimming, and water skiing. Illinois has 1024 miles of navigable waterways on which millions of tons of cargo are moved each year. The quantities of water used in meeting these various needs are conveniently expressed, either in million gallons per day (mgd), or in gallons per day (gpd).

WATER QUALITY

Water supplies are currently obtained from either ground- or surface-water sources and sometimes from both. The location of these resources varies within the State with respect to both availability and quality. The total potential useable quantity of surface water exceeds that of ground water by about a factor of 6. Comparisons of available supplies with existing and projected demands reveal that some users and some user areas are such that steps must be taken in the future to augment or improve existing supplies and sources.

Broad characterizations of the existing mineral quality of ground and surface water have been made. Requirements for quality are largely dependent upon use, but quality of water is of equal importance to adequacy or quantity. Municipal water supplies should be clear, clean, safe, and palatable. Industrial users often can use bacterially unsafe water, but may require a very low mineral content.

Virtually all municipal and many industrial water supplies, regardless of their source, must be treated in some manner before they are fit for use. Some waters taken from ground or surface sources are satisfactory in physical and mineral quality for municipal use and need only disinfection. Others may contain, or have acquired, objectionable constituents in sufficient quantities to make them hard, corrosive, unpalatable, or unattractive. Before the water is sent to the consumer, these objectionable constituents must be reduced to acceptable limits, removed, or changed in character.

Common methods of treating water include sedimentation, either with or without the addition of coagulating chemicals; filtration through sand, anthracite, activated carbon, or through a combination of these materials; disinfection, usually by the addition of chlorine; aeration; softening by addition of chemicals or by ion-exchange; removal of iron, manganese, and other minerals; prevention or removal of tastes, odors, or color; chemical treatment to correct corrosiveness; and the addition of controlled amounts of fluorides for the control of dental caries.

Municipal water supplies must be maintained free from the water-borne diseases of cholera, typhoid and paratyphoid, and dysentery, with the possibility of transmission of the more obscurely water-related diseases—infectious hepatitis, schistosomiasis, poliomyelitis, and methemoglobinemia. Undulant fever and tularemia also have water-borne implications. Water likewise can serve as the medium for worms and parasites causing such illness as dracontiasis, and the protozoic, parasitic, and helminthic diseases.

Control of the mineral and bacteriological quality of water, particularly of municipal supplies, is vested in the State. The State Department of Public Health, through its Division of Sanitary Engineering, supervises the sanitary and mineral quality, operation, and adequacy of public water supplies. The functions and authority of the Department are described in Chapter IX.

DESALINATION

The quality of existing supplies of brackish ground water may be improved by desalination treatment. There may come a time when in certain areas it may be desirable to investigate the economic feasibility of producing fresh water from brackish ground water of 1000 to 5000 mg/l mineral content. It is quite likely that, because of general availability of water in Illinois, only smaller cities of 1000 to 5000 population will consider desalination because they cannot afford the cost of long pipelines to a suitable supply.

Various methods of desalination, or de-mineralization, are being developed or are now being used. The more significant of these are distillation, electrodialysis, freezing, and reverse osmosis.

Desalination has long been practiced in the production of essentially mineral-free water for steam boiler and power generating stations. The chemical costs of production in ion exchange units may vary considerably, but a reasonable figure might be 1 cent per 10 gallons per 1000 mg/l minerals removed. The total unit cost for other methods depends not only on the total mineralization of the water source, but also on the type of minerals, the cost of labor, the interest rate, the rate for electricity, and the plant's capacity. The treatment plant cost may vary from $100 to more than $200 per capita for treatment of waters of 2500 mg/l total dissolved solids (TDS) or less. For the same method, the larger the plant and the closer the water demand to the full plant capacity, the lower the total unit cost of production. Operating costs may vary from $0.50 to $1.00 per 1000 gallons.

These costs are separate from and unrelated to the costs of developing the water supply; of the distribution system; of pumping the water to the consumer; and of maintenance, billing, and additional services. The cost of the distribution system is appreciable; 60 to 70 percent of the investment in a water utility is usually for distribution.

The difficulty of disposing of waste minerals removed from the water and the cost prohibit the early implementation of this method in Illinois. Other methods of augmenting and improving the source of water are available, are being studied, or are in use. These include multi-purpose reservoir construction, streamflow augmentation, artificial recharge of depleted ground-water aquifers with excess quantities of streamflow, and inter-basin transfers of water.

WATER USE

MUNICIPAL USE

Municipal water supplies are ground or surface waters, treated as necessary to improve the quality and remove disease-producing organisms, and supplied for general domestic and industrial use.

In 1965 total municipal water use was about 1765 mgd, or about 200 gallons per capita per day (gpcpd). Of this total, about 290.789 mgd was ground water, and 1474.211 mgd was surface water. The number of municipal supplies using this water is shown in Table 1. Chicago and the suburbs which it serves used 1178.642 mgd in 1965, or about 268 gpcpd.

TABLE 1

MUNICIPAL WATER SUPPLIES

Number of municipal water supplies:							
Year	Serving Incorporated Areas	Serving Unincorporated Areas	Serving State Properties	Total	Population Served	Percent of Total	Total Population Urban*
1965	988	337	140	1465	8,500,000	84.5	99.4
1955	819	197	103	1119	—	80	98

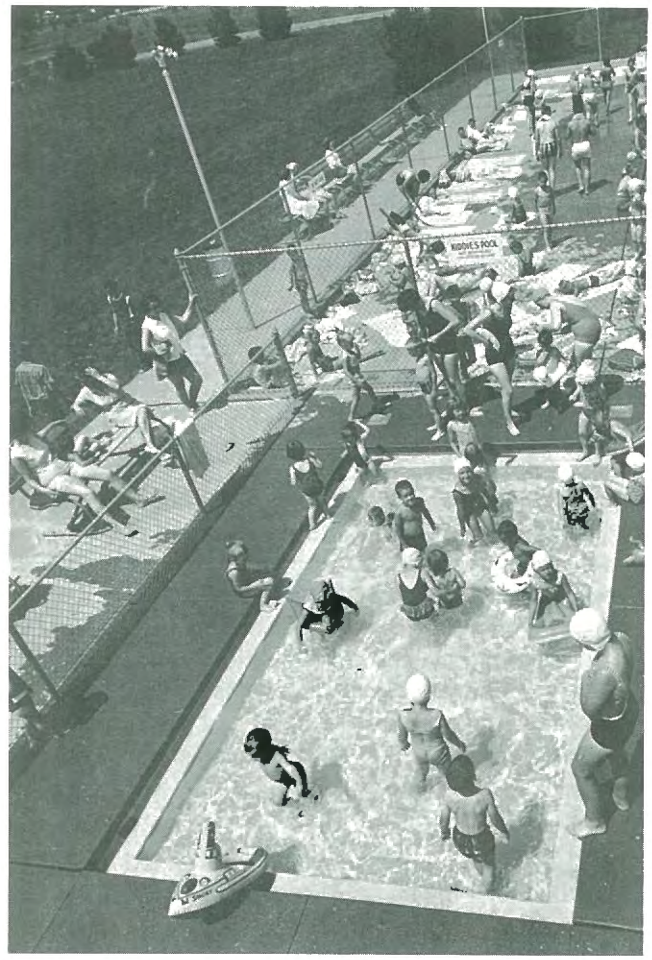
*Incorporated areas with a population of 2500 or more.

Assuming that the percentage of total population served remains at 84.5, that per capita use remains at 200 gallons per capita per day, and that the population projections of 13 million for 1980 and 18 million for 2020 are correct, the municipal demand for water will be 2600 mgd in 1980 and 3600 mgd in 2020.

However, several factors are expected to cause a much higher percentage of service. More communities and rural areas of 5500 population or less will develop water supply systems under the Federal grant and loan programs. This development of water supply systems will be similar to the REA program which brought electricity to rural areas. If the present trend continues, most rural farm and non-farm homes will probably have complete water systems by 1980.

Because of the Federal support of municipal service to so-called rural areas and the rural-to-urban shift in population, the total municipal water use will be more than the figures quoted above, amounting to 2650 mgd in 1980 and 3700 mgd in 2020. Construction of new public swimming pools will also contribute to the projected increases in municipal water use. During the decade 1955 to 1965, the number of swimming pools increased from 507 to 1200.

From 1900 to 1965, rural population dropped approximately 5.3 percent, except for the period 1930 to 1940 when there was a 0.3 percent gain. These percentages are based on the U. S. Census Bureau's definition of rural: areas with a population of 2500 or less. On about this same basis, it is expected that the rural population will drop to 1,750,000 in 1980 and to 1,430,000 by 2020. The present rural population is approximately 1,940,000. The rural farm population is decreasing, thus adding to the rural non-farm, urban, or municipal population.



Daily per capita domestic water use for the rural farm population ranges from 20 to 100 gallons, depending upon the extent of plumbing and number of household appliances. Domestic water use in rural areas in 1965 was estimated at 60 mgd. In addition to farm home supplies, 180,384 individual wells and 8871 other water sources take water directly from springs, creeks, ponds, rivers, lakes, or other sources in the rural non-farm areas of the State.

Agricultural use of water includes watering livestock and poultry, and spraying fruit trees, but excludes any use for supplemental irrigation. Water use ranges from about 0.6 gallons per day for poultry to 35 gallons per day for cattle. The total water requirement for livestock and poultry was about 42.5 mgd in 1965. It is expected that the number of livestock may increase 10 to 20 percent in the next 40 to 50 years. With 566,358 apple trees and 316,613 peach trees in the State, the spray solutions used each year will contain about 13,250,000 gallons of water. The use of sprays probably will not increase significantly in the future because of the development of disease resistant crops, but with increased plantings water use may approach 15 million gallons by 1980 and 18 million gallons by 2020.

It is estimated that all agricultural water use, excluding irrigation, now amounts to approximately 113.5 mgd, which could reach 135 mgd by 1980 and 180 mgd by 2020.

INDUSTRIAL USE

Water for industrial use is taken from municipal supplies, private wells, or drawn directly from rivers, canals, lakes, and streams. Excluding that supplied by municipal systems, about seven-eighths of industrial water comes from surface sources and one-eighth from ground-water sources.

Water needs per unit of product vary considerably, because techniques, efficiency, and degree of conservation vary. The main industrial uses of water in Illinois are for steam power generation and in the steel, petroleum, chemical, food, and distilling industries. Industry's requirements for water are large. In 1965, Illinois industries used about 15,000 million gallons of water per day. Approximately 254.15 mgd of this amount was ground-water pumpage, and the remaining water came from surface sources. The total industrial use, exclusive of cooling water for power generation, was approximately 1443 million gallons per day.

Industrial unit process water requirements are widely variable in amount, as shown in Table 2. Some processes consume water, others do not. The water actually consumed by industrial processes is normally 4 to 6 percent of total intake. In electric utility steam generator plants, less than 1 percent of the water passing through the plant is lost. The balance is returned to the river or watercourse.

TABLE 2

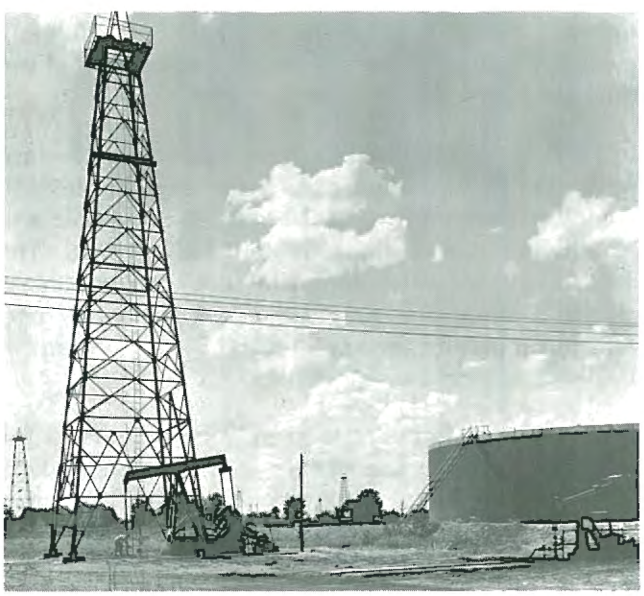
INDUSTRIAL WATER REQUIREMENTS

(By Unit of Product)

Industry	Unit	Water Required (Gallons per Unit)
Gasoline	One gallon	7–10
Canning Vegetables	Case, No. 2 cans	25–35
Electric Power	Kilowatt hour	80
Packing House	Cattle (per animal)	2,200
Coke	Per ton	3,600
Paper	Per ton	50,000
Finished Steel	Per ton	65,000
Rayon Yarn	Per ton	200,000
Synthetic Rubber	Per ton	600,000

The petroleum and mineral industries have a direct effect on an area's water resources, because they require great quantities of water and can adversely affect water quality.

Currently, about two-thirds of Illinois oil is produced by water-flooding, a secondary recovery method in which water is pumped into oil-bearing strata to flush oil toward the wells. In 1964 about 70 million barrels of oil was produced in Illinois; of this, 47.9 million barrels was produced by water-flooding. These operations used a total of about 54 mgd of water. However, about 105 million barrels, or 12 mgd, of this was fresh water from shallow aquifers, streams, and lakes. Sand



Oil well-water flooding operation.

Coal preparation plant.

and gravel aquifers in the Kaskaskia, Wabash, and Embarras valleys provide a substantial amount of the fresh water needed for water-flooding. The remainder, or 41.7 mgd, was "produced waters," pumped from oil producing wells along with the oil and brines from underground brine aquifers. Both produced waters and the aquifer brines are generally much too salty for industrial or residential use. The surface-water needs of the petroleum producing and refining industries for 1965 were approximately 114.1 mgd.

The mineral industries, which are those engaged in the mining and processing of natural resources—coal, limestone, sand and gravel, other non-metals, and lead and zinc—use large quantities of the State's water resources. Fortunately, many mining and processing methods permit the recirculation, or re-use, of a substantial portion of the water used. Thus, the demand for "new" water is held to a minimum. Most of this water is taken from surface-water sources. Water use by Illinois mineral industries in 1962 is shown in Table 3. In 1965, surface-water use by the mineral industries was 52.9 mgd. Table 3 shows that billions of gallons of water are required in processing and mining coal, but only millions of gallons are consumed. This is because the preparation plants are operated as closed circuits, which conserves water for re-use.

TABLE 3

WATER STATISTICS FOR SELECTED MINERAL INDUSTRIES, 1962

Industry	New Water	Water Re-circulated	Total Water Used	Water Dis-charged	Water Consumed
	(Million Gallons Per Day)				
Coal (bituminous).	14.50	61.30	75.80	13.36	1.20
Limestone........	3.03	0.15	3.18	2.94	0.08
Sand and Gravel..	17.60	28.20	45.80	17.10	0.44
Other Non-metals.	1.36	0.46	1.82	1.33	0.03
Lead and Zinc[1]...	3.25	0.22	3.47	3.22	0.02
Total.........	39.74	90.33	130.07	37.95	1.77

Source: Minerals Yearbook, Federal Bureau of Mines, 1962.

[1]Excludes mines and plants producing lead and/or zinc concentrates as byproducts of fluorspar operations.

One of the State's preparation plants is equipped with a cone-shaped 55-foot-high settling tank with a capacity of 325,000 gallons of water. The settling cone tank clarifies water drawn off the top for re-use. The solids are drawn off the bottom in the form of a slurry. The amount of water re-used from the cone is 12.24 mgd. An additional 2.16 mgd from another source is introduced to balance the process at 14.4 mgd. This is the amount needed to properly process the product. An additional 0.72 mgd of water is used to dilute the slurry, to sluice and pump to earthen dams for filtration, to rinse clean coal, and for housekeeping and other general purposes.

All of the State's 54 preparation plants use some device —settling cones, settling tanks, thickeners, cyclones, or settling ponds or basins—to enable them to re-use the amount of water necessary for processing, adding only what is used or lost to balance the system.

Coal mining, like oil-field operations, can impair the quality of water. The chemical action of air and water on the material in spoil piles from coal mining and processing operations results in acidic drainage waters. These waters are capable of dissolving large quantities of mineral matter. If allowed to flow freely into streams or to percolate into aquifers, the acid mine waters can deteriorate water resources.

Of the 1965 total industrial ground-water pumpage, which was 254.1 mgd, 74 percent was withdrawn from aquifers located in seven counties. Industrial use was greatest in St. Clair County and amounted to 55.3 mgd. Madison, Cook, and Tazewell Counties used 45.4 mgd, 29.4 mgd, and 24.0 mgd, respectively. In 27 counties industrial pumpage was negligible; in 18 counties it was less than 100,000 gallons; and in 27 other counties pumpages ranged between 100,000 and 1,000,000 gallons per day. Table 4 gives industrial pumpages for 1955, 1960, and 1965 in 23 counties with heavy pumpage.

Sand and gravel aquifers furnished 162.4 mgd, or 64.5 percent, of the total industrial ground-water pumpage. Bedrock aquifer pumpage was about 92 mgd. The sand and gravel aquifers are largely concentrated in St. Clair, Madison, Tazewell, and Peoria Counties. Bedrock aquifers are largely concentrated in northeastern Illinois.

The industrial pumpage in Christian, Clark, Clay, Clinton, Coles, Crawford, Cumberland, Douglas, Edwards, Effingham, Fayette, Franklin, Gallatin, Jefferson, Lawrence, Macoupin, Marion, Perry, Randolph, Wabash, Wayne, and White Counties is mainly that used for water-flooding operations in the oil fields. Table 5 gives the source of surface waters and percent of the total average daily pumpage that each used.

In 1950-51 the total average daily pumpage of surface water was 7680 million gallons per day; in 1959-60 pumpage similarly expressed was 10,849 mgd; and in 1964-65 it was approximately 14,465 mgd. The major use of the water pumped was for cooling. Steam electrical power plants used the bulk of this: 77 percent of the total pumpage in 1950-51, 83 percent in 1959-60, and 86 percent in 1964-65.

Tables 6 and 7 compare supply and demand for industrial surface-water use. In Table 6, average daily surface-water pumpage is compared with the mean (average) flow in the stream from which water is taken. In the case of the DesPlaines River, this comparison indicates that under average conditions, the demand

TABLE 4

INDUSTRIAL GROUND-WATER PUMPAGES FOR 23 COUNTIES IN ILLINOIS

County	Industrial Pumpage (mgd) 1955	1960	1965
Boone	0.76	0.74	1.30
Champaign	2.05	5.64	3.04
Cook	27.66	29.78	29.39
DeKalb	.79	0.73	0.38
DuPage	4.11	5.60	4.87
Grundy	1.91	2.12	2.99
Jo Daviess	2.02	2.02	2.03
Kane	4.52	4.44	5.56
Kendall	0.28	0.66	0.63
Lake	2.21	2.86	2.36
LaSalle	4.00	4.50	5.20
Lee	1.09	0.78	1.39
Madison	57.99	37.15	45.40
McHenry	1.98	2.09	2.32
Ogle	1.15	1.02	1.69
Peoria	25.00	23.30	13.64
Rock Island	3.50	3.20	3.20
St. Clair	43.05	46.35	55.30
Stephenson	0.97	1.08	3.43
Tazewell	22.90	19.30	24.03
Whiteside	1.68	1.73	1.96
Will	8.77	10.82	13.09
Winnebago	10.70	8.51	6.96
Totals	229.09	214.42	230.16

TABLE 5

SOURCES OF SURFACE-WATER PUMPAGE

	Average Daily Pumpage (mgd)	Percent of Total Pumpage
Calumet and Little Calumet River	471.3310	3.3
Chicago River (North & South Branch)	426.9070	3.0
Chicago Sanitary & Ship Canal	2,331.6130	16.0
DesPlaines River	480.5770	3.3
Fox River	5.5880	0.4
Illinois River	1,512.8829	10.4
Lake Michigan	1,370.2089	9.5
Mississippi River	1,556.0236	10.7
Ohio River	563.6210	3.9
Rock River	1,445.0760	9.9
Wabash and Little Wabash River	155.8548	1.1
Miscellaneous (Private Ponds, Lakes, Springs, Impoundments)	4,145.5246	28.5
Totals	14,465.2078	100.0

TABLE 6

INDUSTRIAL USE OF SURFACE WATER UNDER AVERAGE CONDITIONS OF SUPPLY AND DEMAND

	Mean Flow (mgd)	Percent Use of Mean Flow
Chicago Sanitary & Ship Canal at Lockport	3,777.08	60.8
DesPlaines River at Riverside	241.08	199.2
Fox River at Dayton	974.65	0.6
Illinois River at Meredosia	13,087.92	11.6
Mississippi River at Thebes	116,724.85	1.3
Rock River at Joslin	3,511.44	41.2

TABLE 7

INDUSTRIAL USE OF SURFACE WATER UNDER MINIMUM SUPPLY AND DEMAND CONDITIONS

	Minimum Flow (mgd)	Percent of Use of Minimum Flow
Chicago Sanitary & Ship Canal	58.80	394.0
DesPlaines River	0.26	1,850.0
Fox River	0.65	860.0
Illinois River	1,977.70	76.5
Mississippi River	15,110.00	10.6
Rock River	539.00	268.0

(pumpage) is almost twice the supply (mean flow). Consequently, the flow in the DesPlaines under average conditions is re-used, or used twice in this case. Because of re-use of the DesPlaines, heat loads that are imparted to it by industrial use are not dissipated, and the River does not freeze in the winter.

More critical conditions exist when pumpage demands are at maximum and streamflows are at seasonal minimums. Maximum pumpage demands are approximately 175 percent of the average daily values. Table 7 compares the minimum streamflows to the average daily pumpage.

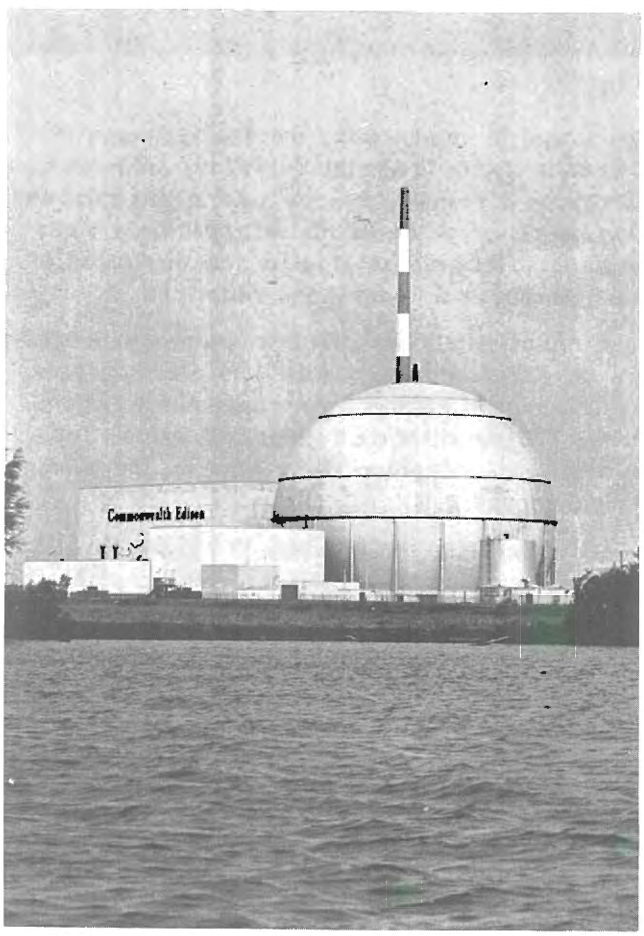
Of the water used during 1964-65 by industry, 98.6 percent was returned to the source, 0.6 percent was discharged to public sewers, and 0.8 percent was disposed of by other methods, indicating a negligible consumption rate. Temperatures were raised in 92 percent of the water used by industry. About 8 billion gallons, or 75 percent of industry's average daily use, required some form of pre-treatment, such as chlorination, softening, screening, clarification, filtration, de-mineralization, de-oxygenation, or pH adjustment. About 95 percent of industrial water is used for cooling. The largest single use is for electric power generation, and this amounts to about 90 percent of the total average daily industrial use.

In the last few years, industrial pumpage has remained about the same because of water conservation programs and more efficient use. The needs of the future are difficult to predict, especially in view of the outstanding promotional work being done to attract industry to the State. It is expected that by 1980 industrial use will amount to about 2208 million gallons; by 2020 it is estimated to be 2975 million gallons. These estimates are exclusive of water use for power generation.

ELECTRIC POWER GENERATION AND WATER USE

Thermal generating plants are built where water is available. Generally, fuel can be transported to the plants and electrical energy can be carried away from the plants to the load centers fairly economically and easily. However, water for cooling purposes cannot economically be moved any great distance to the thermal electric industry.

The principal demand imposed upon water supply by thermal electric plants, which have 99.6 percent of all Illinois electric generating capacity, is for condenser cooling water. Boiler makeup water is required for all steam-electric plants; some installations also use water for sluicing ashes; this use has relatively minor effects on the water supply.



Dresden Nuclear Power Station near Morris.

The two important aspects of condenser cooling are the amount of water required to flow through a condenser to produce an acceptable high vacuum, and the amount of cooling water which evaporates as a result of the increase in its temperature. Heat requirements of steam-electric plants depend on heat loss from boiler furnaces, heat loss from electric generators, the heat equivalent of electric generator output, and the heat energy remaining in the steam leaving the turbines. Thus, the efficiency of generating plants affects the requirements for cooling water.

The Electric Power Industry

The electric power industry in Illinois is composed of 82 generating and distributing systems: 11 investor-owned companies, 43 public systems, and 28 cooperatives. Nine of the investor-owned companies operate generating and transmission systems; two are distribution systems. The public utilities consist of 27 generating and transmission units and 16 distribution companies. There are 28 electric cooperatives in Illinois which operate distribution systems, and one also operates a generating and transmission plant.

The generating capacity and loads of the investor-owned utilities are 90 percent of the total. The remaining 10 percent is about evenly divided between the municipal systems and the cooperatives. About half of the small municipal systems purchase power externally to supplement their output. The type and size of the systems vary widely within the State. Predominately rural areas have a number of small systems; a few major utilities serve densely populated northeastern Illinois.

Hydroelectric power is not an important energy source in the State, because the topography is unfavorable for its development. The ten operating plants generate less than 4 percent of the State's total electric power.

These small plants were built many years ago when steam-electric plants consumed about twenty times more fuel per kilowatt-hour than today. Since then, improvements in steam-electric plants have drastically reduced fuel, operation, and maintenance costs. Meanwhile, the efficiency of hydroelectric plants has been increased by only a small percentage. Apparently, existing plants continue to operate only because their capital cost has been amortized.

Operation and maintenance cost of these plants is about as high or higher than the oldest, least efficient steam-electric plants still in operation. Units are generally retired when a major repair is needed, because the repair cost cannot be justified. The natural limitations of topography and streamflow preclude the development of any additional hydroelectric capacity at a cost competitive with thermal-electric plants in Illinois.

Water Use in Power Generation

Eight plants which serve the northeastern industrial area pump water from the Illinois Waterway System. Presently, they circulate nearly 3.4 bgd. Lake Michigan is the source of 0.7 bgd of water used at one plant in northeastern Illinois. Each of the generating plants along the Mississippi and Illinois Rivers accounts for more than 1.5 bgd. One plant on the Ohio River circulates nearly 0.6 bgd; the remaining plants are located either near the Rock, Wabash, or Fox Rivers or have lake water supplies. These pumpage figures represent only the amount of water required to pass through condensers, rather than that withdrawn from the water supply.

An estimate of cooling water needs should include the demands for nuclear energy. The Dresden plant in Grundy County is the first plant in Illinois to be operated with nuclear fuel. It pumps 280 mgd of Kankakee River water. A second nuclear plant is to be built in the Rock Island-Moline area. Table 8 lists the 1965 pumpage at Illinois steam-power generating plants.

Projections of Water Needs

In the period from 1966 to 1980, it is reasonable to assume that the power companies will add and retire units according to long-range plans. New units will probably be larger and more efficient than the ones they replace. Some will be nuclear powered and will require more water than plants using fossil fuels.

Increased growth can naturally be expected to accompany population growth and economic expansion, but the power industry has historically exceeded these growth rates. A progressively higher standard of living will also expand the future market, but the greatest incentive will come from the reduction in costs for electrical energy relative to other living costs. Among the factors that will influence this growth are:

—Technological developments, i.e., nuclear power, extra high voltage (EHV), pumped storage, and possibly other developments in generation, transmission, and distribution still being researched;
—Lower fuel costs through lower mining and transportation costs and pricing pressures from competing fuels; and
—Coordination of the industry to take advantage of load diversity, sharing of reserves, installation of larger units, and economy exchanges.

The most promising growth markets today appear to be home heating and air conditioning, with other potentials in increased lighting and transportation. These markets will also be sought by other sources of energy. The gas industry is engaged in intensive research that well may lead to aggressive competition in the home heating and air conditioning market. Battery-propelled electric autos may compete with autos powered by fuel cells. The gas industry is also vigorously pursuing the total energy concept for on-site generation and has a potential for competing for up to 10 percent of the electrical energy market.

TABLE 8
PUMPAGE BY ILLINOIS STEAM-POWER GENERATING PLANTS

County	Station		1965 (mgd)
Christian	Kincaid, Commonwealth Edison		500.00
Clinton	Carlyle		7.20
Cook	Calumet C.E.	84.38	
Cook	Crawford C.E.	517.53	
Cook	Fisk C.E.	358.36	
Cook	Northwest C.E.	46.03	
Cook	Peoples Gas, Light & Coke	335.00	
Cook	Ridgeland C.E.	583.56	
Cook	Winnetka	12.00	
Cook			1,936.86
Crawford	Central Illinois Public Service Co.		130.00
Grundy	Dresden C.E.		283.84
Jackson	Central Illinois Public Service Co.		202.00
Jo Daviess	Interstate Power		7.00
Lake	Waukegan C.E.		735.87
Lee	Dixon C.E.		103.56
Madison	Illinois Power		513.60
Mason	Illinois Power		125.00
Massac	Electric Energy		563.00
Montgomery	Coffeen, Central Illinois Public Service Co.		2,110.00
Morgan	Central Illinois Public Service Co.		207.00
Peoria	Central Illinois Light Co.		324.00
Pope	Golconda		.08
Putnam	Illinois Power		220.00
Rock Island	Iowa-Illinois		71.00
Sangamon	Springfield		180.40
St. Clair	Freeburg	.15	
St. Clair	Union Electric	628.00	628.15
Tazewell	Powerton C.E.		182.47
Vermilion	Illinois Power		7.50
Wabash	Mt. Carmel Public Utility		24.88
White	Carmi		8.64
Will	Joliet C.E.	472.88	
Will	Will Co. C.E.	928.49	
Will			1,401.37
Williamson	Southern Illinois Power Cooperative		1,250.00
Winnebago	Central Illinois Electric & Gas	581.13	
Winnebago	S. Beloit Water, Gas & Electric	700.00	
Winnebago			1,281.13
Total			13,004.55

In its efforts to lower costs, the electric power industry must also cope with a new concept—public acceptance. This involves air pollution control, overcoming public concern about nuclear plants in congested areas, and demands for beautification that may require underground distribution and possibly even underground transmission. Further, the industry is faced with increasing costs for rights of way in fast-growing urban areas. Larger capital costs can be expected for cooling towers, where water supply is inadequate. It is apparent that the potential for continued rapid growth in use of electrical energy is good, but may involve a greater competitive struggle in the future.

The total energy generated by the power industry in Illinois in 1960 was reported to be 34.624 million kwh. This represents a growth during the previous ten-year period of 26.5 percent.

The Federal Power Commission estimates that by 1980 requirements for electrical power will increase by 240 percent above the 1960 demand. Increases will amount to 153 percent for farm use, 292 percent for residential, 240 percent for commercial, and 238 percent for industrial use. Street lighting and losses which cannot be accounted for will require an increase in power of almost 200 percent.

These projections indicate that the greatest increase in power consumption will occur in residential and industrial use, while the farm use will increase less. On the basis of these projections, it is estimated that power companies in Illinois will be producing 117,946 million kwh, which will require about 31 billion gallons of water per day to meet the demand in 1980. In 2020 electrical energy requirements will be nearly 18 times the present use.

The conversion of fossil fuel energy to electrical energy has been brought to a high present efficiency, but the amount of heat energy lost in the power generating process still exceeds that which is used. More efficient methods of generating electrical power are being developed. Common practice has been to dissipate the greater part of heat losses that are incident to the production process into large bodies of natural water. Other methods such as the use of cooling towers or cooling ponds are available, but only at an appreciable increase in cost, and the need to replace water lost through evaporation still remains.

When considering plant sizes of 5000 to 10,000 million watts (mw) indicated for the future, it is necessary to find huge water bodies capable of absorbing waste heat energy. Illinois has two such sites—on the west shore of Lake Michigan and along the lower Mississippi River.

If we accept the estimate of the Federal Power Commission that by 2020 the demand for electrical energy in Illinois will be 615,500 million kwh, there will be need for a cooling capacity of 162.8 billion gallons per day. This estimate takes into account a probable increase in nuclear plant efficiency at the rate of 1 percent per year and the fact that the greater cooling demands of nuclear power plants will not exceed those of fossil fuel plants by more than 10 percent. Table 9 summarizes existing and projected power and water requirements.

TABLE 9
ELECTRIC POWER AND WATER REQUIREMENTS FOR ILLINOIS

Year	Power Requirements (million kwh)	Water Pumpage (bgd)
1960	34,624	9.1
1980	117,946	31.1
2020	615,500	162.8

New methods of converting the energy in fossil fuels and nuclear energy into electrical energy would appear to be quite probable within this period, since these innovations are already in the laboratory stage, or beyond. These approaches include the development of magnetohydrodynamics (MHD), electrogas dynamics (EGD), thermonuclear fusion reactors, thermoelectric generation, thermionic generation, and fuel cells. Some of these could be highly efficient and fairly simple through a direct conversion of a non-electrical energy source into electrical energy. Although much confidence may exist that some of these developments will materialize, they cannot be precisely predicted, but should be recognized.

If traditional methods of power generation are followed, the water demands will far exceed the supply. Thus, more extensive re-use of water, location of industries with large demands near large supplies, and development and use of generating methods which do not require such large supplies will be necessary.

BALANCING SUPPLY AND DEMAND

A critical element in water resources planning is the balancing of available resources against predicted future demands. It is only through such a procedure that areas of potential deficiency can be identified and serve as the basis for decisions, possible legislation, and programs designed to cope with any anticipated shortages before they become critical.

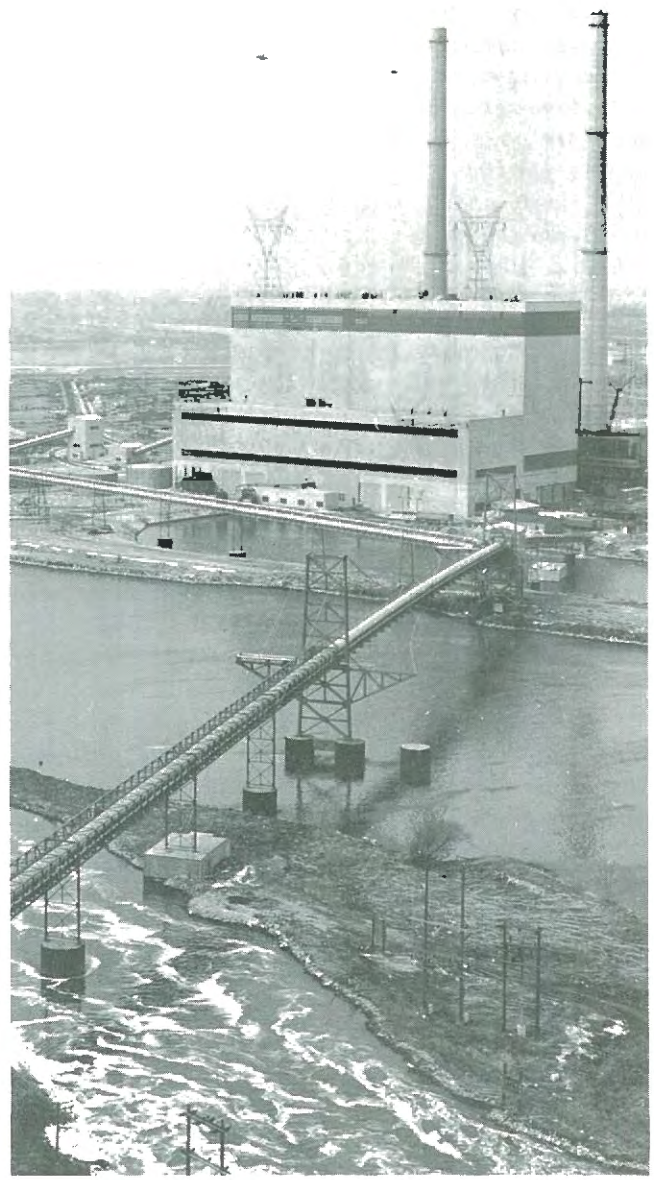
Without the aid of detailed study, it can be shown that Illinois water resources as a whole are far greater than our demands for any predictable time into the future. But broad pictures and averages can mask possible deficiencies which might develop in smaller areas. Therefore, it is desirable to strike balances for smaller areas such as watersheds, or as in this study, by counties.

No claims are made that the balancing of supply and demand in this section has great accuracy. In fact, this is a first crude effort in this direction. The quantitative information on capabilities of the resource in streams, ground water, and existing and potential reservoirs has only recently become available. The estimates of demand as far into the future as 2020 are obviously subject to great error. Nevertheless, the analysis has considerable value for guidance.

Estimates of future water requirements are limited to what might be called primary requirements. These are for municipal supplies, rural requirements, and estimated industrial demands. No estimates have been made at this time of possible future requirements for low-flow augmentation or dilution water. Such requirements may become substantial and should be considered at an early date. Likewise, no specific provision is made for the rate of growth or location of requirements for cooling water needed for power generation. Such demands are treated in a separate section in this chapter.

Present cooling water requirements in power generation are largely of the once-through type, and this use will increase. However, the number of places where such future plants can be expanded or located is limited, as revealed by this balancing of supply and demand. Such future locations or expansions are treated separately, because they cannot be viewed as a predictable local, i.e., county, demand. Undoubtedly, each future location of a power generation plant will be considered individually on the basis of available quantity and quality of water, as well as other factors.

It is believed that the present analysis, by excluding specific forecasts of water requirements for power production, does reveal the locations of water excesses in 1980 and 2020, and thus identifies the locations where major surpluses may be considered for power cooling. These include sites on the Mississippi and Ohio Rivers on the Illinois borders and, internally, on the Illinois and Rock Rivers.



Joliet Generating Station located on the DesPlaines River.

STATE ANALYSIS BY COUNTIES

The demand for municipal, industrial, and rural water has been estimated for 1965, 1980, and 2020. The estimate is based on the current measured pumpage from supplies of ground and surface water. Municipal needs were estimated on current per capita use, adjusted upward 1 percent per year compounded for 15 and 55 years, respectively, using populations estimated for these periods as given in Chapter I. In Cook County half that rate of per capita increase was assumed. Estimates of industrial water needs for 1980 were based on current use and an expansion factor based on a ratio of 1980 to 1963 manufacturing value added in constant 1963 dollars (Chapter I). The 2020 industrial water demand was estimated to be the 1980 value, plus the incremental increase between 1963 and 1980. Rural pumpage for 1965 was estimated, using the 1965 annual farm census and a per capita consumption by people and livestock. The amount of water pumped for irrigation is small and variable from year to year and was not included in the statewide analysis. The total water demands for the State for 1965, less cooling water for power generation, is estimated at approximately 3.3 billion gallons per day. Cooling water for power in 1965 was estimated at 13 billion gallons per day. The State's total water demand for 1980, less cooling water for power, is estimated at 5.0 billion gallons per day. In 2020 this same demand will be a little more than 6.9 billion gallons per day.

An inventory of the practical water resources yield for primary water supply from all sources was made by counties for the entire State. The inventory consisted of an analysis of the principal ground water aquifers, induced infiltration from rivers, surface runoff in rivers, reservoir storage, and Lake Michigan in northeastern Illinois.

The potential yield from the unconsolidated and the bedrock aquifers was determined by examining these potentials and estimating the yield from those aquifers that have a probability of development. The river aquifers were analyzed for their potential induced infiltration. The combined total ground-water yield was estimated at approximately 6.9 billion gallons per day. This is the practical sustained yield and was derived from the theoretical potential of the ground water, reduced by one-half, which is the amount assumed to be feasible to capture. Some aquifers are of low permeability, while some are too small and scattered to warrant development. It is also recognized that mounds will exist in the water table between wells or pumping centers, and some of this water will escape into streams, rather than flow into wells.

The yield of existing water supply reservoirs and potential reservoirs was taken as that available in a drought of once in 40 years using half the storage. The yield of potential reservoirs is 2.2 bgd for the State. In assuming only half the reservoir storage, it is recognized that some reservoirs may be developed for multiple purposes such as recreation and flood control, and that the storage may be partially or entirely unavailable for water supply. Further discounts would need to be made if it were assumed that some sites may prove unfeasible upon detailed examination or that the sites may be lost through urban or other development.

The streamflow was analyzed for its potential yield and found to be approximately 43 billion gallons per day on the basis of flow available 95 percent of the time. This eliminates all but the major streams, as the 95 percent flow in the many small streams is not a useful quantity for direct diversion without storage. The total flow (at the 95 percent level) of a major stream passing through a county was assumed to be available, and later review was made to insure that demands in 1980 and 2020 did not involve unreasonable re-use of water.

COMPARISON OF SUPPLY AND DEMAND

Table 10 lists the counties of Illinois and shows for each the water use in 1965 and the estimated demand for 1980 and 2020. The potential supplies from ground water, streams, and reservoirs is also shown. For existing and potential reservoirs, the yield in a drought of once in 40 years is shown using half the reservoir storage. Streamflow is for 95 percent availability, while the ground water is the practical sustained yield.

An inspection of Table 10 shows that virtually all counties will have increased demands in 1980 and 2020, but these demands are generally within the capability of the resource. The State as a whole will have a surplus within the study period. Those counties where conditions may become marginal or deficient are discussed individually in the following paragraphs.

Knox County is predicted to experience a growth in all demands for water from 9.5 million gallons per day (mgd) in 1965 to 12.6 mgd in 1980 and 26.7 mgd in 2020. The County is presently importing about 6 mgd, which is piped from wells near the Mississippi River to Galesburg. Resources are estimated to be adequate to 1980, but the substantial increase projected for 2020 will make the resource marginal by that date, unless further supplies are developed. It appears that further water can be imported, and local resources can be developed as necessary and feasible.

Macon County, with the assumed addition of 11,000 acre-feet of storage in Oakley Reservoir, will have adequate resources in 1980. Assuming that full development of the ground water may not be achieved, the County will be definitely in need of additional resources by 2020. This could take the form of industrial re-use of water, the reallocation of Oakley Reservoir storage, the importation from Shelbyville Reservoir, or other alternatives which can be developed.

TABLE 10 EXISTING AND POTENTIAL WATER SUPPLIES AND DEMANDS BY COUNTIES

No.	County	Municipal, Industrial & Rural Demand (mgd)			Existing Water Supply Reservoirs*	Potential Water Supplies (mgd)		
		1965	1980	2020		Ground Water	Stream-flow	Reservoirs
1	Adams	8.23	10.08	19.90	0.07	196.1	3,840	58.1
2	Alexander	2.89	4.08	7.34	—	262.9	15,120	6.1
3	Bond	1.61	1.91	3.50	0.02	11.7	3	10.2
4	Boone	5.42	11.25	20.78	—	39.5	28	2.7
5	Brown	.67	.74	1.17	0.09	19.2	4,090	64.7
6	Bureau	5.98	9.31	22.86	—	147.2	2,801	60.9
7	Calhoun	.45	.47	.70	—	49.8	9,130	0.9
8	Carroll	3.62	5.63	10.43	—	146.1	4,210	32.4
9	Cass	1.32	1.59	3.09	—	86.4	4,090	13.5
10	Champaign	17.62	29.08	55.29	—	92.8	1	1.6
11	Christian	7.14	8.89	17.62	0.69	32.3	2	4.9
12	Clark	2.74	3.34	6.18	—	56.9	550	27.4
13	Clay	1.59	1.96	3.60	—	15.2	1	63.4
14	Clinton	2.25	3.96	5.34	—	38.3	27	—
15	Coles	4.25	6.60	11.80	3.14	23.7	5	56.7
16	Cook	1,900.28	2,708.00	3,977.00	—	128.9	10	0.6
17	Crawford	7.90	7.97	10.49	—	32.2	550	9.0
18	Cumberland	.84	1.50	2.64	—	14.4	5	83.1
19	DeKalb	7.85	13.57	26.55	—	81.4	8	2.2
20	DeWitt	2.26	2.60	5.44	—	39.2	3	29.3
21	Douglas	1.34	1.59	3.07	—	25.1	2	0.3
22	DuPage	38.49	55.01	156.42	—	50.3	12	3.8
23	Edgar	2.30	3.14	5.97	0.85	30.2	—	16.3
24	Edwards	.65	.84	1.36	—	5.5	10	0.3
25	Effingham	2.70	3.89	7.42	0.08	13.2	—	7.9
26	Fayette	3.19	6.41	11.32	0.15	39.4	24	9.1
27	Ford	2.80	3.67	7.34	—	50.6	1	0.8
28	Franklin	5.01	7.29	13.08	1.37	12.2	2	53.2
29	Fulton	9.82	12.74	19.57	2.74	50.6	3,050	52.5
30	Gallatin	.75	2.02	3.63	—	137.0	13,313	27.2
31	Greene	2.02	3.60	6.60	0.06	67.9	4,092	14.6
32	Grundy	18.09	32.20	53.90	—	32.1	2,860	2.3
33	Hamilton	1.68	2.87	5.09	0.21	15.0	—	5.9
34	Hancock	2.62	2.62	4.73	0.06	93.8	3,240	85.4
35	Hardin	1.20	1.15	1.58	—	24.6	13,310	21.4
36	Henderson	.54	.62	.91	—	168.0	3,456	22.9
37	Henry	4.64	6.24	11.91	—	69.9	1,280	28.4
38	Iroquois	4.15	5.36	8.84	—	136.9	30	3.6
39	Jackson	4.92	7.50	15.01	0.37	107.2	18,004	19.9
40	Jasper	1.08	1.23	2.19	—	17.2	12	27.3
41	Jefferson	3.19	4.60	7.63	1.19	14.6	1	44.4
42	Jersey	1.08	1.32	2.50	—	47.1	4,090	23.5
43	Jo Daviess	6.27	14.35	26.00	—	102.3	4,368	31.5
44	Johnson	.45	.44	.66	—	20.4	—	38.7
45	Kane	29.67	42.99	96.98	—	70.9	127	1.9
46	Kankakee	19.72	29.53	59.89	—	95.9	383	6.4
47	Kendall	2.75	4.73	12.80	—	34.7	153	6.0
48	Knox	9.50	12.61	26.71	—	18.7	14	21.0
49	Lake	65.35	98.29	224.09	—	72.2	2	3.1
50	LaSalle	60.17	104.16	176.36	—	85.9	3,047	23.1
51	Lawrence	3.40	5.34	10.41	—	84.8	509	.2
52	Lee	4.39	5.95	11.74	—	108.3	8,249	4.8
53	Livingston	5.34	6.62	12.81	—	40.8	6	3.3
54	Logan	4.82	6.26	12.48	—	60.6	52	2.1
55	McDonough	2.59	3.91	7.46	0.12	20.3	2	15.9
56	McHenry	12.03	17.45	41.52	—	74.4	78	10.6
57	McLean	13.16	21.11	40.92	2.80	55.9	3	15.0
58	Macon	27.30	36.64	60.48	6.20	44.5	6	9.1
59	Macoupin	3.42	4.26	7.62	2.12	23.4	2	30.8
60	Madison	166.80	222.76	315.91	4.63	94.2	17,850	11.1
61	Marion	5.65	7.95	15.87	2.31	15.6	—	32.0
62	Marshall	1.63	2.21	6.01	—	60.3	2,700	7.3
63	Mason	1.92	2.22	4.34	—	197.2	4,000	.6
64	Massac	4.01	4.90	7.36	—	121.1	13,310	7.6
65	Menard	.79	.89	1.61	—	22.4	148	13.3
66	Mercer	1.54	1.85	3.23	—	148.6	3,706	66.6
67	Monroe	1.39	1.90	3.73	—	190.9	17,850	9.8
68	Montgomery	3.70	4.79	9.42	5.05	19.6	—	61.7
69	Morgan	4.34	5.32	10.54	—	33.2	4,090	28.8
70	Moultrie	1.14	1.30	2.51	—	16.7	—	3.9
71	Ogle	7.73	11.32	20.50	—	111.6	665	26.3
72	Peoria	168.84	208.98	333.58	—	58.8	2,652	47.8
73	Perry	8.76	20.02	33.60	0.64	11.9	—	22.4
74	Piatt	4.01	4.83	9.46	—	47.9	3	5.3
75	Pike	2.20	2.54	4.45	0.79	259.3	8,530	48.8
76	Pope	.47	.55	1.02	—	51.8	13,310	68.2
77	Pulaski	.81	.82	1.47	—	72.0	13,310	3.1
78	Putnam	.40	.98	3.59	—	47.8	2,700	27.4
79	Randolph	3.41	4.90	7.95	0.05	152.9	19,468	57.9
80	Richland	2.44	3.14	6.21	0.46	10.5	1	10.5
81	Rock Island	117.23	166.86	240.16	—	93.9	4,902	22.1
82	St. Clair	102.08	140.36	213.56	—	81.9	17,908	7.8
83	Saline	4.43	8.25	14.29	0.18	10.7	—	38.8
84	Sangamon	25.63	34.06	69.09	11.83	27.5	25	10.9
85	Schuyler	2.84	5.11	6.50	—	31.4	4,000	53.5
86	Scott	.61	.67	1.17	—	48.7	4,090	19.7
87	Shelby	2.35	3.07	5.07	—	22.3	3	8.3
88	Stark	.92	1.12	2.14	—	9.9	4	27.5
89	Stephenson	9.80	15.78	27.00	—	77.6	152	30.1
90	Tazewell	54.78	70.84	114.36	—	152.4	2,650	8.5
91	Union	1.94	2.13	3.77	—	124.0	16,500	41.9
92	Vermilion	19.02	27.05	49.36	5.09	67.6	25	29.7
93	Wabash	3.36	5.26	9.60	—	49.8	1,050	—
94	Warren	1.88	2.49	4.63	—	22.9	4	26.3
95	Washington	1.26	1.52	2.66	0.12	18.9	53	7.9
96	Wayne	2.66	2.99	5.40	—	24.3	10	3.8
97	White	3.65	8.26	14.81	0.05	132.6	1,060	.8
98	Whiteside	68.32	109.75	157.55	—	177.1	5,104	8.1
99	Will	45.78	67.10	127.39	—	115.9	2,800	16.1
100	Williamson	6.03	7.93	14.29	0.35	12.1	2	16.2
101	Winnebago	40.62	87.97	172.82	—	97.6	623	9.6
102	Woodford	2.28	2.87	8.23	—	53.0	2,603	68.7

*Net Yield (mgd)

Perry County is projected to have a substantially increased demand, which will increase from 8.8 mgd in 1965 to 20.0 mgd in 1980 and 33.6 mgd in 2020. A substantial portion of this demand is for use by the coal industry. Difficulty could develop by 1980. It is recommended that the demand and alternate supplies in this County be examined in detail to determine the optimum combination of industrial re-use, complete dedication of reservoir storage, or importation of water which will best meet the anticipated needs.

Sangamon County will probably experience local water supply difficulties and will need early and substantial reservoir development and maximum practical development of the ground-water resources between now and 1980. Before 2020, these local potential resources will be inadequate, and presently apparent alternatives appear to be the Illinois River and Shelbyville Reservoir.

Cook, DuPage, Kane, Lake, and Will Counties are considered together, because of their common water sources, and because they share to varying degrees in the Chicago Metropolitan Area development. Resources of the area are described in detail in Chapter II and are briefly summarized here. Ground-water resources are greater than the present pumpage, but the deep aquifers are being over-pumped, while shallow sources are underdeveloped. The Kankakee River has potential for further municipal and industrial development, while the Fox and DesPlaines carry a heavy burden of waste, and their further use is dependent upon the quality that is maintained in those rivers. Some potential exists for artificial recharge, and some potential remains in small reservoir impoundments, if these are controlled before urban developments engulf them. Lake Michigan is the largest and most important water resource in the region. Although the possibility of extending its present use is clouded by litigation in the U. S. Supreme Court, its continued use is the only reasonable basis for planning.

Cook County, which presently makes the heaviest use of Lake Michigan through the Chicago and North Shore communities, must continue a heavy dependence upon the Lake, since local resources and conservation fall far short of meeting present and projected needs.

DuPage County is presently experiencing some difficulties and is participating in the over-draft of the deep aquifers. While a relatively small reserve of ground water presently exists, this will be inadequate before 1980. The eastern portion of the County will then need to supplement local resources by importing Lake Michigan water.

Kane County is presently supplied from ground-water sources, with minor industrial use of the Fox River. Ground sources will probably prove inadequate well before 2020, after which time a changed concept with regard to the Fox River use must be adopted, or water will need to be imported into the County.

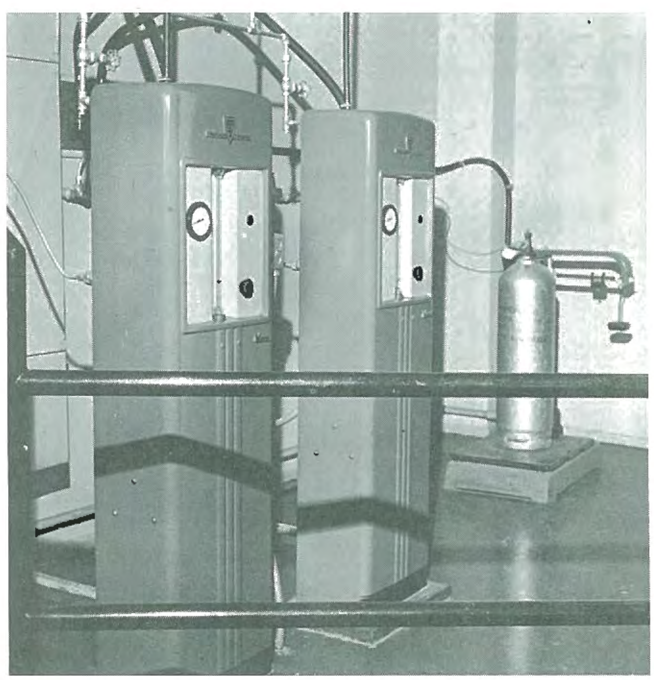
Lake County is presently making substantial use of Lake Michigan. Further potential exists for ground-water development, but major dependence will be upon the Lake as a source.

Will County is presently anticipating a deficiency, and Joliet is considering the Kankakee River among alternate sources of additional water. The DesPlaines River is a large source, and it is believed that increasing use will be made of it for industrial purposes. However, importation of water is anticipated before 2020.

MAJOR INTERIOR AND BORDER RIVERS

Relatively light use for water supply is made of the major rivers bordering or flowing through the State. For example, the total estimated water demand for municipal, industrial, and rural use in 2020 for all counties adjoining the Mississippi River is about 1 billion gallons per day (bgd). This is about one-fourth of the Mississippi flow that is equalled or exceeded 95 percent of the time. Of course, not all the water use in those bordering counties will be from the River, because the ground-water and reservoir potentials are substantial. Similarly, the total water supply demand of all counties, exclusive of power demands, through which the Illinois River flows from Will County to the mouth is only one-third of the River's flow. On the Wabash River, the water demand of bordering counties is less than one-tenth of the 95 percent flow. Projected use of the Ohio River in 2020 is even less.

These comparisons are of interest in showing that projected water demands for 2020 in areas other than northeastern Illinois are well below the ultimate capability of the resource, if our rivers are maintained in useable condition and some inter-basin transfers are assumed.



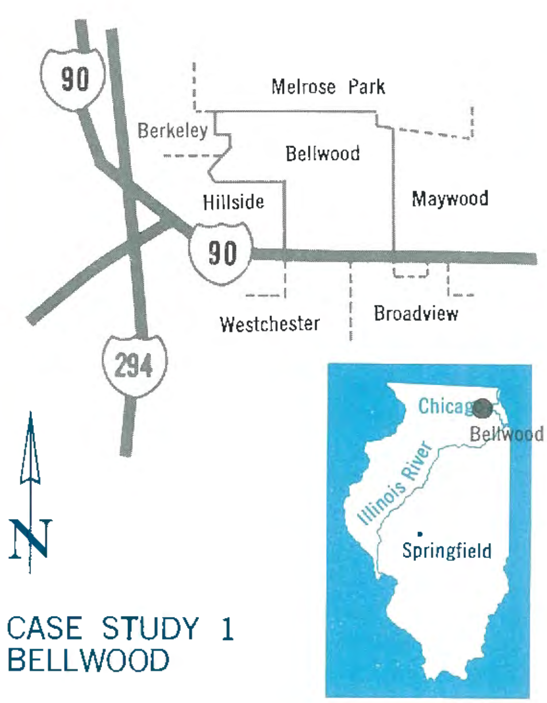
CASE STUDIES

The following case studies illustrate the range of conditions and problems encountered by typical Illinois cities and regions in providing adequate, safe water supplies. Several of the case studies describe unique situations. Chicago, for example, supplies water to a vast metropolitan area from one source, Lake Michigan. Bellwood has problems common only to other suburban metropolitan communities. The Kaskaskia River Basin and the Rend Lake area illustrate cooperative development of reservoirs to supply water to a number of communities in rural areas.

CASE STUDY 1. BELLWOOD

Bellwood, a village in western Cook County, illustrates the problems in maintaining an adequate water supply despite a receding water table. The village is about 13 miles west of Chicago and 2.5 miles west of the Des-Plaines River.

The 1960 population was 20,729. Fifty-one industries employ 8893 people, although the normal work force for a town of this size would be 5930. Bellwood has remained essentially industrial. Other than manufacturing, commercial development is essentially limited to service enterprises, and no major development of other kinds of commercial facilities is expected. Other suburban Chicago communities have surrounded Bellwood. Because the village cannot expand physically and now has a population density of about fifteen people per acre, the population probably will not increase greatly in the future.



CASE STUDY 1
BELLWOOD

A well drilled in 1913 served Bellwood until 1925. The water level in the formation had receded to 190 feet, and the pump failed to supply the demand. The Bellwood system was connected to nearby Maywood and to several factory wells. In 1928 a new well with 1.37 mgd capacity was drilled, and the old well was abandoned. The water level in the bearing formation had dropped from 75 to 210 feet, an annual decline of 9 feet per year from 1913 to 1929. By 1930 Bellwood's population was 5000, and the water use was 400,000 gallons per day, or 80 gallons per capita, a rate which reflects industrial use beyond domestic use.

In 1936 the abandoned well was reconditioned, and a 500,000-gallon ground-level storage reservoir was built to raise the capacity of the water supply to 2.16 mgd. Water consumption was 0.6 mgd. Continuous chlorination of the water was also begun.

The water supply remained essentially unchanged until 1951, but consumption had continued to increase. A new well with a capacity of 3 million gallons per day was put in service to help supply the 1.8 to 2 mgd demand. Water from the new well had an excessive natural fluoride content and was used sparingly. By this time, the water level had receded to 495 feet, a decline of 305 since 1925, or 11.7 feet per year.

The present water supply system is four wells with a capacity of 5.5 mgd; a new ground-level reservoir has a capacity of 1.5 million gallons; and an elevated tank has a capacity of 0.2 million gallons. Bellwood is interconnected with its neighbors of Maywood, Melrose Park, Hillside, and Beverly, but the connections are used only during an emergency.

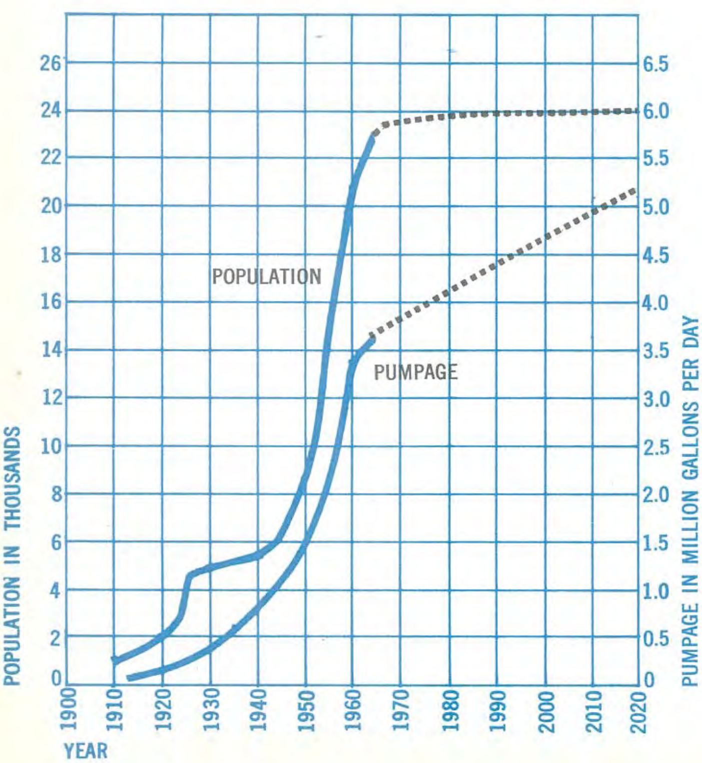
Future Requirements

The Bellwood population has grown rapidly and steadily, except during the depression (Figure 1). The growth trend will not continue in this pattern because of physical limitations on the expansion of the village. Growth will level off by 1970, and the population will remain almost static after that. The population is estimated at 23,600 in 1980 and 24,000 in 2020.

During the past 57 years, the per capita water consumption has increased at a rate of 1.3 gallons per capita per year; the present consumption rate is approximately 150 gallons per capita. The 1965 consumption figure of 3.4 mgd includes 1.2 mgd of industrial consumption. A local ordinance prohibits private and industrial water supplies in Bellwood. The water requirements of Bellwood's industries are expected to increase at a lesser rate because of water conservation and re-use. Therefore, it is assumed that future per capita consumption will increase at the national average of 1 gallon per capita per year. Water demands are expected to increase to 4.0 mgd in 1980 and 5.04 mgd in 2020.

FIGURE 1

BELLWOOD
POPULATION AND PUMPAGE
ESTIMATES



At the present capacity of 5.5 mgd, it would appear that the water needs of Bellwood would be secure in 2020, but the wells which penetrate the deep sandstone and limestone formations are the entire source of the supply. The water level in the aquifer in the Bellwood vicinity is now 510 feet below the ground surface. During the past few years it has dropped 10 feet.

The water level has declined because water has been withdrawn faster than nature replenishes it. The practical sustained yield of the water-bearing formation is rated at 46 mgd, but water withdrawal is approximately 100 mgd. The aquifer is being mined, and future decline in the water level is inevitable. If water withdrawal continues at the present rate, the level can be expected to drop another 300 feet by 1980, to about 810 feet below ground surface.

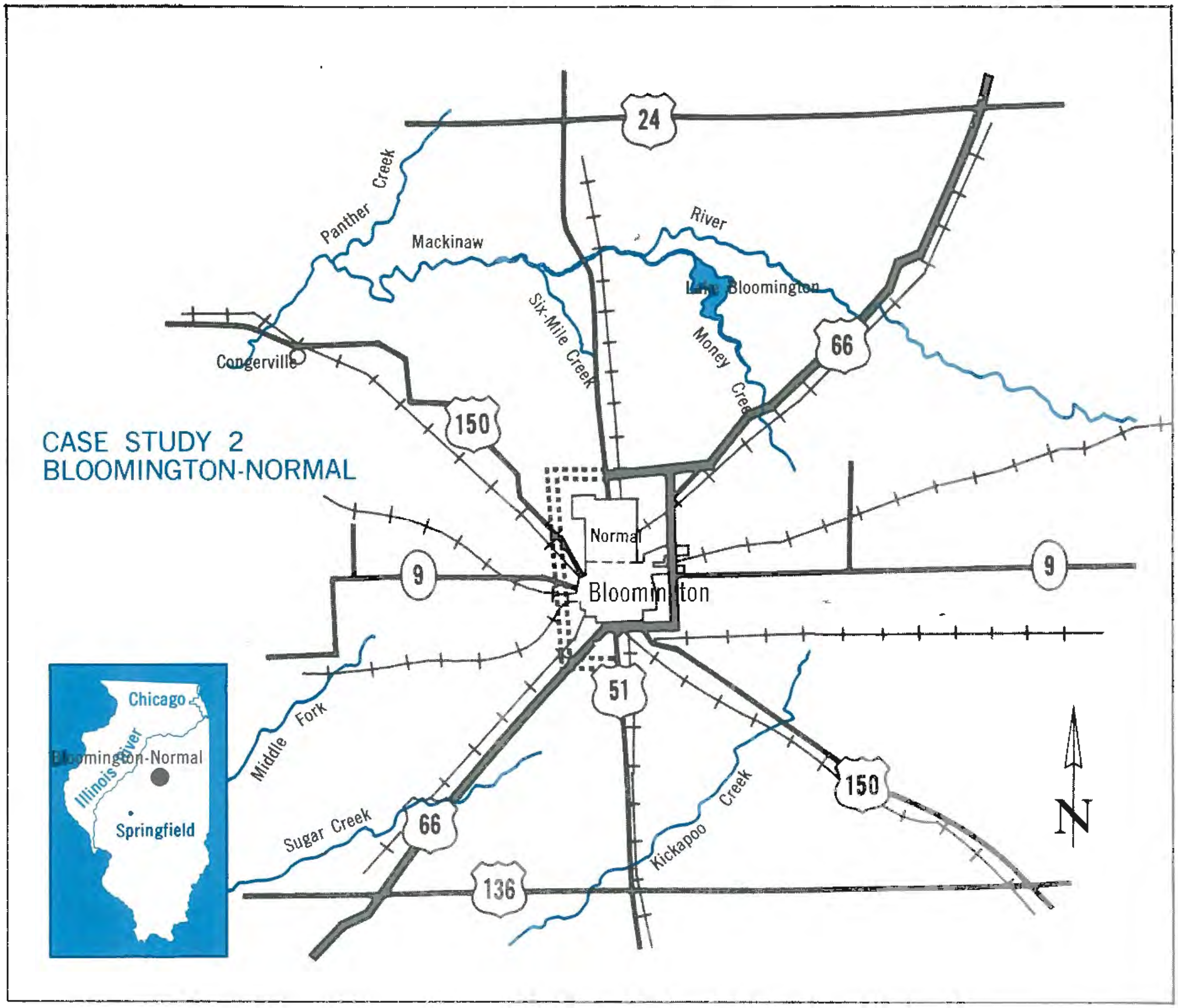
The gradual recession of the water level could continue until, at some future date, the water level drops to the bottom of the water-bearing formation and further pumpage is impossible.

Although pumpage to the ultimate capacity of the water bearing formation is possible, as the water level in the wells recedes, the pumps must provide the pressure necessary to raise the water from the deep levels. A pumping pressure of 350 pounds per square inch will barely raise the water from an 810-foot depth. Such extreme pressures tax the pumping equipment, require more maintenance, and would use 70 percent more power than at present.

Bellwood may be expected to begin looking for an alternate source of water supply in about 1975. Bellwood appears to have two alternatives for another source of water. One solution might be found in a large field of wells about 250 to 300 feet deep. Such wells would draw water from the Silurian Dolomite, which at Bellwood is about 200 feet thick. Although the aquifer is not presently being used in Bellwood and its exact potential is not known, hydrogeological data suggest that a yield of approximately 9 mgd could be expected. However, another problem may confront the village, because the mineral characteristics of water from the Silurian formation are poor. It might be necessary to treat the water to remove iron and to soften it.

The second alternative open to Bellwood is to buy water from Chicago, as Bellwood's adjoining neighbors and other suburban communities do now. Chicago would be a more dependable source of supply and its water is softer, contains less iron, and has a controlled fluoride content. However, the boundaries of the Chicago water distribution system are somewhat limited, and during periods of peak water use, pressure is low in outlying areas. Adding Bellwood to the system would only aggravate this situation and might demand premature augmentation of the water mains leading to the outlying suburbs of Chicago.

CASE STUDY 2
BLOOMINGTON-NORMAL



In Bloomington and Normal sources of surface and ground water are operated as separate supplies. Both cities have grown steadily; Normal's growth has been stimulated by the expansion of Illinois State University, and continued rapid growth is predicted. To meet the increasing demand, a new source of water will be needed, possibly in an impoundment on the Mackinaw River.

From its early settlement, Bloomington has been the center of a highly productive farming area. Bloomington was incorporated in 1839 with a population of about 1000. Illinois Wesleyan College was founded there in 1850. Normal, several miles north, grew up around Illinois State Normal University, founded in 1857.

Bloomington-Normal was not on a navigable waterway, so railroads quickly developed to transport farm produce. Several agricultural industries prospered, and the industry in Bloomington began to develop.

Since the early 1900s, both Bloomington and Normal have continued to grow. Bloomington remained an industrial and commercial city; industry and the workers prospered. Wage scales and working conditions improved as the labor unions grew in power. Normal's population increased, but the community retained its original character as a residential college town. Since 1950 Normal's population growth has accelerated. The population increased from 9772 in 1950 to 18,300 in 1965, primarily because of the recent increase in the University's enrollment, from 6600 resident students in 1963 to 8643 in 1965. Illinois Wesleyan now has an enrollment of more than 1000, while its State-supported neighbor has developed into a major educational institution.

Bloomington-Normal is still a railroad center, now served by four major lines. The cities are well served by highways, including I-55, the future I-74, and other roads; they also have airline service.

Bloomington industry produces electric appliances, heating equipment, dairy products, lumber products, farm machinery, candy, railroad equipment, machined parts, and metal castings, and processes seed. Several insurance company home offices are located there.

Bloomington's Water Supply

Bloomington's first water supply was from a well dug in 1874. The well penetrated the water table in the drift. The history of the well water supply for Bloomington is mostly one of problems, makeshift repairs, and unplanned expansion. The City was often in desperate need of additional water, and to supply the need, additional wells were drilled. Overpumping of the water-bearing formation increased and, in turn, caused a steady recession of the ground-water level.

In 1921 Bloomington had an acute water problem. The City retained a consulting engineer to locate a new source of water. The improvements suggested by the engineering firm were sound, but the recommendations were tabled by the City Council. In 1926 the General Water Committee rekindled the water crisis controversy and formed a not-for-profit corporation. The City quickly authorized the Bloomington Water Company to find a source of water supply for Bloomington. The engineers' recommendations made five years earlier were followed. Construction of a dam to impound water from Lower Money Creek was completed in 1930 at a cost of $1,285,000. For the first time the 30,930 inhabitants of Bloomington had a dependable supply of clear, soft, safe water, The well water supply was abandoned in late 1930, because the 5 mgd capacity of the new waterworks system was more than ample.

The Bloomington Water Company died of success in 1931, when the City became sole owners of the entire system. The system consisted of an impounding reservoir with a surface area of 530 acres and a capacity of 2.25 billion gallons. Water from the lake was treated by a conventional lime softening purification plant with 5 mgd capacity. Storage capacity was 0.16 million gallons at the plant, and 9.7 million gallons at the North Side Pumping Station in Bloomington.

Except for expansion of the distribution system, the Bloomington water supply system remained unchanged until 1953, when the capacity of the treatment plant was doubled to 10 mgd. Other facilities installed were a new transmission main between the plant and the City, a new 0.3-million-gallon storage reservoir at the treatment plant, a new 5-million-gallon ground level reservoir and booster station, and a 0.75-million-gallon elevated tank.

Although the existing purification system has been adequate to meet the daily demand for water in Bloomington, the impounding reservoir has silted somewhat since 1931 and has put the water supply in a rather precarious position during periodic droughts. Because of this situation, plans are presently underway to augment the old reservoir with new impounded storage facilities. As part of the new construction, the purification plant is being expanded to 14.8 mgd capacity.

Normal's Water Supply

Normal's first water supply was from two wells near the center of town. By 1912 increased consumption by Normal's 4100 residents and the University prompted the City to drill a third well, also in mid-town. The water from the wells was stored in a 13,000-gallon reservoir. In 1912 construction started on a new 150,000-gallon reservoir to provide about one-half day's storage for the 275,000 gpd consumption. Water was drawn from the reservoirs by electrically-driven pumps and discharged to the City system and a 50,000-gallon elevated storage tank. The original three wells became defective and were abandoned; new ones were drilled in 1917, 1921, and 1931.

Another well was drilled in 1943 and a fifth well in1947. The need for improved mineral quality of the water became apparent, and a new treatment plant with 1.15 mgd capacity was installed to remove iron and soften the water from the five wells. During 1948 water use in Normal ranged from 475,000 to 920,000 gpd.

In 1952 and 1954 two new wells were drilled and one was abandoned. In 1955 a new 500,000-gallon elevated tank was built and fluoridation of the public water supply was established. Additions to the iron removal softening plant in 1956 raised its capacity to 1.44 mgd. Consumption from the remodeled plant was 790,000 gpd, with a maximum of 1 mgd. Until 1965, no major changes were made to the Normal public water supply, but the demand had increased to more than 1.5 mgd.

Because the capacity does not equal the demand, water has been purchased from Bloomington on various occasions during the past few years. A new treatment facility consisting of iron removal and lime softening has recently been proposed. The combined capacity of the old treatment system and the proposed system is rated at 4.5 mgd, a substantial increase from the present 1.5-mgd capacity. However, the new facilities are expected to be loaded to capacity a few years after completion. An additional 4-mgd treatment facility will probably be on the drawing boards before the new plant is completed.

Future Requirements

The public water supplies of both Normal and Bloomington need expansion in the near future, as is evident from the proposed construction program.

Because the Illinois State University at Normal is expected to be the prime influence on the population, the rate of growth for the University is estimated separately from that for Bloomington and Normal. It appears that Bloomington's population will grow at its present rate, but Normal's population is expected to increase as the University grows. The University plans to convert from a teachers college to a multi-curriculum university in the near future. Its rate of growth is expected to increase substantially. The resident student population is projected at 13,600 in 1970; 25,750 in 1980; 33,000 in 2000; and 40,000 students in 2020. These figures are, of course, subject to error, since they are dependent upon several control factors not yet thoroughly established. The rate of construction of junior colleges in Illinois and the development of State universities at other campuses will influence the University's growth.

Between 1870 and 1940, the average rate of growth in Normal was 84 persons per year, and has been 450 per year since then. The influence of the growth of the University on the town's growth is obvious (Figure 2). Normal's population will increase from 18,300 in 1965, to 28,000 in 1980, and 50,000 in 2020.

Bloomington's rate of growth has been approximately 200 to 250 per year. The rate of population increase has decreased from 2 percent per year in 1880 to 0.6 percent in 1960. In view of this rate, it would be unreasonable to predict that Bloomington's population will increase at the national average rate of 2 percent per year. Several past population projections have predicted an upswing in the population of Bloomington which has not materialized. No major change in general conditions in Bloomington is anticipated, and it is assumed that the future growth will keep pace with the past records of Bloomington for an average annual increase of 250 people per year. Therefore, the population of Bloomington is expected to be 41,000 in 1980, and 51,000 in 2020 (Figure 2).

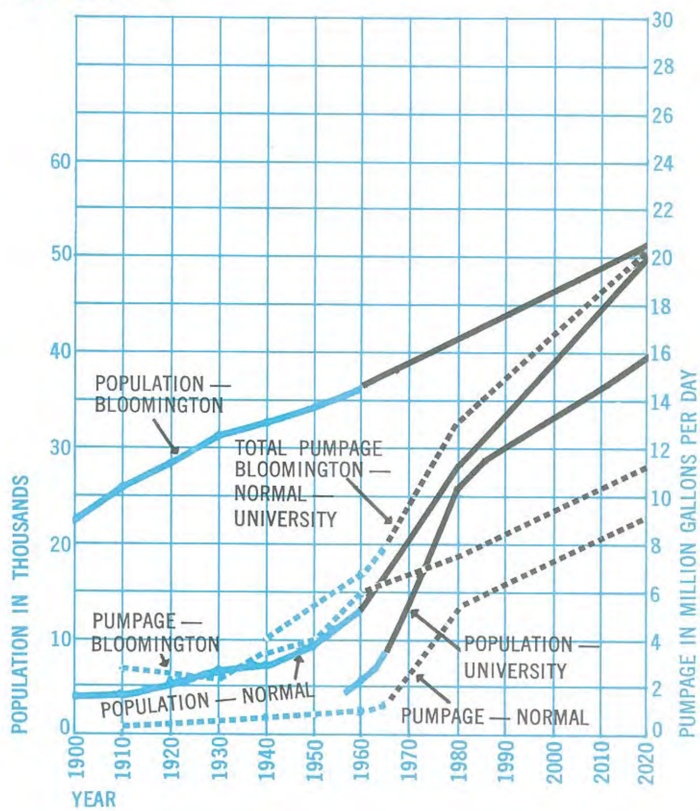
The combined populations of Bloomington, Normal, and the University show a total area population forecast of 73,600 in 1970, 94,000 in 1980, and 141,000 in 2020. To correlate Normal's population with expected water use, it must be assumed that the University will continue to obtain water from the Normal public water supply. The University's future demands were added to the town's expected demands to estimate the total demand on the City water supply. The combined estimated demand is 5.5 mgd in 1980, 7.6 mgd in 2000, and 9 mgd in 2020 (Figure 2).

The present capacity of the Normal water plant is 1.4 mgd. Plans have been made to increase the capacity to 4.5 mgd, but the present wells which furnish raw water to the plant have a long-term yield of 3.6 mgd.

Because the yield of the existing aquifer is insufficient, wells are being drilled several miles south of Bloomington in the bottom land of Sugar Creek. No exact data on the capability of the aquifer is available, but it is hoped it will yield 3 to 4 mgd. Assuming that the aquifer can be so developed, the composite water supply will provide 4.5 mgd in 1967. An additional plant expansion is expected to be needed in 1970 to extend the plant capacity to 7.9 mgd, the expected yield of the existing and proposed aquifer.

FIGURE 2

BLOOMINGTON, NORMAL, AND UNIVERSITY POPULATION AND PUMPAGE ESTIMATES



These estimates depend not only upon the hydraulic capacity of the proposed water-bearing aquifer, but also may be influenced by another potential problem. The Bloomington sewage disposal plant discharges to Sugar Creek, several miles upstream from the proposed well site. Although the sewage plant effluent is not considered to be organically pollutional, the stream is left with a definite reddish-brown color. Drawdown in the water-bearing formation may result in aquifer recharge by the stream and undesirable color may develop in the well water supply. Since the chlorination of the sewage system effluent from Bloomington now being installed may bleach some of the color, and water from the creek will have to recharge through sand, the remaining color may be removed. It is assumed here that the water from the proposed use of the aquifer will be abundant to the extent of 4 mgd and will be suitable for subsequent treatment.

Normal may ultimately consider another potential ground-water-bearing site 15 miles southwest in sands and gravels of the buried Mahomet valley. This aquifer has not been tested, and no records are available to substantiate an opinion. Again being optimistic, it is assumed that the aquifer will yield 4 mgd. This, plus the other ground-water pumpage, will total 12 mgd. It is assumed that the aquifer will be made available for use by 1975, at which time it is expected that the softening plant capacity will be expanded to 12 mgd. A final plant expansion of 4 mgd will be required in 1995 to provide a plant capacity of 16 mgd. The long-term yield of the aquifer is expected to be 12 mgd, while the plant capacity is proposed to be expanded to 16 million gallons per day. The 2020 average demand is expected to become 9 million gallons per day (Figure 2). Therefore, it is expected that the water-bearing formation can be overloaded to 16 mgd on a short-term basis in order to provide 15.3 mgd on the maximum-use day.

Although the population of Bloomington is not expected to increase at a substantial rate, it is expected that the per capita water consumption will increase at the national average rate of 1 gallon per capita per year. This estimate is reasonable in that the industrial pumpage from private wells is approximately 1.5 mgd. Based upon these assumptions, it is estimated that the average daily use from the Bloomington public water supply will be 7.4 mgd in 1980, 9 mgd in 2000, and 11.2 mgd in 2020. In addition, the projected maximum-use figures are 8.9, 10.9, and 13.5 for the respective years.

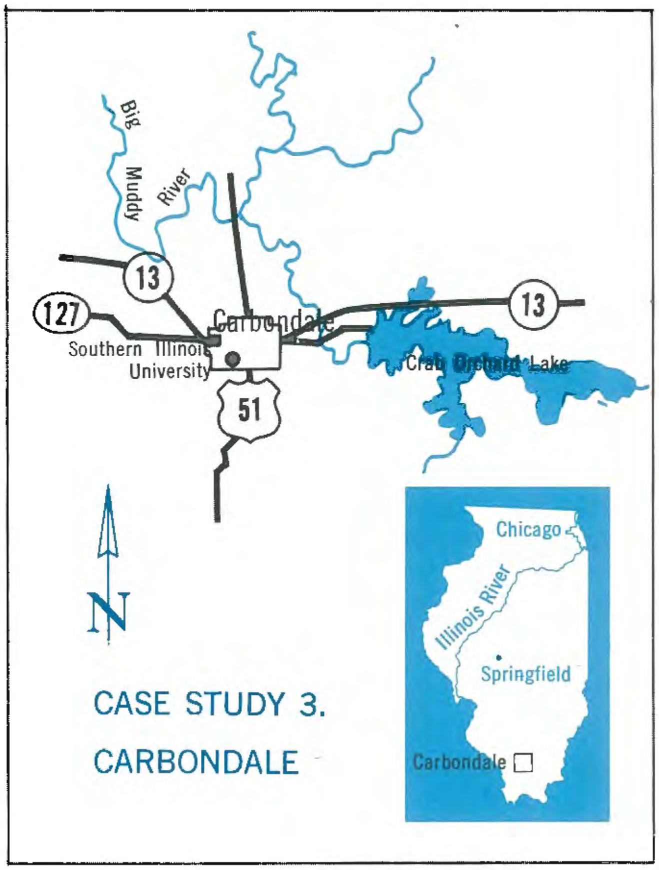
At present, the average yield of the Bloomington public water supply is limited to 8.7 mgd by the storage volume of the impounding reservoir. Within a few years, the City water supply will be in critical condition. As a result of the inevitable future requirements, a new reservoir is being built on Six Mile Creek, and remodeling of the purification plant will probably be completed in 1967 or 1968. The new reservoir will add a considerable volume of storage, and the purification plant will establish the water system capacity at 14.8 mgd. No further major improvements will be required through 2020.

Assuming that the yields of the aquifers explored by Normal are insufficient, the alternative of combining the Bloomington and Normal water supplies should be considered. Demand curves of combined average and maximum use are shown in Figure 2. Combined average demand would be 12.9 mgd in 1980, and 20.2 mgd in 2020. Comparable maximum demands are 17.3 mgd in 1980 and 28.8 mgd in 2020.

Existing combined total capacity of the two water supplies is 10.4 mgd. Completion of a new impounding reservoir and expansion of treatment facilities for Bloomington and a new softening plant for Normal would increase this capacity to 18.4 mgd by 1970. However, this is less than the maximum demand in about 1983 and less than the average demand in 2010. Therefore, an alternate source of water would be required.

The most practical alternate would appear to be a surface source. Several possible sites for dams on the Mackinaw could be considered. One such site, located upstream from Congerville, has been studied by the Corps of Engineers for a multi-purpose reservoir that would yield 36 mgd, using one-half the reservoir capacity during a 40-year drought. This yield would be adequate to meet the combined maximum demand of 28.8 mgd estimated for 2020.

Assuming Federal participation in a major portion of such a reservoir construction, the two municipalities would still be faced with construction of an adequate purification plant—either by totally new construction or expansion of existing facilities—and construction of a transmission system to carry water to Bloomington and Normal. With a treatment plant capacity of 30 mgd at a cost of $3.5 million and a 42-inch transmission main at $1.5 million, the estimated (1965) cost of this project totals $5 million.



Carbondale, in the eastern part of Jackson County, was established in 1852 on the Illinois Central Railroad. Carbondale is on the watershed of the Big Muddy River. The land is moderately rolling with good drainage both to the east and west and to tributaries of Crab Orchard Creek, which flows into the Big Muddy about 4 miles to the north.

The City has been predominantly residential since its founding, although some commercial and light industrial enterprises developed from the southern Illinois coal industry, and the demands of World War II and the Korean War. However, these developments did not materially affect the social and cultural character of the community. Carbondale's population growth may be attributed primarily to the Illinois Central Railroad in the early years and to Southern Illinois University in recent times.

The Illinois Central Railroad was the City's major employer and principal land user in the downtown area for about 100 years. Carbondale is still a main division point for the railroad. The railroad's annual payroll of more than $2.5 million is an important factor in the economy of the area, but the rapid development of Southern Illinois University has brought about a shift in the economic character of the community.

In 1870 a small State-supported teachers' college was established in Carbondale. Student enrollment was 2000 by 1947, when the College was made a State University. Expansion of facilities as well as degree curricula resulted in a rapidly-increasing enrollment.

The population of Carbondale in 1880 was 3551. During the 50-year period from 1880 to 1930 the population doubled, and again almost doubled from 1930 to 1960. According to a special Federal census, in November 1964 the population was 18,531; the estimated population for 1980 is 37,336. Assuming the rate of growth to be correct, the population of the City would more than double from 1960 to 1980. Such growth will probably come from annexation of fringe areas to the City.

Southern Illinois University is now by far the largest employer in Carbondale. The number of employees of the University exceeds the total for all industries in the City. The University is also the largest single water user. Assuming the absence of any new major industry, it can safely be said that the future of Carbondale and the demands for water are directly related to and dependent upon the growth of the University.

The Public Water Supply

The Carbondale public water supply system, established in 1897, was owned by private interests until the City bought it in 1925. In 1913 four wells were available, but the capacity of these was limited and they produced barely enough to supply the needs of the community. The bacteriological content was unsatisfactory. The source of contamination could not be determined and pollution seemed to persist in the supply; chlorination was instigated in 1918. A sandstone aquifer was the source of the well water. In addition to the somewhat limited quantity of water available and its poor bacteriological characteristics, the water from the sandstone formation was highly mineralized.

A new impounding reservoir with a capacity of 400 million gallons on Pyles Fork about 1.5 miles south of the City limits was completed in 1926. Drainage area for the reservoir was 2400 acres; the depth at the dam was 16 feet. Water flowed by gravity through a 16-inch cast iron pipeline to the treatment plant, which had a capacity of 1.5 mgd. Water was processed by coagulation, sedimentation, filtration, and chlorination. Water use was approximately 1 mgd. Clear well capacity at the new plant totaled 565,000 gallons. A 250,000-gallon elevated tank provided equalizing pressure on the distribution system.

Carbondale now gets its raw water from two surface impounding reservoirs—the City reservoir on Pyles Fork and Crab Orchard Lake, a U. S. Fish and Wildlife Lake on Crab Orchard Creek about 3 miles east of the City. It is anticipated that the Pyles Fork Reservoir will be silted up by 2085.

Crab Orchard Lake was completed in 1941. The Lake has a water storage capacity of 23 billion gallons, with a drainage area of 185 square miles. It is anticipated that the life of the Lake will be 250 years, or to the year 2190. Two lines supply Carbondale with water from Crab Orchard Lake.

The City has an agreement with the U. S. Department of Interior, Fish and Wildlife Service, to use a maximum of 4 mgd from January through May, and a maximum of 2 mgd from June through December. In case of an emergency, the City may use as much as necessary. This agreement will terminate in 1970. Presently, the City is using approximately 1 mgd from the City reservoir. The remainder of the raw water is pumped from Crab Orchard Lake.

The total average daily use of water is approximately 3.4 mgd. A maximum finished water pump capacity of approximately 8.5 mgd is provided. The water is treated in a rapid sand filtration plant in the southeast part of town. Fluoridation of the supply was started in the early 1950s. The facilities and capacity of the plant have been changed and enlarged several times. The last major change in 1958 increased the capacity to 4 million gallons, based upon a standard filter rate of 2 gallons per square foot per minute. The purified water storage is in two concrete ground storage reservoirs at the water purification plant, which have a combined capacity of 1,850,000 gallons. Each of three steel elevated storage tanks has a capacity of 250,000 gallons, and a new steel elevated tank has a capacity of 750,000 gallons. Daily laboratory tests have consistently shown a satisfactory bacteriological analysis of the water.

Carbondale supplies water to DeSoto, Southern Illinois University, and the Water Districts of South Highway, Crab Orchard, and Murdale. The City will also supply the proposed Lakeside District.

The City feels that supplying the outlying water districts greatly influences the growth and economic development of Carbondale and the immediate area. The Crab Orchard Water District was the second such district in the State and the first in downstate Illinois.

There are approximately 4671 service connections to the system in Carbondale itself. About 100 houses in the northeast section of the City have common yard services—one service used by two or more houses. The present average daily per capita demand is 110 gallons per day based on the total population served.

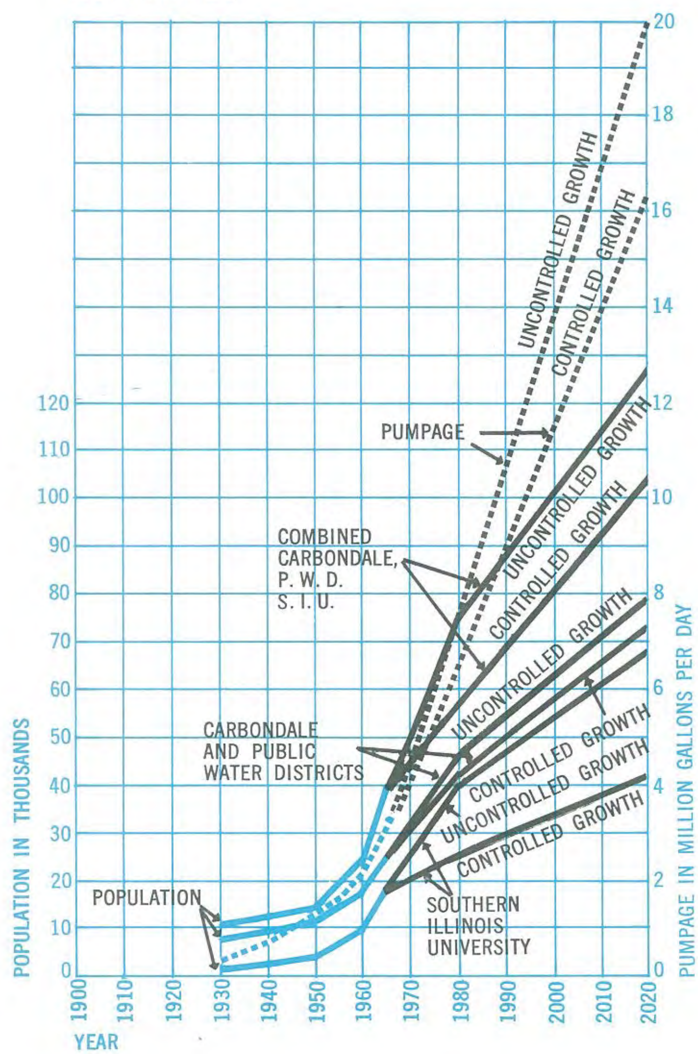
Future Requirements

In making population estimates for this study, it is assumed that the non-University population in the Carbondale area will increase at a rate of 2 percent per year to 1980 and 1.8 percent per year beyond that date. It is also assumed that Carbondale will continue to furnish water to DeSoto and the area within the various water districts presently served, as well as those now proposed. In estimating growth, the populations of these areas and of Carbondale have been combined.

As indicated in Chapter I, there has been some migration from southern Illinois, but this trend should slow down or cease by the year 2000, partly because population densities should be sufficiently high in other parts of the State to result in some migration to southern Illinois.

Two methods were used to arrive at estimated populations of Southern Illinois University for 1980 and 2020, as well as the effective population which will require water service from Carbondale. The first of these methods is termed "normal growth" and the second is called "controlled growth" (Figure 3). In the normal growth method, enrollment projections to 1980 were based on data from the University. Beyond 1980, it has been assumed that the rate of growth will parallel the growth rate for the non-University population. To determine the effective population to be served with water beyond

FIGURE 3
CARBONDALE
POPULATION AND PUMPAGE
ESTIMATES



1980, the estimated non-University populations were added to three-fourths of the estimated total University enrollment. The estimated University figures were adjusted, because many of the students commute and do not contribute to the total water demand.

The Illinois Board of Higher Education is presently engaged in a study of future facility requirements for higher education which indicates that future growth of S.I.U. may be limited to a maximum enrollment and may be controlled by minimum entrance requirements.

Normal-growth estimates may not be representative. To weigh the estimates, the controlled-growth method was developed.

In this method, the non-University population was estimated on the same basis as that used under the normal growth procedure. The University population was reduced by 33 percent for the 1970 to 1980 period, but adjusted upward by 2 percent per year to account for normal population growth during this time. The University population was reduced by 33 percent, because about 30 to 40 percent of the present enrollment comes from the Cook County area. After the establishment of junior colleges and additional four-year schools in Illinois, it was assumed that fewer Cook County students will attend downstate campuses. Beyond 1980, the University population growth was projected on a 1.8 percent increase per year. No assumption was made

Crab Orchard Lake

as to the ultimate maximum student population, since the Board of Higher Education has not yet established recommended limits. The effective population to be furnished water service under the controlled-growth method is the total of the projected non-University population and three-fourths of the anticipated adjusted University enrollment.

The present water sources for Carbondale are the City Reservoir (Pyles Fork) and Crab Orchard Lake. In 1948 the State Water Survey estimated the useful life of the City Reservoir would continue to 2006, at which time its original capacity would be reduced 50 percent by siltation. It is assumed here that 1 mgd can be obtained from this source until 2006. Crab Orchard Lake is expected to have its original capacity reduced 50 percent by siltation by 2066, but the Federal Government, which owns the Lake, has indicated that the contract with Carbondale, which expires in 1970, will not be renewed. Thus, it is assumed that the City can obtain an average of 3 mgd from Crab Orchard only to 1970.

Projected maximum daily water demands indicate that existing raw water sources and finished water storage will be adequate through the year 1967. By that time additional treatment plant capacity will be needed. It is possible to increase the present treatment plant capacity to 8 mgd, which will continue to be adequate through 1976. The expansion as proposed would provide an additional 1.6 million gallons of finished water storage. This would bring total finished water storage to 4.7 million gallons.

It is concluded that an expansion of the treatment plant with existing raw water sources should satisfy the 1967 maximum day. However, these facilities will not meet the projected 1968 maximum-day demands. Consequently, an additional raw water source will become a necessity by at least 1968. The discontinuance of the Crab Orchard Lake agreement in 1970 would mean a deficit of 3.3 mgd when raw and finished water storage is compared to the 1970 estimated maximum daily demand.

The necessary raw water required during the 1968 to 1970 period could be provided by a side-channel reservoir, and such a reservoir has been proposed. It would have a total capacity of 900 million gallons, with an effective volume of 783 million gallons after deducting evaporation loss. Assuming that the reservoir would provide 180 days storage without any inflow, the net volume represents 4.35 mgd. The reservoir would be filled with water pumped from Crab Orchard Creek during floods and at other times when water is available. The construction of this reservoir by 1968, along with the City reservoir and 4.7 million gallons of finished water storage, would meet the 1970 maximum-day demand with a small excess in capacity.

Therefore, by 1970 a major raw water source is imperative. A new reservoir known as Cedar Creek Lake 4 miles south of the City has been proposed. This is part of a multiple-purpose project that is being planned with the assistance of the U. S. Soil Conservation Service under the P. L. 566 (Watershed Protection and Flood Prevention Act). This structure includes benefits from flood prevention and municipal water supply for the City of Carbondale. This impoundment would have a capacity of 7 billion gallons and a surface area of 1150 acres, the equivalent of 21,000 acre-feet. Assuming a siltation rate of 0.5 percent per year, this source plus the existing City reservoir for its expected life would provide adequate raw water storage to the year 2020. At that time a new source of supply would be needed. The estimated net volume of water available from Cedar Creek Lake is 5.4 billion gallons after evaporation. Assuming no inflow for a period of 180 days, this reservoir would provide, when new, 30 mgd for the 180-day period. Capacity would be reduced by siltation, as previously noted.

Raw water storage will be needed by 1968 to 1970. Whether or not construction of a side-channel reservoir is economically feasible will depend upon a detailed engineering study. Such a study might show that construction of Cedar Creek Lake in 1968 would be the best solution, since its completion in 1970 will be a necessity.

The 1980 maximum-day demands estimated by normal growth and controlled growth are expected to reach 12.0 and 10.5 mgd, respectively. On the basis of normal growth, a new treatment plant facility will then be required to meet this demand. If growth is as projected on the basis of controlled growth, the construction of the plant could be postponed until 1993. A plant will be necessary, however, before 2020.

In connection with the Cedar Creek Lake, a new treatment plant is proposed which is to have a capacity of 15 mgd. Doubling the capacity of the existing 4-mgd treatment facility will result in an installed treatment capacity of 23 mgd. This amount, with present and future finished water storage, should supply the maximum daily demand of 30.5 million gallons as projected for normal growth. If growth is at a controlled rate, the estimated maximum daily demand in 2020 would be 25 mgd.

The estimated cost of the side-channel reservoir near Crab Orchard Creek, including equipment, is $650,000. The existing treatment plant facility can be doubled for an estimated $550,000. Cedar Creek Lake will cost an estimated $720,000 for construction of the reservoir, intake structure, and pumping facilities. Land acquisition and clearing will cost an estimated additional $576,000. A new 15-mgd treatment plant would cost an estimated $1.7 million. To these must be added raw and finished water piping, engineering, legal, and other costs.

CASE STUDY 4. CHICAGO

Chicago supplies water to 66 suburban communities in addition to the City proper from one source—Lake Michigan. Although the supply is almost unlimited, distribution of water to this wide area and protection of Lake Michigan from pollution are problems peculiar to this metropolitan water system.

Chicago was incorporated as a town in 1833, when there were about 150 wood houses scattered along both sides of the Chicago River in an area about three-eighths of a mile square with no frontage on the Lake. Everything east of State Street was a government reservation.

Congress voted $25,000 for a harbor, the State constructed a canal from the Illinois River to Lake Michigan, and the community boomed. Chicago was incorporated as a city in 1837. Since the 1840s when Chicago got its first railroad, the City has grown rapidly, except during periods of national depression. It became a center of lake shipping trade, railroads, and export trade. Today, it is an important transportation, manufacturing, distributing, educational, and financial center. According to the 1960 census, Chicago is the second-largest city in the U. S., with a population of 3,550,404.

The Public Water Supply

The first settlers at the mouth of the Chicago River used the River for their water supply. As the number of settlers increased, the River, "a sluggish stream," soon became contaminated and wells became a necessity.

The earliest recorded effort to provide a public water supply for Chicago was in 1834, when the Board of Trustees paid $95.50 to dig a well. However, Chicago was situated on a low and nearly level prairie a few feet above the level of Lake Michigan, and the wells were contaminated by surface water. The Lake was the better source of water.

For some years peddlers sold Lake water from carts for from 10 to 25 cents a barrel. In 1836 the Legislature gave a 70-year charter to the Chicago Hydraulic Company, a private firm established with $25,000 capital. The Company began operations in 1842, when the City had a population of 4500, and built Chicago's first pumping station and reservoir at the corner of Lake Street and Michigan Avenue to draw water from Lake Michigan.

The water was pumped through an intake pipe extending about 150 feet into the Lake. The reservoir, constructed of wood, was elevated about 80 feet above the ground surface. Water pressure was sufficient to force water to the second floor of a building. Water was distributed in 2 miles of wooden mains made from 10-foot cedar logs.

In 1840 the total area of the City was 10.7 square miles. The water supply reached only a small part of the southern and western sections. Four-fifths of the City still obtained its water from the River or from water carts.

Public Ownership

The works of the Chicago Hydraulic Company were operated with varying success until 1852, when the City took over the company. A three-man Board of Water Commissioners was given authority to borrow money and issue bonds up to $400,000.

To keep up with the rapid growth of the City, which now had 45,000 people and an area of 17.93 square miles, a new water supply system was planned. The plans provided for a pumping station on the Lakeshore at Chicago Avenue. A timber crib was to be sunk 600 feet from the shoreline, and from this crib a 30-inch wooden inlet pipe was to be laid in a trench on the bottom of the Lake to carry water to the pump well in a new pumping station.

After several attempts to lay the crib and main were thwarted by rough weather, the plan was abandoned, and the water was permitted to enter the pipe close to the shore. By the time the system began operations in 1854, the population had increased to 65,000 people. This, the first municipally-owned pumping station in Chicago, was at the site of the present Chicago Avenue Pumping Station. The original pumping engine, nicknamed "Old Sally," was installed in 1853 and served Chicago faithfully for more than 50 years.

The water was distributed through three reservoirs, each holding 500,000 gallons. The first cast-iron distribution pipe was laid in Clark Street in 1852. From then on, cast iron replaced wood for all mains. The first full year of operation of the new waterworks was 1855. The total cost of the works was $650,000, and the pumpage averaged 2.39 mgd. The water system was based on an estimate that by 1866 the population would be 100,000. In 1866 the population was more than double that number.

Pollution Problems

During the succeeding years, the water system not only had to meet the demands of the rapidly rising population, but also control the increasing pollution of Lake Michigan along the shoreline. During this period the sewage from Chicago was discharged either directly into Lake Michigan or into the Chicago River, which flowed into the Lake. As the City's population increased, the sewage dangerously contaminated the water supply. Finally, the intake point had to be moved beyond the shore contamination.

Chicago's first water tunnel was completed in 1867. It was a daring feat of engineering and brought international fame to its designer, Ellis S. Chesbrough. The 2-mile tunnel was dug through clay 60 feet below Lake level and lined with two shells of brick to a finished diameter of 5 feet. It was designed to deliver 50 mgd.

The original timber crib was placed 2 miles offshore at the Lake end of the tunnel, and the shore end was connected to a new pumping station completed in 1869. This new system marked the real beginning of the modern Chicago waterworks. The old water tower at the intersection of Michigan and Chicago Avenues, which was completed in 1869, was part of the project. It still stands as a monument to the vision and skill of the pioneering waterworks engineers.

Since 1870, the record of the Chicago waterworks has been one of almost constant expansion and improvement. More and larger intakes located at greater distances from shore, larger and longer tunnels to the two filtration plants, and pumping stations have been built.

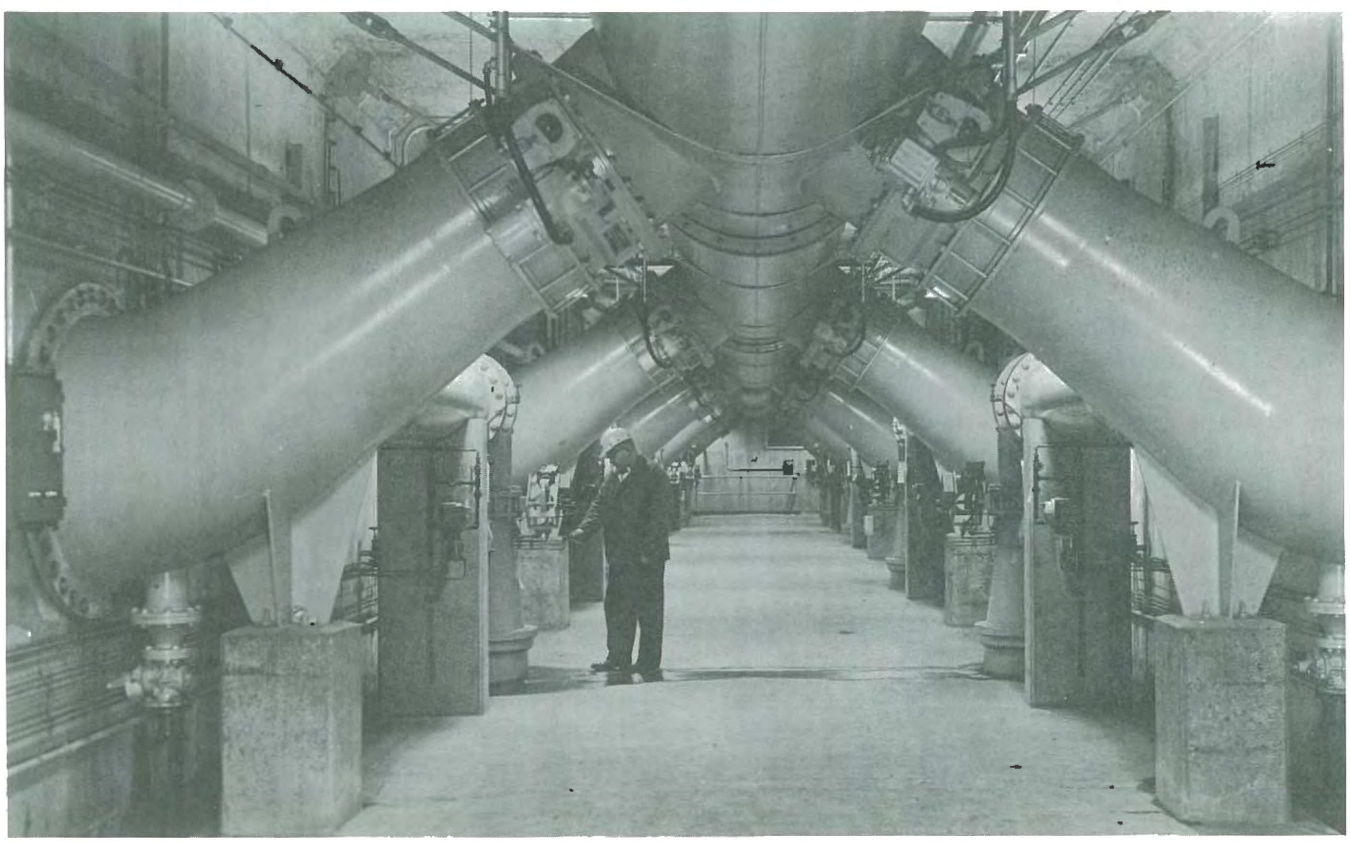
The water is now taken from Lake Michigan through two intake cribs 2 to 3 miles offshore in water depths of 32 to 37 feet and at two shore intakes at the filtration plants. Two additional cribs are presently used on an emergency standby basis. Tunnels convey the water from the cribs to filtration plants, then to the pumping stations. The water flows from the cribs by gravity through the tunnels to large pumps at the filtration plants. The pumps raise the water to a height some 20 feet above the Lake level to a point where it starts to flow by gravity through the water filtration system.

The South District Filtration Plant on the Lake Front near East 79th Street was the largest in the world when it was completed in 1947. Coagulation and sedimentation treatment began in late 1945, filter treatment in 1947. It serves the area south of 39th Street and the suburban towns which use Chicago water. The plant has low lift pumps, chlorination, coagulation, taste and odor control, sedimentation, and filtration.

Based upon the normal rating of 2 gallons per square foot per minute of filtering surface, the filtering capacity of the original plant was 320 mgd. The filters, however, were constructed to operate at a 4-gallon rate, and all other parts of the plant were designed accordingly. There are 80 rapid sand filters. From the filters, the water is discharged to eight filtered-water basins with a combined capacity of 15 million gallons. The water flows from these basins to two filtered-water reservoirs with a combined capacity of 32 million gallons. From the filtered water reservoirs, the water flows by gravity to four pumping stations serving the southern area.

At present, the entire plant is being expanded 50 percent to increase the rated capacity to 480 mgd and the peak capacity to 800 mgd. Fluoridation of the water began in 1956.

The Central District Filtration Plant just north of Navy Pier went into full operation in October 1964. It serves the area north of 39th Street and the contiguous sub-



urban towns that use Chicago water. It is the largest water purification plant in the world, with a normal capacity at the 2 gallons per square foot per minute per filter area of 960 mgd, but is capable of safely treating 1700 mgd. The settling basins, filters, and clear wells are divided into four identical quadrants, with a central head house between the two east and two west quandrants. This gives great flexibility in the operation of the plant. Each quandrant has 4 settling basins, 24 filters, and 2 clear wells. Plant operations are monitored by a computer-data logger system, and a telephone-loudspeaker-closed circuit television communications system.

Filtered water is discharged to clear wells under the filters, then through two filtered water collectors to the storage reservoirs. Combined storage capacity of all clear wells and reservoirs is 111 million gallons. From these reservoirs, the water flows by gravity through the tunnel system to the six pumping stations serving the area.

Chicago's municipal water system has grown from one pumping station with one 8-mgd pump to ten stations with 50 pumps with a combined capacity of 2890 mgd.

Distribution System

There is only one storage reservoir on the distribution system, at the Western Avenue Pumping Station. It is a concrete ground reservoir with a storage capacity of 30 million gallons, which was put in operation in 1956. This reservoir, in effect, increases the capacity of the water tunnel and allows for a greater pumpage at the hours when needed without overtaxing the capacity of the tunnel.

From the 1842 distribution system with 2 miles of wooden water mains, Chicago's system had expanded to 4083 miles of underground pipe by 1965, when there were 509,297 service connections to serve 227 square miles in the City.

In addition, water is supplied to 66 suburban cities (Figure 4). A substantial portion of Cook County uses Chicago water and is also within the corporate limits of the Sanitary District of Greater Chicago. The Illinois Revised Statutes of 1965 make it incumbent upon Chicago to supply water to other communities within the District under certain conditions.

Projections

Chicago reached its maximum population between 1949 and 1950. Since that time, there has been a 1.9 percent decrease, but there has been a decided increase every year in the population of communities outside the City that are served by the District. They increased from a population of 140,250 in 1920 to 1,041,000 in 1965.

Chicago's water use in 1965 was less in both total gallons pumped and per capita use than in 1930, but the population served by the Chicago Water System—the City and the suburbs—has increased by 25 percent during that 35-year period. At the same time, the standard of living of the residents of the Chicago area has risen steadily, which means that use for consumption, sanitation, lawn sprinkling, and household appliances has increased. Per capita use of water in 1930 was 288 gallons per day, and by 1965 it had declined to 216 gallons per day per person.

To explain this reduction, factors which influence the use of water must be considered. Obviously, weather is a major factor. The water use in very cold winters and very hot summers is usually greater than in the more moderate seasons. Similarly, in years when the annual precipitation is less than normal, water demands increase. The comparatively mild weather in 1964-65 might account for part of the decrease.

The increase in metering has also affected water use in Chicago. Metering tends to reduce wastage of water. Thirty-three percent of water pumped in the Chicago Water System in 1930 was metered; 50.4 percent was metered in 1965.

Another factor is that high water consumption is typical in slum and blighted housing, primarily because of leaky plumbing. From 1950 through 1965, the number of substandard housing units in Chicago was reduced from 255,000 to 111,000 units, a decline of 56 percent. Most of these were torn down in the City's urban renewal and expressway construction programs.

The active inspection program of the Department of Buildings, including plumbing inspection, also helped improve or eliminate substandard housing. Last year, approximately 57,516 plumbing inspections were made. Leaky plumbing fixtures waste hundreds or even thousands of gallons per day. Inspection and repair conserves a great deal of water. The Department also has aggressive underground leak detection and repair programs. During 1965, about 2,835 leaks were detected and repaired. Public cooperation in this program was good. No conservation program is successful without cooperation from the people who use water.

On January 1, 1953, the administration of the water and sewer system of the City was transferred from the Department of Public Works to the Department of Water and Sewers. The new Department, headed by a Commissioner, has five divisions responsible for purification, pumping station operation, water distribution, metering, and collection.

In the years prior to the World's Fair of 1893, Chicago was internationally known as the typhoid fever city. Today, it has one of the lowest typhoid rates of any of the large cities of the world because of extraordinary measures to dispose of its sewage and strict supervision over the safety of the water supply.

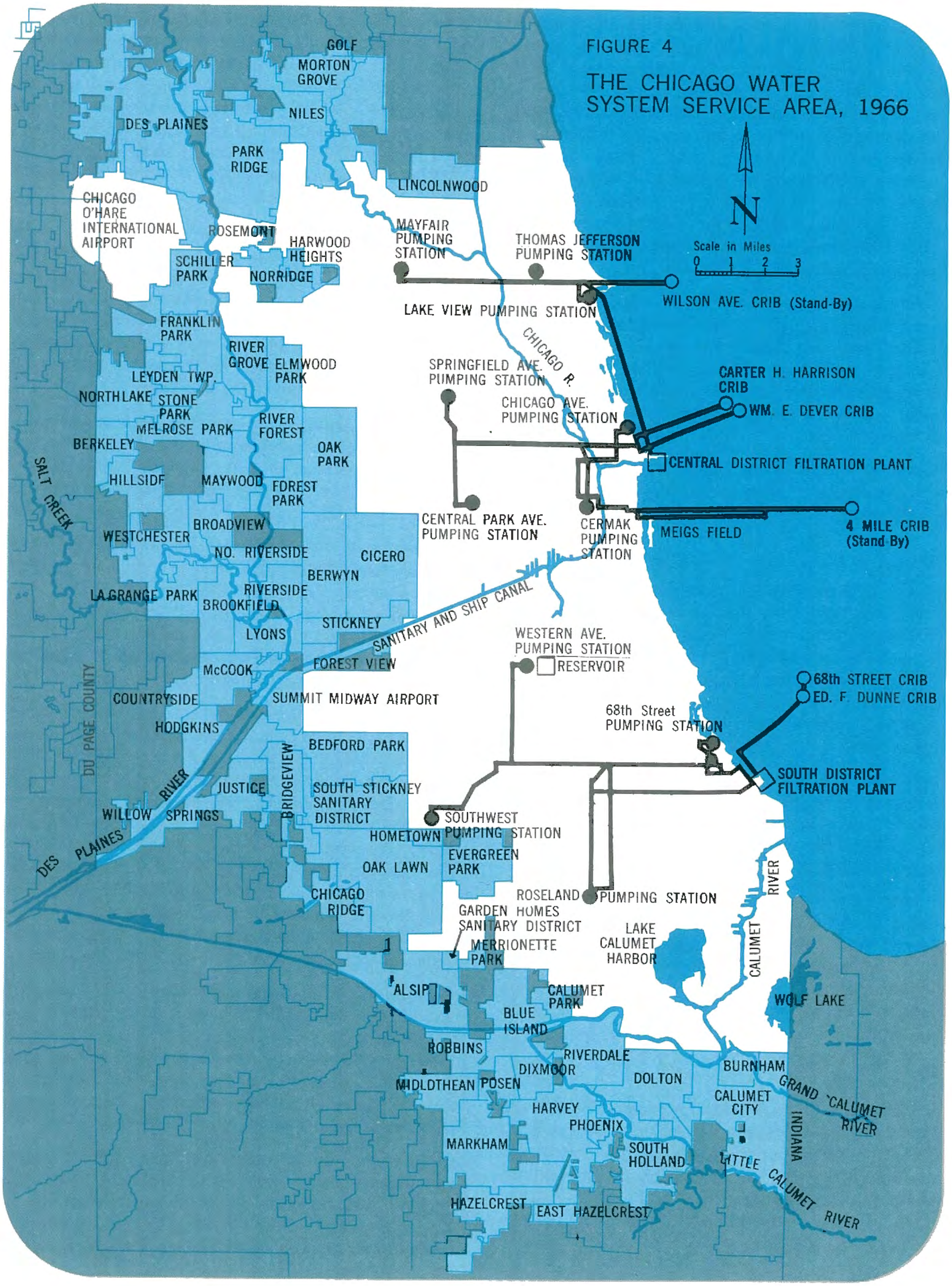


FIGURE 4
THE CHICAGO WATER SYSTEM SERVICE AREA, 1966
N
Scale in Miles
0 1 2 3
GOLF
MORTON GROVE
NILES
DES PLAINES
PARK RIDGE
LINCOLNWOOD
CHICAGO O'HARE INTERNATIONAL AIRPORT
ROSEMONT
HARWOOD HEIGHTS
SCHILLER PARK
NORRIDGE
MAYFAIR PUMPING STATION
THOMAS JEFFERSON PUMPING STATION
LAKE VIEW PUMPING STATION
WILSON AVE. CRIB (Stand-By)
FRANKLIN PARK
RIVER GROVE
ELMWOOD PARK
LEYDEN TWP.
NORTHLAKE
STONE PARK
MELROSE PARK
RIVER FOREST
SPRINGFIELD AVE. PUMPING STATION
CHICAGO R.
CHICAGO AVE. PUMPING STATION
CARTER H. HARRISON CRIB
WM. E. DEVER CRIB
CENTRAL DISTRICT FILTRATION PLANT
BERKELEY
OAK PARK
HILLSIDE
MAYWOOD
FOREST PARK
SALT CREEK
BROADVIEW
WESTCHESTER
CENTRAL PARK AVE. PUMPING STATION
CERMAK PUMPING STATION
MEIGS FIELD
4 MILE CRIB (Stand-By)
NO. RIVERSIDE
CICERO
BERWYN
LA GRANGE PARK
RIVERSIDE
BROOKFIELD
STICKNEY
SANITARY AND SHIP CANAL
LYONS
WESTERN AVE. PUMPING STATION
RESERVOIR
McCOOK
FOREST VIEW
COUNTRYSIDE
SUMMIT
MIDWAY AIRPORT
68th STREET CRIB
ED. F. DUNNE CRIB
DU PAGE COUNTY
HODGKINS
68th Street PUMPING STATION
BEDFORD PARK
BRIDGEVIEW
JUSTICE
SOUTH STICKNEY SANITARY DISTRICT
SOUTH DISTRICT FILTRATION PLANT
WILLOW SPRINGS
DES PLAINES RIVER
SOUTHWEST PUMPING STATION
HOMETOWN
EVERGREEN PARK
OAK LAWN
CHICAGO RIDGE
ROSELAND PUMPING STATION
GARDEN HOMES SANITARY DISTRICT
LAKE CALUMET HARBOR
MERRIONETTE PARK
CALUMET RIVER
WOLF LAKE
ALSIP
CALUMET PARK
BLUE ISLAND
ROBBINS
RIVERDALE
DIXMOOR
MIDLOTHEAN
POSEN
DOLTON
BURNHAM
GRAND CALUMET RIVER
HARVEY
CALUMET CITY
PHOENIX
INDIANA
MARKHAM
SOUTH HOLLAND
LITTLE CALUMET RIVER
HAZELCREST
EAST HAZELCREST

Lake Clean-Up

The clean-up of the Lake began with the opening of the Drainage Canal by the Sanitary District of Chicago. Over the years, many projects have restored Chicago's Lakefront almost to its original beauty and cleanliness and removed serious pollution from the water there.

Chicago has an abundant source of water available at its doorstep. Lake Michigan is a part of the Great Lakes system which, according to some authorities, contains about 57 percent of the world's soft, fresh, surface water. The total hardness averages 134 parts per million, as calcium carbonate. At the Dever Crib in 1965 the water temperatures averaged 48.5 degrees Fahrenheit, with a maximum of 73 degrees and minimum of 32 degrees.

Nature has been kind to Chicago in providing an ample water supply, but man has not always been so considerate. The pollution of the southern end of Lake Michigan has been increasing continually for a number of years, creating a number of new operating problems for the Chicago Water System. Industrial wastes in enormous quantity and complexity and the inadequately treated effluents from a number of sewage treatment systems from communities and industries to the north and south of Chicago have been allowed to flow into Lake Michigan. This industrial and domestic pollution has introduced disagreeable tastes and odors into the raw Lake water supply. In addition, the phosphates and nitrates from the effluents contribute to the growth of plankton. Some of them cause disagreeable tastes and odors, some of the filamentous algae clog screens that are ahead of the pumps in the filtration plants, and some of them change the chemical nature of the raw water supply, making it more difficult to treat.

The most seriously polluted conditions at the South District Plant intakes occur when slugs of wastes drifting to the intake have abnormal hydrocarbon-like odors similar to those obtained by diluting effluent from oil refinery wastes with Lake water.

A Federal pollution conference, held in Chicago in March 1965, was attended by representatives from the regulatory agencies of Illinois, Indiana, the Metropolitan Sanitary District of Greater Chicago, the city of Chicago, and industry to discuss the pollution problem in the southern end of Lake Michigan and its principal tributaries, the Calumet River and its branches and the Indiana Harbor Ship Canal. The city of Chicago presented a fifteen-year history of pollution in southern Lake Michigan and its tributaries and proposed criteria for a public water supply. This report became the basis of a program in which the offending industries and municipalities were given definite periods of time in which to develop programs and plans for reducing the pollution for which they were considered responsible.

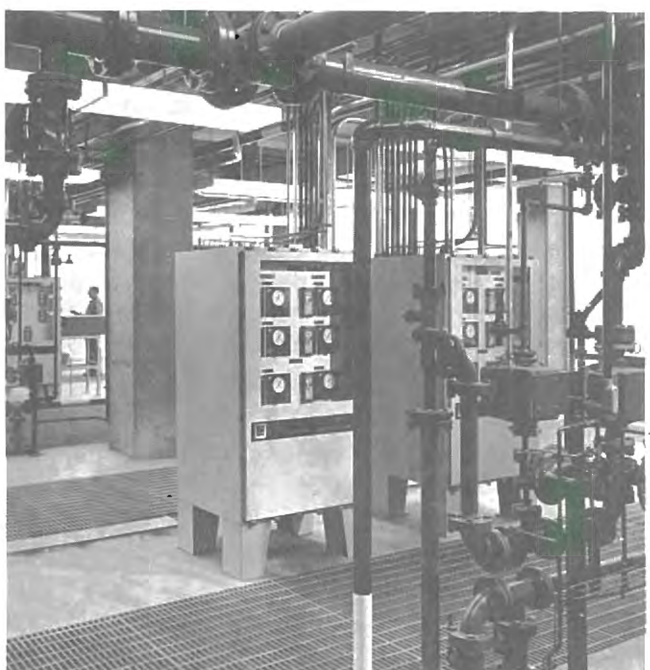
During the year, the U. S. Congress passed the Water Quality Control Act, which provides, among other things, that the individual states can establish water quality criteria similar to those proposed by Chicago's Bureau of Water. If this is not done, the Federal Government will then have the right to step in and establish such criteria. It is hoped that this program of water pollution control will reduce the pollution of the southern end of Lake Michigan and result in an improved raw water supply for Chicago.

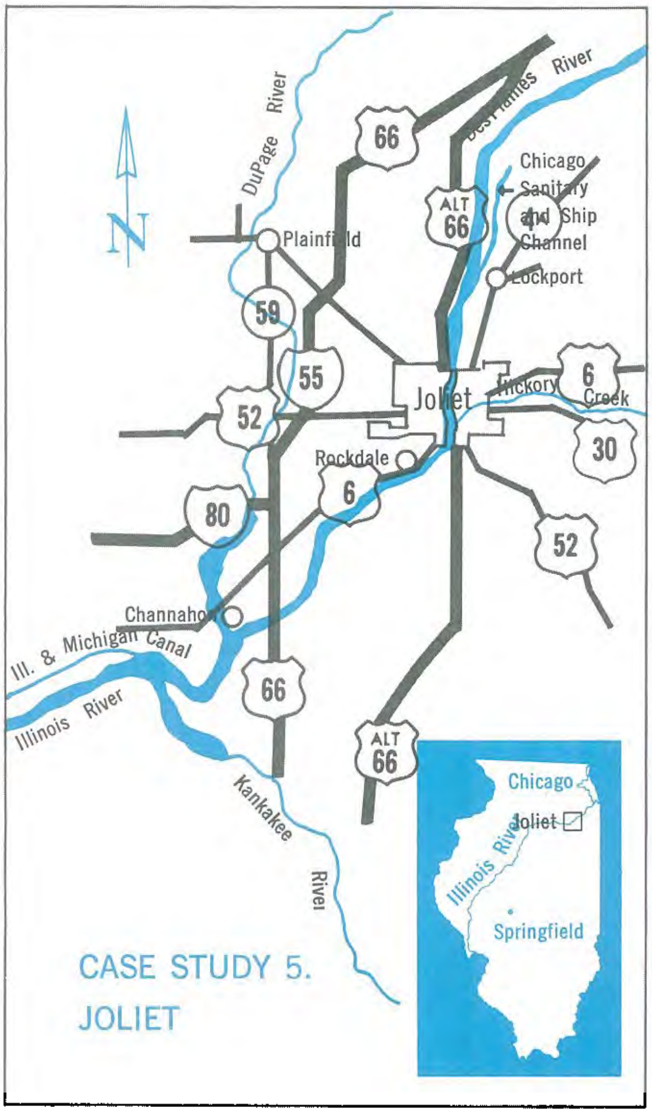
The average coliform organisms per 100 milliliters in the finished water delivered to the consumers in 1965 was 0.07, or well below the U. S. Public Health Service standards for safe drinking water which permit a maximum average of 1.0 coliforms per 100 milliliters. The American Insurance Association (formerly the National Board of Fire Underwriters) rates the Chicago Water System in Class I, the highest rating given by the Association. No other city with more than a million population has been so rated.

The Future

For many years the Department of Water and Sewers has prepared an annual Five Year Capital Improvement Program designed to provide the necessary waterworks facilities when and where needed. These improvement programs have been most successful, as measured in the results to date. The present system is capable of satisfying the expected demands through 1980.

Chicago is fortunate in having Lake Michigan as an unlimited source of water for the future, but water pollution control measures must be vigilantly carried out to maintain a satisfactory source for the future.





Joliet, a highly industrialized city, uses both rock and drift aquifers as a source of water supply. The known limitations of these ground-water sources, in relation to the estimated demands, ultimately may require use of water from the Kankakee River and construction of a new treatment plant.

Joliet, one of the oldest cities in Illinois, was established about 1675 and incorporated in 1845. The terrain is moderately rolling, with frequent outcroppings of bedrock. The topographic relief is in valleys carved by Spring Creek, Hickory Creek, and the DesPlaines River. The area is also pock-marked by limestone quarries and gravel pits.

Farming, lumbering, coal mining, and limestone quarrying developed early. Later, steel, petroleum, clay, paper, and chemical industries were added. At present, Joliet has more than 200 manufacturing plants.

The Illinois and Michigan Canal, completed in 1848, passed through the center of Joliet. The Canal was used extensively until it was replaced in 1938 by the Chicago Sanitary and Ship Canal, which today carries more than 27 million tons of cargo each year. Joliet is served by six railroads and major highways, including I-55. I-80 is expected to be completed through Joliet within the next year.

Joliet grew at a moderate rate until 1870, when industrialization brought a marked increase. The population trend remained essentially constant until the depression years of the 1930s. The population declined, but rebounded and was 51,603 in 1950. It is estimated that the population of Joliet can be expected to expand from 66,780 in 1960 to 94,000 in 1980, and 140,000 in 2020. These estimates are based upon past growth trends.

The Water Supply

The original water supply system was built in 1884 by private funds and consisted of twenty shallow sand and gravel wells. Prior to that date, residents of Joliet apparently got water from private wells and lakes, streams, and rock quarries. The water supply was purchased by the City in 1888.

By 1900 six new wells had been drilled to draw water from sandstone and limestone formations from 400 to 1700 feet deep. These wells increased the capacity of the waterworks to 2.65 mgd.

In 1907 the City turned to Hickory Creek to meet increased demands for water. This proved to be a drastic mistake. In the summer and fall of 1910 Joliet had an extensive typhoid outbreak; 120 typhoid cases were reported and eighteen people died. Chlorination of the water supply began in 1910 and greatly reduced the number of typhoid cases in the following years, but the users did not like the creek water because it was extremely turbid. More deep wells were drilled and chlorination was abandoned. By 1913 the City had in operation 31 wells with a combined capacity of 6.527 mgd.

The capacity of the original twenty shallow gravel wells seemed to decrease with age, and by 1922 they were no longer used. In 1922 the water supply for Joliet consisted of ten deep wells with a capacity of approximately 4 mgd to serve a population of about 40,000. The waterworks did not supply any industries of consequence, so the use in Joliet was almost 120 gallons per person per day. The City, industries, and several other towns in the area had begun to make extensive use of the deep sandstone and limestone formations. A decline in the water level began then and has continued and accelerated since.

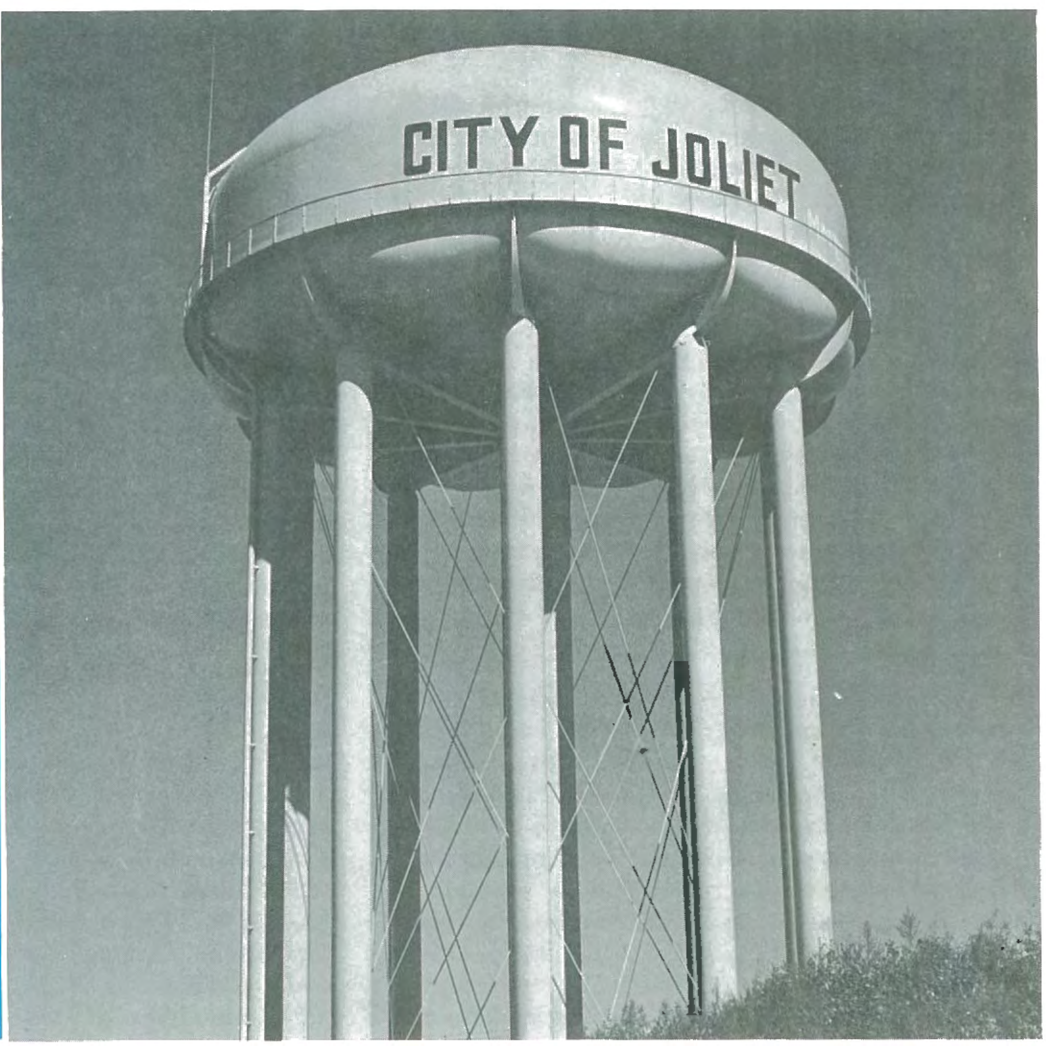
In 1938 Joliet's water supply was drawn from five deep wells with a combined capacity of 6.1 mgd. Chlorination facilities were installed in 1931. In 1939 most of the 33 industries in the area drew water from the deep rock formations. The water level had continued to recede and had dropped 56 feet between 1922 and 1939.

During the early 1940s Joliet began to realize that additional sources of water supply would be needed. One of the abandoned wells was rebuilt. During the early 1950s three new deep wells were drilled, but because of the critical recession of the water level in the deep rock formation, the Legislature appropriated special funds to study the Joliet situation in an attempt to locate an acceptable source of water. As a result of the study, the City investigated a shallow gravel aquifer several miles northeast of Joliet.

Five wells, each about 90 to 100 feet deep, were drilled into sand and gravel deposits which lie in a bedrock valley known as Hadley Valley. Although the quantity of water available from the Hadley Valley deposits seemed to be abundant, its mineral quality was undesirable. As a result, an iron removal treatment plant was installed in 1951. The combined capacity of the deep well supply and the shallow gravel well supply had increased to 13.7 mgd, but 7.7 mgd of this was drawn from the deep formations. The water level in the deep sandstones had dropped from a depth of about 385 feet to about 450 feet between 1948 and 1951, a yearly drop of 22 feet. The pumping facilities for the Hadley Valley aquifer had a capacity of approximately 6 mgd, but its long-term yield was calculated to be only 4 mgd. If two deep well units were out of service for repair, the maximum useable yield of the waterworks in 1951 was 11.9 mgd. The maximum average use during that period was 6.4 mgd.

The water supply facilities have remained essentially unchanged since 1951, but the water level has continued to drop from 9 to 24 feet per year and has reduced the capacity of the deep wells. When all pumping units are in service, the water supply is approximately 11.6 mgd. With an average daily use of about 8 mgd and a maximum use of about 12 mgd, Joliet is again in dire need of an additional source of water.

In addition to wells and iron treatment facilities, the Joliet water system includes five ground-level storage reservoirs with a combined capacity of 13 million gallons. Each reservoir site has a booster pumping station which draws water from the reservoir and discharges it at high pressure to the distribution system. The system has two elevated storage tanks with a combined capacity of 1.25 million gallons. The distribution system consists of approximately 160 miles of mains.



Future Requirements

The 9 mgd removed from the deep rock formations by the City in 1961 is only a portion of the total 22 mgd pumped from the aquifer in the Joliet area. The other 13 mgd is industrial pumpage. Because of the continuous increase in the volume of water pumped from the deep rock aquifer, the water level has decreased through the years by about 600 feet. If water removal from the aquifer is further increased in the future, not only will the water level continue to decline, but also the cost of raising the water from such depths can be expected to increase accordingly. The practical sustained yield of the deep rock aquifer has already been exceeded. Therefore, the aquifer must not be considered in seeking future sources of water supply for Joliet.

During periods of peak demand, water is pumped from the aquifer through the shallow gravel wells in the Hadley Valley at a rate approaching 4 mgd—the practical sustained yield of the aquifer using the existing wells. Unless new well sites are developed in the Hadley Valley formation, future problems can be expected if pumpage is increased. Even with new well sites, the entire formation cannot be expected to yield more than 6.5 mgd.

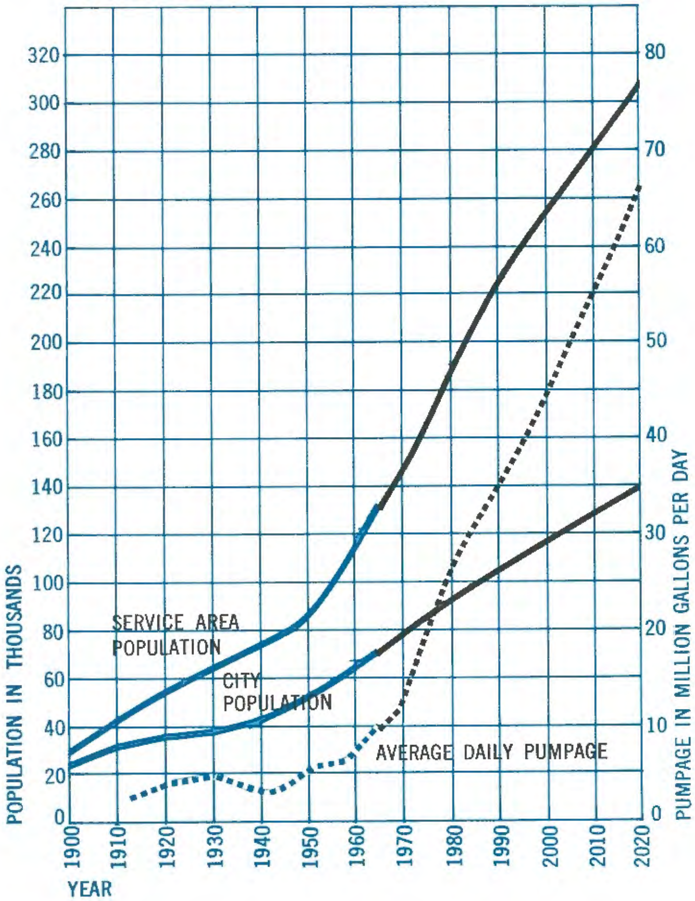
Population

The trend in the population of the Joliet area will influence the water requirements of the future. The 1964 population served is estimated at 130,000 and use at about 10 mgd, or 77 gallons per capita per day. It is expected that a vigorous effort will be made to serve the existing, densely-populated area within Joliet Township. In addition, it appears that the deep sandstone well supplies of the surrounding villages of Lockport, Crest Hill, and Rockdale will in time be placed on standby, and the water supply of Joliet will be extended to these areas and to Shorewood. A definite population trend has been established on the west side of Joliet and is expected to expand to encircle Shorewood. Water for this area will probably come from the Joliet system. The existing public water supplies in the Joliet suburbs are expected to transfer gradually to purchase water from Joliet. It is assumed that the transfer will be completed between 1967 and 1975.

The estimated population served by the Joliet public water supply will be 192,000 by 1980; and 305,000 by 2020 (Figure 5). In an attempt to relate the water demands to the population, it is assumed that the per capita use will increase at the national average rate of 1 gallon per capita per day per year. It will be necessary for the City to seek a new source of water supply, and it is expected that the deep wells of the public water supplies of Joliet, Rockdale, Crest Hill, and Lockport will be abandoned. This action will release approximately 10 mgd of available yield for use by industry.

FIGURE 5

JOLIET POPULATION AND PUMPAGE ESTIMATES



Industrial Use

In the recent past, the yearly water use by industry has increased about 1 mgd per year, but it is expected that industry will reduce the rate of increase in water use through more conservative methods of cooling. Assuming an industrial water use increase of 2.5 percent per year until 1990 and 1.6 percent thereafter, industry will be using the present yield of the aquifer by 1992. The public water supply of Joliet will have to serve the normal population growth of Joliet and surrounding urban areas and after 1992 will be required to meet expanded industrial needs.

Enormous quantities of water are drawn from the DesPlaines River, used for cooling and returned to the River. This practice is expected to continue. Cooling water is not included in water use figures here. The expected average daily pumpage from the public water supply for Joliet, industry, and the suburbs will be approximately 26.8 mgd in 1980 and 65.6 mgd in 2020. The maximum daily demand is expected to reach 35 mgd in 1980 and 85.4 mgd in 2020. Industry is expected to continue to use the deep rock formations, and a maximum of 22.5 mgd will be pumped. If the industries choose or are forced to abandon their well supplies because of depletion of the aquifer, the pumpage from the public water supply can be expected to increase accordingly.

New Sources of Supply

In an attempt to locate a source of supply to satisfy the expanded future water demand of Joliet, several locations might be considered. In the interest of economy, available ground-water sources must not be overlooked. Because of existing problems, the deep formations will not be considered, and, in all probability, existing facilities will be completely abandoned or maintained for emergency use. An increase of only 2.5 million gallons can be expected from the existing Hadley Valley deposits and is considered at best to be a stop-gap measure of short duration. Several additional locations of possible available water from the glacial drift are: east of Joliet along Hickory Creek, with an estimated yield of 2.4 mgd; northwest of Joliet near Plainfield, with an estimated yield of 3.2 mgd; and north of Joliet along Long Run Creek, with an estimated yield of 1.8 mgd. These formations are somewhat limited in available yield, and in all probability the water from these aquifers would require treatment for public use.

Although it has been very little developed, the Silurian Dolomite appears to be worthy of investigation. There appear to be two such potential areas where well fields might be developed, one northeast and the other southwest of Joliet. It is estimated that yields of 12 mgd might be expected from each of these areas. Although the yield is quite favorable, the feasibility of its development is questionable. The sanitary quality of the water can be expected to be somewhat less than desirable because of the lack of earth cover over the limestone in some areas of Joliet. Although treatment can be installed to make the water suitable for use, the project may not be economically feasible. Many wells dispersed over a fairly large area and an elaborate collection system would be necessary. In addition, the limestone is exposed at many places in the bottom of the DesPlaines River, and pumpage from the aquifer might result in reverse of flow in the aquifer and, in effect, make the DesPlaines River a source of recharge for the aquifer. Because the flow in the DesPlaines includes effluent from the Chicago sewage treatment plant, a considerable amount of study and testing would be required to prove the aquifer acceptable for use by Joliet, even with complete purification treatment.

The only known alternate ground-water source in the Joliet area is the Mt. Simon Sandstone. Available hydrogeological data indicate that it is reasonable to assume that the practical sustained yield does not greatly exceed the present pumpage in the northeastern Illinois region. For this reason and because the quality of the water is not good, it would not be advisable to develop wells in the Mt. Simon aquifer at Joliet.

Because the ground-water potential in the area does not exceed Joliet's water demand, it appears that the only alternative is to consider using streams and lakes. The DesPlaines River appears to be sufficient insofar as yield is concerned, but sewage pollution makes its quality unsatisfactory for water supply, except for rough industrial uses such as cooling.

An engineering study shows that purchase of treated water from Chicago is not economically feasible. As a second alternative, it might be possible for Joliet to get raw water from Lake Michigan and treat it, but because of extensive court litigation concerning withdrawal of Lake Michigan water, it is not advisable for Joliet to consider this as a source of supply.

The most practical and most feasible source of water for Joliet appears to be the Kankakee River about 13 miles south. The general sanitary quality of the Kankakee is good, and mineral content is not particularly objectionable. The minimum recorded flow is 132 mgd, while 323 mgd has been available during 99 percent of any year. The mean flow is 2485 mgd, which is far in excess of the estimated demand of 85.4 million gallons on the maximum day in 2020

Because transmission mains would have to carry the water from a purification plant on the Kankakee River to Joliet, it would be safe to assume that Elwood, Wilmington, Manhattan, Blodgett, and the U. S. Army Arsenal would also receive water from the proposed system. It appears feasible that water service could also be extended further north to Plainfield, Romeoville, Lemont, and east to New Lenox, Frankfort, Mokena, Tinley Park, Orland Park, Palos Park, and Palos Heights. Although these areas are not within the area of this study, the total average water use that would be required from the Kankakee River plant has been estimated at 53 mgd in 1980 and 134 mgd in 2020. The minimum recorded flow in the Kankakee River is 132 mgd, which indicates that some raw-water storage would be required, or the existing facilities of the Dresden Island Lock and Dam might be made available for this purpose.

It is suggested that a 50 mgd purification plant be located near the Kankakee River, and transmission facilities provided to carry treated water to Joliet and its suburbs at an estimated cost of $15 million (1965 dollars). The date of expansion of these facilities would depend primarily upon the extent of expansion of the area served by the water supply. Assuming that the area served is limited to that covered by this study, the purification facilities should be increased in 1990 to 100 mgd at a cost of $3.5 million (1965 dollars). However, if the Joliet system expands to cover a larger area, it will be necessary to remodel the plant in 1975 to 100 mgd capacity and expand it again in 2004 to 150 mgd capacity at an additional expense of $3.5 million (1965 dollars).

CASE STUDY 6. KASKASKIA RIVER BASIN

Although principally rural in character, the Kaskaskia River Basin has two multi-purpose reservoirs which can provide an abundant water supply to the entire area. Carlyle Reservoir is almost complete, and Shelbyville Reservoir is under construction. Formation of new water districts may be necessary to distribute the water.

The Kaskaskia River rises in Champaign County and flows in a general southwesterly direction for about 325 miles. It empties into the Mississippi River about 8 miles above Chester. In its headwaters in Champaign and Douglas Counties, the bed of the River is only slightly below the adjacent prairie. Downstream in Moultrie and Shelby Counties, the Kaskaskia has cut a distinct valley, which varies in width from 0.2 to 1.5 miles. About mid-point of the River in Fayette County, the valley widens to about 3 miles and continues at this width to Carlyle.

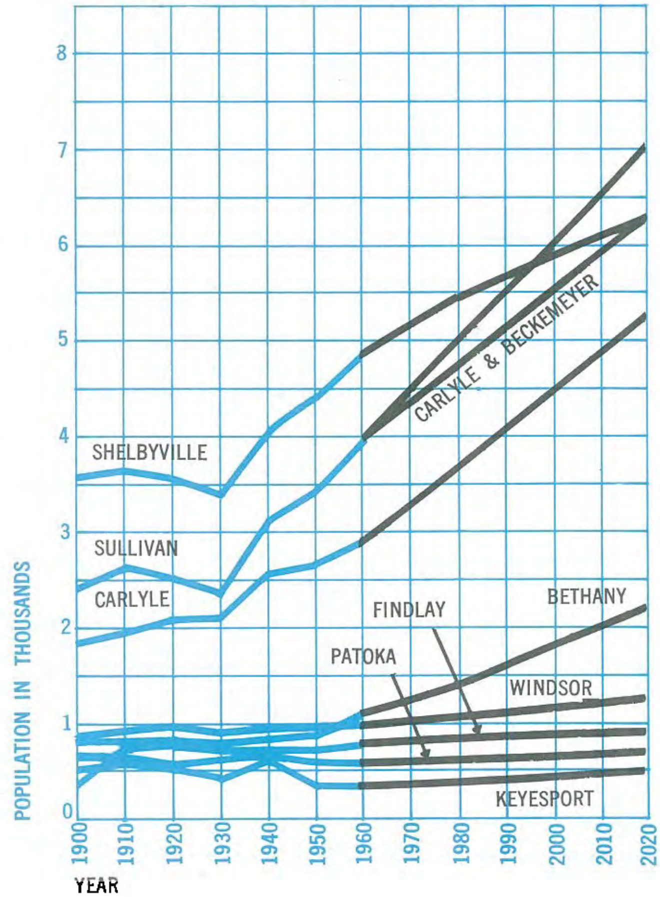
The Basin has no large cities or industries. Two major industries in Shelbyville and two in Sullivan employ from 200 to 600 persons each.

Five of the fourteen public water supplies in Shelby and Moultrie Counties are within the Kaskaskia River Basin. All public supplies in the two-county area now use ground water as the source of supply. Vandalia and the State Penal Farm, immediately adjacent to the River in Fayette County, take water from the Kaskaskia. Population estimates are shown in Figure 6.

Further downstream in Clinton County, Keyesport and Carlyle use surface water, and Carlyle furnishes water to Beckemeyer. Six other communities in the County use ground water, and one takes water from Shoal Creek, a tributary of the Kaskaskia.

FIGURE 6

CITIES AND TOWNS IN THE KASKASKIA RIVER BASIN POPULATION ESTIMATES



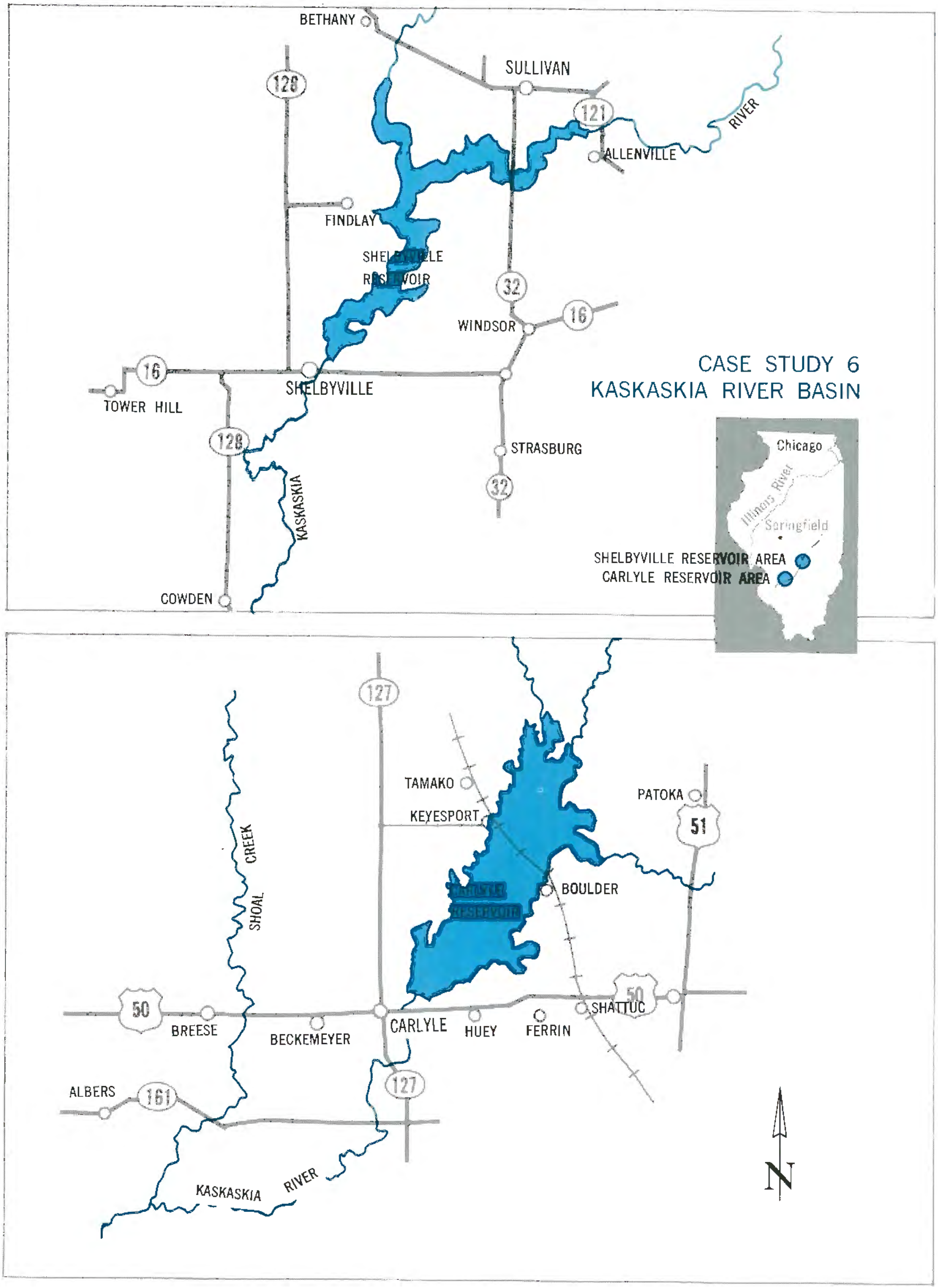
Ground Water

Ground-water supplies in Shelby and Moultrie Counties are in sand and gravel glacial deposits and in running water on the bedrock surface. Except in the lowlands of the Kaskaskia and its tributaries, the probability of constructing high-capacity municipal and industrial wells is generally poor to fair. The Corps of Engineers is constructing the Shelbyville Reservoir, which will inundate the lowlands in much of Moultrie County and in Shelby County above Shelbyville. Consequently, many of the better deposits will not be available as future sources of supply. The remaining ground-water areas are underlain by a moderate thickness of unconsolidated materials, which fill shallow valleys or are on the uplands that border the main valleys. These materials include thin, discontinuous deposits of sand and gravel. Extensive test drilling is necessary to locate water-yielding deposits in these locations. The Shelbyville wells are 2.5 miles southwest of the City in an area well below the proposed dam for the Shelbyville Reservoir. Water comes from a sand and gravel aquifer.

In Moultrie County north of the Reservoir, the glacial fill of the Middletown valley ranges in thickness from 150 to 200 feet. Sullivan gets its water supply from this aquifer. At many locations in this valley, the fill is composed principally of clay, but may contain localized sand and gravel deposits, which may be a source of water for industrial and municipal supplies. Testing is needed to locate suitable deposits in the Middletown valley which will not be flooded by the Shelbyville Reservoir.

Thick deposits of sand and gravel are present in the partially buried bedrock valley of the Kaskaskia River in Clinton County. Construction of the Carlyle Reservoir has made many of these deposits inaccessible for industrial and municipal use, particularly where the River and the bedrock valleys coincide. At present, ground-water sources above Carlyle exist only where the bedrock valley and the present River valley do not coincide, or where sands and gravels can be found in shallow valleys or uplands that border the main River valley. In general, these deposits are discon-

CASE STUDY 6
KASKASKIA RIVER BASIN



tinuous and their ground-water potential varies within short distances. The probability of developing large industrial or municipal wells in the vicinity of the Carlyle Reservoir is poor to fair.

Water Resources and Water Quality

Shelbyville, Findlay, Windsor, Bethany, and Sullivan, all of which are near the Shelbyville Reservoir site, obtain water from sand and gravel aquifers. The quantity of ground water available to these communities appears to be adequate to meet their water requirements to the year 2020, but they may wish to investigate the feasibility of using the Reservoir as a source of supply.

The mineral characteristics of these ground waters are such that treatment is required to reduce the iron content, hardness, or both, sufficiently to make the water acceptable for domestic use. The iron content ranges from 0.1 to 6.0 mg/l. The hardness (as $CaCO_3$) ranges from 245 to 384 mg/l, manganese content from 0 to 0.4 mg/l. The efficiency of iron removal is often impaired by the presence of organic matter which promotes the growth of organisms. Windsor has had treatment problems of this nature for many years. The quality of water which may be expected in the Reservoir would approach the average values of Kaskaskia River water samples taken in 1965 (Table 11).

TABLE 11

ANALYTICAL VALUES OF KASKASKIA RIVER WATER SAMPLES

Determination	Average	Minimum	Maximum
Water Temperature, degrees F....	56.2	33.0	77.0
Dissolved Oxygen, mg/l.........	7.8	6.0	10.8
Total Solids, mg/l..............	399.0	230.0	700.0
Chloride, mg/l..................	39.0	8.0	82.0
Sulfate, mg/l...................	81.0	19.0	210.0
Alkalinity (as $CaCO_3$), mg/l......	223.0	126.0	272.0
Hardness (as $CaCO_3$), mg/l.......	306.0	152.0	400.0
pH..........................	7.7	7.1	8.3
BOD, mg/l....................	2.6	1.0	9.0
Coliform, No. per 100 ml.........	5,176.0	80.0	44,000.0
Enterococcus, No. per 100 ml.....	666.0	2.0	6,100.0

In the immediate area of the Carlyle Reservoir, Keyesport takes water directly from the Reservoir. Carlyle will continue to take water from the Kaskaskia River below the dam. Beckemeyer is supplied with treated water from Carlyle. The rest of the communities, which lie to the west of the Reservoir, except Breese, use ground water as sources of supply. Breese takes its water supply from Shoal Creek.

The Reservoirs

The Shelbyville Reservoir will lie on the Kaskaskia River within Shelby, Moultrie, and Coles Counties, and it will have a total drainage area of 1030 square miles. The dam is to be located about one-half mile above Shelbyville and will be approximately 3025 feet long, including the spillway section. Spillway crest will be approximately 108 feet above the stream bed. The lake will have a normal surface area of 11,100 acres. Capacity of seasonal pool level will be 180,000 acre-feet. Of this, 25,000 acre-feet is allocated for water supply. Using the entire seasonal pool, yield of the Reservoir during a drought of 40-year recurrence would total 130 mgd. Deducting 6 mgd for low-flow augmentation, 124 mgd is available for water supply and other uses.

The Carlyle Reservoir is on the Kaskaskia River in Clinton and Fayette Counties. Its total drainage area is 2680 square miles, but 1030 square miles is tributary to the Shelbyville Reservoir. The dam, which is about 1 mile upstream from Carlyle, is 1.25 miles long and 67 feet above stream bed. Because of the topography at the dam site, two saddle dams were required to control water at maximum pool level. A loop levee about 2 miles long protects Keyesport from flooding.

The Carlyle Reservoir will have a seasonal pool capacity of 233,000 acre-feet, with 26,000 acres of water surface. Of this total, 200,000 acre-feet is allocated for low-flow augmentation, and the remaining 33,000 acre-feet to water supply. Calculated yield of the Reservoir for water supply during a drought of 40-year recurrence is 112 mgd.

At Carlyle it is expected that 50 cubic feet per second, or 22,500 gallons per minute, will be released continuously from the lake to regulate downstream flow. Carlyle will continue to use its present raw-water intake below the dam on the Kaskaskia. As at Shelbyville, a rather uniform water quality can be expected in the Kaskaskia River below the Carlyle Dam. Keyesport can also expect a water of uniform quality, since water is taken directly from the Reservoir. The availability of ground water to communities in the immediate area of the Reservoir is poor to fair. Therefore, future water supplies in this area must rely on the Carlyle Reservoir or the River. In either case, the quantity of water available is adequate to meet area needs to the year 2020, provided the amounts of water allocated for water supply and downstream flow regulation are not decreased.

Future Requirements—Shelbyville Reservoir

Existing water treatment and production facilities of Shelbyville, Findlay, Windsor, Bethany, and Sullivan are adequate to meet expected individual water requirements to about 1990. If ground-water sources are still in use at that time, additional treatment plant capacity will be required at Bethany and Windsor. After 1990 and before 2020 the treatment plants at Findlay and Sullivan will need to be expanded. Ground-water resources at Shelbyville are adequate to meet the demands estimated for 2020, but additional high-service pumping and storage facilities will be required in order to meet maximum-day demands and fire-fighting requirements as the population increases.

In estimating future water supply needs in the vicinity of the Shelbyville Reservoir, allocations must be made for water use in the sixteen State park and Federal access areas which are proposed. The proposed recreational development is described in Chapter VIII. These areas are located so that a number of individual water plants would be required to provide water service to all, if a common supply is not constructed. The construction of many small water systems creates operational, maintenance, personnel, administrative, and financial problems. Development of adequate ground-water supplies in all of the recreational areas may not be feasible. Where ground-water supplies are developed, treatment facilities will be required because of the mineral quality of the water.

Assuming a development pattern similar to that at the Carlyle Reservoir, one or more water districts may be formed. Such districts could construct treatment and distribution facilities and furnish treated water to communities, to recreational areas, and to rural users. A water district or districts to include communities which now have water systems could be organized with a sufficiently broad revenue base to provide a financially stable district and sufficient funds to attract competent personnel. The two largest communities could construct treatment facilities and sell treated water to the water districts.

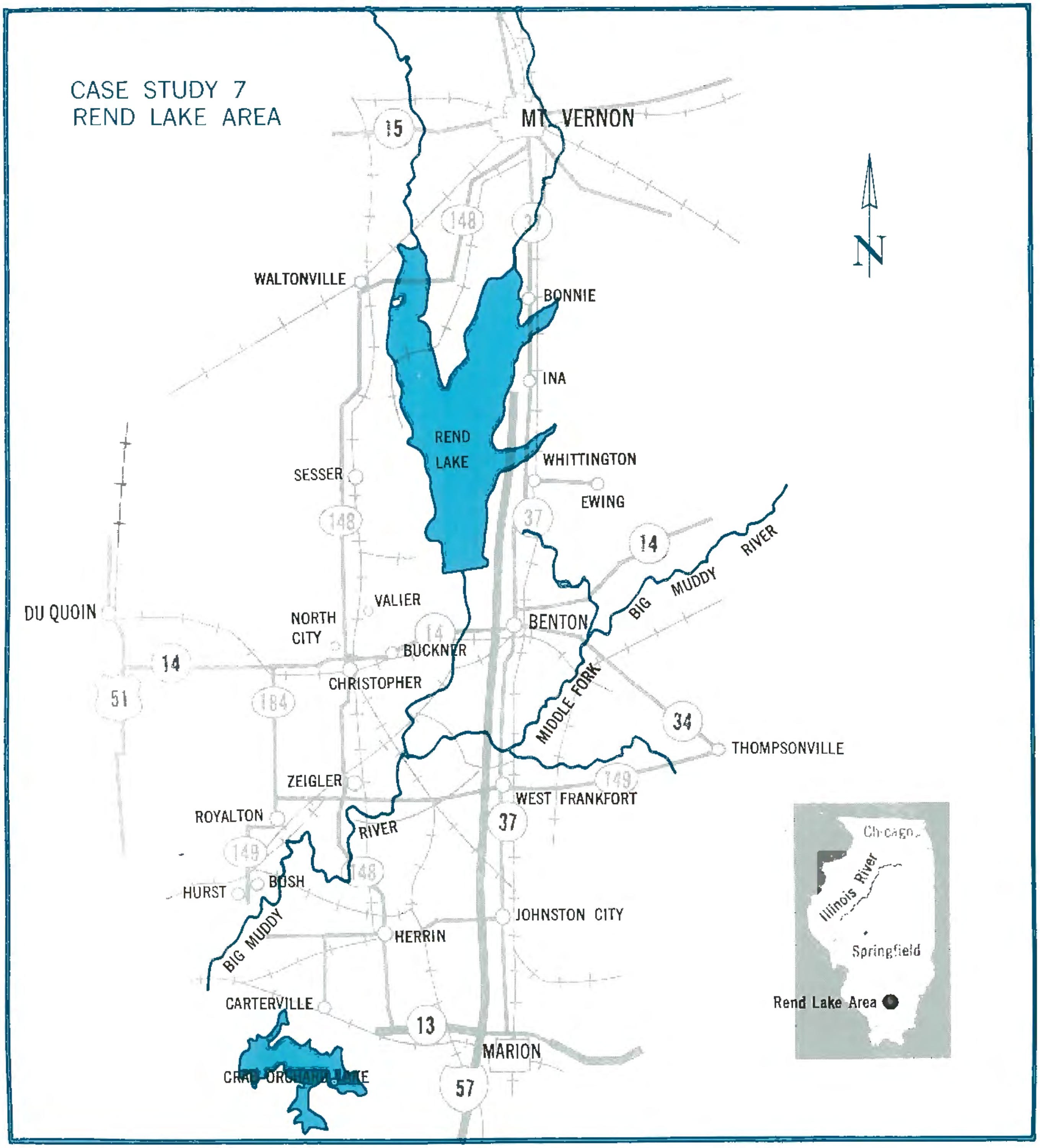
It appears most likely that the first water district might be located in the area south of the Reservoir, possibly including the area bounded on the west by Shelbyville, on the east by Windsor, and on the north by the Reservoir. Assuming such a district were formed, the estimated average water use would be 0.68 mgd in 1980 and 1.1 mgd in 2020. If Findlay were to become a part of this district, the total estimated average use would then approach 0.73 mgd in 1980 and 1.2 mgd in 2020. Estimated demands for the recreational areas to be supplied by the district must be added to these amounts. Total estimated use for the two major recreational areas is 200,000 gallons per day. For the remainder of the fourteen areas around the Reservoir, water use is estimated at 100,000 gallons per day.

Estimated average use resulting from the formation of a water district to the north of the Reservoir, including Sullivan, Bethany, and Kirksville, may be about 1.0 mgd in 1980 and 1.7 mgd in 2020. Total average water use for the entire area around the Shelbyville Reservoir is estimated to be 2.0 mgd in 1980 and 3.2 mgd in 2020.

Future Requirements—Carlyle Reservoir

The Clinton County East Public Water District has been organized near Carlyle Reservoir, and will purchase water from Carlyle. The District covers the area in Clinton County to the east of the Reservoir and includes the communities of Boulder, Shattuc, Ferrin, and Huey. The District will also furnish water to Federal access areas and a State park. Combined average water use for Carlyle, Beckemeyer, and the Water District is estimated to be 0.85 mgd for 1980 and 1.3 mgd for 2020. Existing water treatment facilities at Carlyle are adequate to meet demands to 1980, but additional treatment capacity will then be required. These estimates assume that no major water-using industry will locate in the area.

The possible development of another water district to the west of Carlyle has been studied. This district would extend west along U. S. 50 to Lebanon and south to Mascoutah and would include New Baden and Albers. Formation of this district would add an estimated average demand of 1.5 mgd to Carlyle's production requirements, and additional treatment facilities would be needed at Carlyle to serve this district.



Rend Lake, a multi-purpose reservoir now under construction, illustrates the potential of a Federal-State reservoir to meet water supply demands. The entire urban population of Franklin County and limited portions of the adjoining counties of Perry, Jackson, Jefferson, Hamilton, and Williamson are in the Rend Lake area.

Coal mining was the primary reason for development of the area. The urban population grew rapidly until 1920, but by 1940 the coal mines had begun to close, and a general decline in population began. From 1940 to 1960, the urban population dropped from 78,755 to 67,412. Construction of Rend Lake and development of an inter-city water system servicing much of the urban population is expected to arrest the declining population trend, stimulate industrial development, and increase the recreational potential of the area. Since there also seems to be a migration trend into the less populated areas of the State, the Rend Lake area may expand somewhat.

The area is served by six railroads and an excellent network of State and Federal highways. These rail and highway facilities should influence considerably the industrial rehabilitation of the Rend Lake area.

The topography is moderately rolling, with several hilly sections. The rolling areas are glacial drift overlain by windblown loess, while the more acute relief is the result of erosion by streams.

The Public Water Supplies

Development of municipal water supplies in the Rend Lake area began at Mt. Vernon in 1891, although that City's present source was not developed until 1912. In the late 1800s and early 1900s municipal supplies were established at Duquoin, McLeansboro, Zeigler, Johnston City, Benton, Herrin, Christopher, West Frankfort, Carterville, Sesser, and Royalton. Buckner installed facilities in 1964. These municipal supplies also serve villages in the area.

All of these water supplies use impounded surface water and have purification plants, because groundwater supplies are inadequate. Naturally pure surface water is difficult to obtain, and self-supplied industrial pumpage is limited to less than 0.5 mgd. Light industrial and commercial water needs are supplied from the municipal systems. These demands are reflected in moderately-high per capita water use for DuQuoin, West Frankfort, and Herrin.

DuQuoin, West Frankfort, Johnston City, Herrin, and Carterville now have various water supply problems, including silting of impounding reservoirs and antiquated purification equipment. Also, increased demands exceed supplies, and the contracts for water supply from Crab Orchard Lake will soon expire. Several of the municipalities are faced with expanding their water supply systems.

In addition, many small communities in the area are not served by public water supplies. Because they are small, they could be served best by one of the existing supplies in the area. Extension of water service to these communities can be expected to place a further burden upon existing facilities and will hasten the need for expansion of existing sources of water. The Rend Lake project and the inter-city water system will provide a central source of supply for many communities and eliminate the need for rehabilitation and expansion of many existing facilities.

Future Requirements

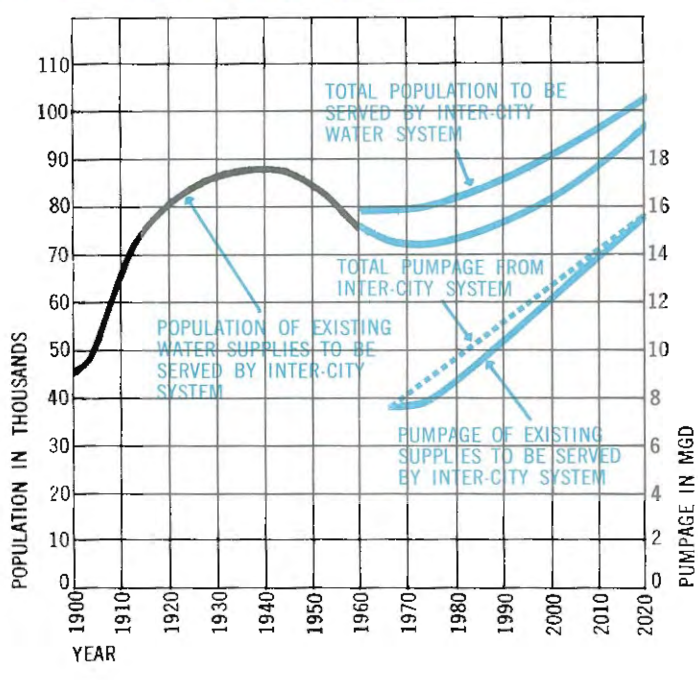
Local, State, and Federal agencies proposed the Rend Lake project because of deficiencies in existing water supplies, declining population, and economic depression in southern Illinois. The first part of the project will be a dam across the Big Muddy River at a site just northwest of Benton to create a multi-purpose reservoir 10 to 12 miles long and 3 to 5 miles wide. The Rend Lake Reservoir is to be used for flood control and recreation and has 40 million gallons per day allocated for water supply. It appears feasible that a considerable additional volume of water could be made available for industrial cooling, if such use does not adversely affect the quality of the water, and if the withdrawn water is returned directly to the Lake.

It is intended that a centrally-located, single purification plant be built near the Rend Lake dam. The initial construction will provide water treatment facilities with a capacity of 18 mgd, at a cost of about $10.5 million for the treatment and distribution system and a total project cost of $12.3 million. The transmission-distribution system will carry pure water to all of the municipal systems in Franklin County; to Johnston City, Herrin, and Carterville in Williamson County; to McLeansboro in Hamilton County; to Mt. Vernon in Jefferson County; and to DuQuoin in Perry County. The water supply is expected to be abundant, and many of the smaller communities in the area which have no municipal supplies will build distribution systems and connect to the Rend Lake inter-city water system. This will provide water service to an additional 3000 people.

In order to evaluate properly the proposed system with respect to future water demands, it is essential to determine present population and to estimate future population (Figure 7). In these estimates it has been assumed that fluctuations in the urban population will

FIGURE 7

REND LAKE AREA AND INTER-CITY WATER SYSTEM POPULATION AND PUMPAGE ESTIMATES



generally parallel those of the counties. Assuming that the inter-city water system will provide service for all of the existing public water supplies in the area and for the population of the several villages and rural customers who propose to develop municipal water systems, the total population served was 79,440 in 1960 and will be 83,661 in 1980 and 101,588 in 2020.

It has been assumed that per capita water use for each town will increase at the national average rate of 1 gallon per capita per year. Total use by existing water systems to be served by the inter-city water system is estimated at 7.65 mgd in 1960, 8.47 mgd in 1980, and 14.82 mgd in 2020. If the several small villages, rural customers, and recreational areas around Rend Lake are connected to the inter-city water system, total water pumpage can be expected to be 8.95 mgd in 1980, and 15.45 mgd in 2020. Maximum daily demands, assuming maximum use to be 25 percent of average use, was 9.64 mgd in 1960 and will be 11.04 mgd in 1980, and 19.30 mgd in 2020.

The allocation for water supply from Rend Lake is 40 mgd; the treatment plant is expected to be capable of producing 18 mgd; and the transmission-distribution system capacity is expected to be 18.7 mgd. Thus, it can be expected that no future major construction will be required through the year 2020.

CASE STUDY 8. ST. CLAIR AND MADISON COUNTIES

In St. Clair and Madison Counties a number of water utilities use the Mississippi River and ground water to supply an industrial metropolitan complex. An adequate supply of water is available, but new treatment and distribution facilities may be needed to meet the future demand.

St. Clair and Madison Counties are in southwest central Illinois, bounded on the west by the Mississippi River. Alton, Edwardsville, Wood River, Granite City, and East St. Louis are the principal cities in the area. The area near the Mississippi River is primarily industrial, while the eastern part is residential. The two counties have an excellent labor market and excellent air, water, highway, and rail transportation.

Because of an abundance of natural resources, people began to migrate to the area in the early 1800s and the population grew rapidly. As the population density increased, a wide variety of industries developed.

The present industrial complex is in the vicinity of Alton, Wood River, and Granite City in Madison County; and to the north and south of East St. Louis in St. Clair County. There are 19 industries in Madison and 25 in St. Clair County. They produce steel, petroleum, chemicals, metal products, and food products. Major industries with more than 100 workers employ 30,879 people, and there are also many smaller industries.

Current Water Use

Large quantities of both ground and surface water are required in this area for industrial, municipal, irrigation, and domestic use. Self-supplied industrial use of surface water is not estimated in this study, since its primary source is the Mississippi River, which has an average flow of 112,000 mgd and a minimum of 11,600 mgd. So long as reasonable quality is maintained, the Mississippi obviously is more than adequate for industrial demands during the time period considered. Industrial ground-water use is currently about 101 mgd, and is largely taken from the sand and gravel aquifers of the American Bottoms.

Municipal systems take water from the Mississippi River, Silver Creek, Mud Creek, the Kaskaskia River, the sand and gravel aquifers of the American Bottoms and the Uplands, and from Pennsylvanian and Mississippian aquifers. Current pumpage from the various sources is:

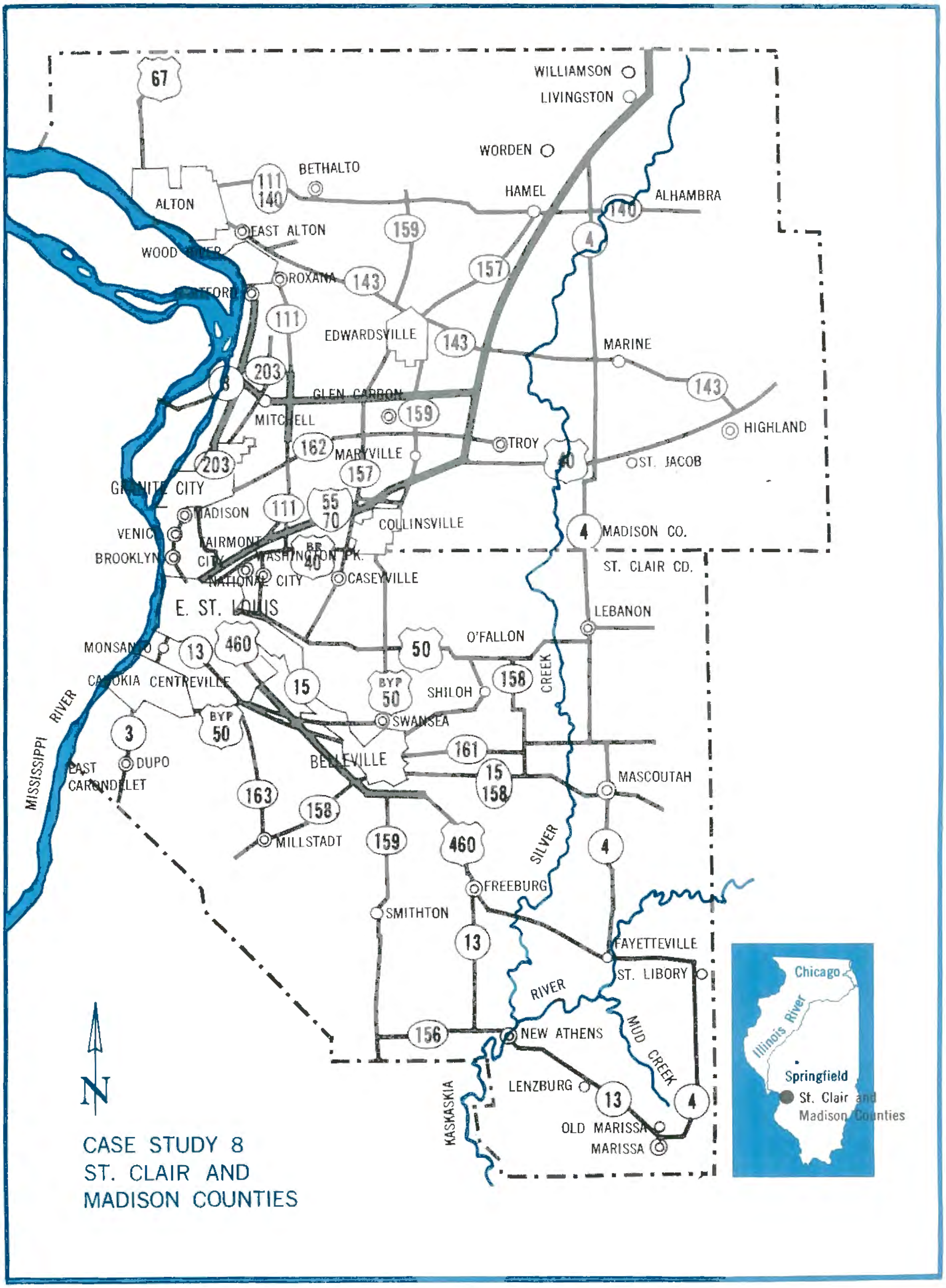
Mississippi River	49.60 mgd
Silver Creek	0.93 mgd
Mud Creek	0.14 mgd
Kaskaskia River	0.14 mgd
American Bottoms aquifers	5.30 mgd
Uplands sands and gravels	1.50 mgd
Pennsylvanian-Mississippian aquifers	0.14 mgd

Present population served is estimated at more than 380,000, with service provided by 56 municipal supplies.

Future Requirements

Future municipal water requirements for the bi-county area are discussed in relation to the sources listed above and are based on population estimates of 597,000 in 1980 and 895,000 in 2020. The 103-year recorded minimum flow of the Mississippi River at St. Louis is 11,600 mgd. Total municipal pumpage for supplies now taking water from the River will be an estimated 91 mgd in 1980 and 130 mgd in 2020. The River resource is adequate to meet these municipal demands in addition to the demands of industries and other municipalities that may find it necessary to turn to the River. Treatment plant expansions at Alton, East St. Louis, and Granite City will be required by 1980 to meet maximum-day demands in all cases and to meet average daily demands at Alton and East St. Louis. Expansion of the Alton treatment facilities will be required in the immediate future. Additional storage facilities will be required from time to time at each location to meet peak hourly and daily water demands and for fire protection.

Freeburg, Highland, and Mascoutah take water from



CASE STUDY 8
ST. CLAIR AND
MADISON COUNTIES

Silver Creek, Marissa from a tributary of Mud Creek, and New Athens from the Kaskaskia River. Current use of these surface sources totals 1.21 mgd and is estimated to increase to 1.84 mgd in 1980 and 3.97 mgd by 2020.

A study of the 1952 through 1955 drought based on streamflow data indicated its recurrence interval to be from 75 to more than 100 years. During that drought the reported maximum period of no flow in Silver Creek at Mascoutah was 45 days. Assuming that a drought of equal severity could occur within the next 64 years, it is apparent that a 45-day water supply should be available at all times to the communities listed above. Highland, Marissa, and New Athens appear to have adequate water sources to meet such an emergency, but Freeburg and Mascoutah would need additional raw-water storage capacity or another source of supply before 2020. Freeburg may require an additional raw-water supply before 1980, but Freeburg had no raw-water supply problem during the 1952 through 1955 drought.

Mascoutah must augment its existing surface-water source before 2020 in order to meet a record drought. This additional supply could come from existing wells or could be provided by constructing new raw-water storage. None of the nineteen potential reservoir sites in the two Counties is near Mascoutah. Formation of a water district which would supply Mascoutah with water from Carlyle is being considered.

Mascoutah is the only community which will need additional treatment facilities and treated water storage by 1980. Marissa probably will have to construct some additional treated-water storage facilities by 1980. Highland is the only community of the five which won't need to expand its treatment plant before 2020. Marissa could meet both average and maximum daily water demands in 2020 by providing additional finished-water storage.

Ground water in the American Bottoms is replenished by recharge from precipitation and by induced infiltration of water from the Mississippi River. In 1965 not all of the ground-water recharge in the area was being diverted toward centers of ground-water withdrawal. Thus, the ground-water potential was not exceeded.

A State Water Survey study estimated that 188 mgd could be withdrawn from the permeable sands and gravels in the area by development of selected well fields, without creating critical water levels or exceeding recharge. The plan suggested was to develop new well fields at Dupo and Mitchell, three new fields immediately adjacent to the Mississippi River, and to develop the present well field to full capacity. Assuming that pumpage will continue to increase in the future, by 2020 total pumpage in the area will equal or exceed the potential yield of the aquifer so developed.

Municipal use of ground water is projected to be 8.5 mgd by 1980 and 17.8 mgd by 2020. The available ground-water resource is adequate to meet projected municipal ground-water demands to 2020. Concentrated pumpage in a relatively small area may create critical water levels. Municipalities should be cautious when planning large ground-water supplies within a small area or near an area of heavy ground-water withdrawal.

Precise predictions of future industrial water requirements for this highly industrialized area are difficult, if not impossible, because it is impossible to pinpoint future locations of industries. It can be assumed, however, that new industries will locate in the area and that water use for all purposes will increase. This conclusion is based on data on employment and worker productivity, which predicts a 14.7 percent increase in manufacturing employment from 1963 to 1980. The Alton-East St. Louis area is one of the most highly industrialized in the State and will undoubtedly share in this predicted growth. An increase of 120 percent in per capita personal income (in 1963 dollars) from 1960 to 1980 is estimated for St. Clair County. Since domestic water use is directly related to personal income, it should also increase.

Both industries and municipalities can use the Mississippi River when the maximum yield of the American Bottoms aquifer is reached.

Present withdrawal by municipalities from sand and gravel aquifers in the Uplands is estimated to be 1.5 mgd. Pumpage is expected to be 2.3 mgd in 1980 and 4.6 mgd in 2020. The potential yield of these sands and gravels has been estimated to be 9.6 mgd, considerably more than projected pumpage. Although sufficient ground water is available for municipal use, yields of wells are relatively low near most the municipalities. Large quantities of ground water could be pumped only from a large number of wells, spaced at considerable distances from the user. The sands and gravels in the lowlands along the Kaskaskia River are also a potential municipal source.

Municipalities are now withdrawing about 0.14 mgd from wells in the Pennsylvanian and Mississippian rocks. However, yields of wells and the recharge rates are low, and the projected demands of 0.25 mgd in 1980 and 0.62 mgd in 2020 are not great. The sources should be adequate.

CONCLUSIONS AND RECOMMENDATIONS

I. Water supply for rural, municipal, and industrial requirements exclusive of power generation will grow from 3.3 billion gallons per day (bgd) in 1965 to 5.0 bgd in 1980 and 6.9 bgd in 2020. It is clear that these requirements can be met from existing and potential sources of ground water, streamflow, reservoirs, and Lake Michigan without dramatic changes in our present methods, except for pollution control. Intelligent management will be required in the form of maintaining water quality for re-use, greatly increased reservoir storage, and the transfer and distribution of surplus water between river basins.

One of the principal findings of this report is that a comprehensive and detailed systems analysis of the total water resource should be made in the immediate future. Such an analysis would be an extension of this plan and should be the basis for determining an economical means of balancing water supply and demand in every area of the State. The systems analysis should relate not only to water supply and use, but also to water quality control, recreational use of the waters of the State, and control of water through flood control and soil and water conservation measures.

Specific recommendations regarding water supply and use which should be given immediate consideration are:

A. Every effort should be made to direct substantial new uses for water into locations where large water supplies exist.

New industry is potentially the most likely source of heavy demands on water supply. At present the State maintains liaison with industries seeking locations in Illinois and supplies information on the water resource available in the State. This exchange of information with industry and with other potential users of large supplies of water should be given increased attention in order to avoid future water supply problems.

Because of the tremendous potential water demands of the electric power industry, the State should increasingly be concerned with water requirements in approving future site locations for power generating plants. Future plant locations will be limited to the major rivers, or industry must provide special recirculating systems. The sites with sufficient water supply for flow-through plant operation and adequate fuel sources are so limited that industry will increasingly move to closed-system operation.

B. A fundamental change should be made in the laws regarding rights of water use. It is recommended that the statutes be amended to clearly establish the State's right to store and transfer surplus floodwaters between river basins.

C. It is recommended that sites for reservoirs which will be required for future water supply, low-flow augmentation, and other uses be acquired by the State to assure their future availability. Suitable sites should be reserved and protected to prevent their being extensively developed for other uses.

Sites for acquisition should be identified on the basis of further detailed study. Upon recommendation of the Technical Advisory Committee on Water Resources, or its successor, the Water Resources Board, specific sites should be acquired, which would then be leased until development of reservoirs is possible or necessary. Cities and counties should be encouraged to enact zoning and land use regulations which would protect potential reservoir sites.

D. It is recommended that all municipal water supplies be metered. (In many cases private residences are not now metered. Customers are charged a flat rate.) Not only does metering tend to prevent wastage of water and provide a realistic basis for setting water rates, but it also is fundamental to the efficient management of the resource.

E. It is recommended that those industries which estimate water use rather than measure it accurately be encouraged to make such measurements on a continuing basis. This would aid in making an accurate and detailed systems analysis.

II. Lake Michigan is the largest source of municipally-supplied water in Illinois, and is obviously a resource of great value which must be protected. The legal right to make continuing use of Lake Michigan water is threatened, as exemplified by the current litigation in the U. S. Supreme Court. A second threat to this important supply is the degradation of the quality of the water in the Lake from pollution. Five counties in northeastern Illinois — Cook, DuPage, Kane, Lake, and Will—will require varying amounts of water from the Lake during the period to 2020 which is under study here.

A. It is strongly recommended that every reasonable effort continue to be made to divert used or polluted waters away from the Lake.

III. The citizens of Illinois have decided that the waters of the State must be maintained at an improved level of quality. Keeping the streams clean is socially desirable for aesthetic reasons; more specifically, it is absolutely necessary if we are to make full use of the waters of the State for recreation.

Maintaining high quality in the surface waters of the State is also economically desirable. Good quality water requires less expensive treatment for all uses. Control of water quality at the source attaches the cost of preventing pollution to the polluter rather than to the user.

Water quality must be maintained at a high level if we are to use it for multiple purposes. Our ability to make repeated use of it will be an ultimate measure of the extent to which the resource can meet increasing demands.

Obviously, maintenance of water quality is highly interrelated with pollution, which is the subject of the next chapter where specific recommendations for pollution control are made.

IV. Consistent with the general findings of this study, a major trend in water supply and use will be the interconnection of water supplies now existing in cities, towns, and industries to make the interchange of water possible. The goal is that public water supplies be extended to all areas of the State where residential or use density makes it practical or where unfavorable physical conditions limit the quantity or quality of water available from ground or surface sources. Central water systems similar to the rural electrification system increasingly should supply finished water to rural areas, including non-farm areas and industries, as well as to municipalities. General authority for development of such central water systems now exists in enabling legislation that establishes various special purpose districts. It is recognized that, although central interconnected systems to serve the entire State are a desirable goal, certain areas may be more efficiently served by local supplies.

A. It is strongly recommended that the State investigate and pursue all possible means to establish an interconnecting water system to serve as much of Illinois as is practical. The systems analysis should establish a model for developing the system. If legislative authority for such development is found to be inadequate, new enabling legislation should be proposed. Until further studies are made, it is premature to recommend a State financial aid program, but this possibility should be considered in the systems study.

ACKNOWLEDGMENTS

This chapter was prepared under the direction of Mr. Clarence W. Klassen, Chief, Sanitary Engineering Division, Department of Public Health. The late Mr. W. J. Downer of that Division was the principal author. The Water Survey Division, through the coordination of Mr. Robert H. Harmeson, contributed the material on industrial water use, water requirements for power generation, and the balancing of supply and demand. He was assisted by Mr. Julius H. Dawes, Mr. W. J. Roberts, and Mr. Donald H. Schnepper. The Federal Power Commission and the Commonwealth Edison Company supplied information on future power generation.

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chapter four
pollution and pollution control

illinois technical advisory committee on water resources

"No one has a right to use America's rivers and America's waterways that belong to all the people as a sewer. The banks of a river may belong to one man or to one industry or one state, but the waters which flow between those banks should belong to all the people."

Lyndon B. Johnson

SUMMARY

It is public policy established by the Illinois Legislature to maintain reasonable standards of purity of the waters of the State, consistent with the use of those waters and including their use in carrying away the water-borne waste products of society. The current Federal Water Pollution Control Act, in reference to pollution abatement, gives the states discretion in assessing the physical and economic feasibility of complying with water quality standards.

Use of lakes and streams for recreation, particularly for fishing, boating, and water skiing, has increased. These are activities in which the body comes in direct contact with the water. Thus, it becomes increasingly important to emphasize the bacterial content of water as a measure of contamination.

Nearly all streams in the State have bacterial contents in excess of the level considered desirable for body contact. Currently, facilities for disinfection of sewage works effluents are in operation or being installed in the Northeastern Illinois Metropolitan Area, by municipalities on the Rock River, and by other cities which discharge treated sewage into lakes, reservoirs, or streams used for public water supply.

As time and programming permit, facilities for effluent disinfection must be provided for most of the sewerage works in the State. This will greatly increase the cost of sewage treatment, but is necessary to meet the public demand for increased recreational use of all waters of the State. Related treatment procedures, processes, and facilities to increase the degree of treatment must also be added. This includes separation of storm and sanitary sewers and other construction to reduce the quantity of organic and pollutional material discharged to streams through storm drain systems. In some situations, the disinfection of storm flow settling basins will also be necessary to reduce bacterial levels.

Federal grants are available to help local communities finance treatment facilities. Currently, about $6 million is distributed annually on a priority basis by the State from Water Pollution Control Administration funds. Recent legislation authorizes a substantial increase in this program. New programs in the Department of Housing and Urban Development, the Farmers' Home Administration, and the Economic Development Administration are also available under certain conditions. However, the cost of achieving water quality goals as outlined in this chapter is very great. It is clear that, in order to assist the local communities and to take full advantage of Federal programs, the State must participate in funding the pollution control programs of the future.

This chapter attempts to define pollution and to define the degrees of pollution which now exist in Illinois. It also summarizes certain criteria of water quality which are useful in interpreting pollution problems; sets desirable goals for the control of pollution; and refers to authority, duties, and responsibilities of the Sanitary Water Board, which is Illinois' functioning water pollution control agency.

Guidelines to the solution of existing and potential water pollution problems are indicated in a series of case studies for selected areas and communities throughout the State. The case studies are for Greater Chicago, Decatur, the East St. Louis area, Lombard, the Peoria-Pekin area, Rock Island-Moline, Urbana-Champaign, and industrial oil field operations.

POLLUTION SOURCES AND INDICATORS

Each use of water adds some material or alters some characteristic enough to change the original quality of the water, and often to pollute it. Thus, it is immediately evident that the sources of pollution are virtually inexhaustible. The transport and dilution of municipal, industrial, and agricultural wastes is an important and necessary use of water. Therefore, special emphasis is placed on the control of water pollution from these sources. Some of these wastes can be carried in limited amounts without damage to the resource. Some of the inorganic wastes of industry reduce the effectiveness of treatment processes applied to organic wastes; therefore, some industrial wastes must be handled separately from municipal wastes. Other wastes are toxic or otherwise harmful, both to treatment processes and to the receiving stream. Some wastes, if discharged into watercourses, can make their way into underground aquifers and pollute the ground water so that it is unsuitable for further use.

Pollution, by definition and interpretation, is a matter of degree. Since it is inevitable that the quality of water will be altered when it is used, it is of critical importance to control the degree and extent of pollution. Methods of control vary with the degree and type of pollution. The degrees of pollution may be classified as:

—Natural pollution—The water picks up soil, mineral, or bacterial impurities from the earth's cover, even though man does not use the resource.

—Permissible pollution—Planned use of the water resource, with good pollution control and abatement practices, maintains quality consistent with the use.

—Allowable limited pollution—Reasonable overloading of the streams is permitted and reduces the full usefulness of the water resource for a limited zone or reach of the stream, but does not damage the resource beyond use in other places.

—Excessive or gross pollution—Misuse degrades the water resource to such an extent that it is of extremely limited use. The stream is, in effect, an open sewer.

Surface waters have the intrinsic ability to purify organic wastes to some degree. This natural waste-assimilating capacity is limited, variable, and dependent upon the physical, chemical, and biological characteristics of the stream. Inorganic wastes generally accumulate, since both man-made and natural impurities tend to increase as the use of water increases. The limit of the self-purification capacity of a stream is easily exceeded.

MUNICIPAL AND INDUSTRIAL WASTES

Municipal wastes are the heterogeneous accumulation of man's excretions, secretions, and ablutions and are made up of inorganic, organic, and biological components. They are carried by water to the point of treatment or discharge. Some of these wastes are carried in suspension in the water; others are taken into solution; still others are so finely divided that they are colloidal. Much of the waste is organic with a high energy value and is subject to attack by the microorganisms of decay. Pathogenic (disease-producing) organisms are always potentially present in municipal wastes.

Industrial wastes originate from washing, cooling, and flushing processes, chemical treatment, and many similar operations. Industrial wastes vary in quantity and composition as greatly as the products and processes which generate them. They include toxic metals and chemicals, solids carried in suspension, salt brines, strong acids and alkalies, organic and inorganic chemicals, oils, dyes, floating solids, and organic by-products, and the heat generated by industrial processes. Table 1 summarizes the types of pollution that originate with the various industries.

A few Illinois industries presently discharge untreated wastes into the streams, but most, especially industries of small and medium size, typically discharge wastes through municipal systems. A number of large industries, particularly those with special waste problems, have their own facilities to treat wastes prior to discharge to streams or re-use of the water.

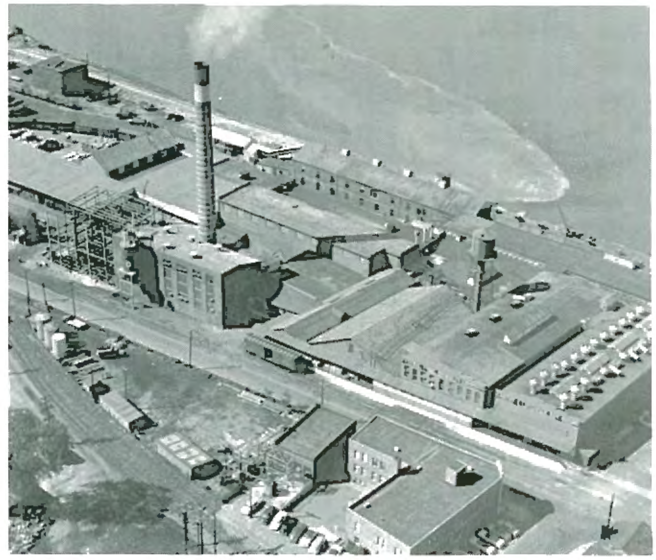


TABLE 1 INDUSTRIAL WASTES—SPECIFIC TYPES AND CAUSES OF POLLUTION

Water pollutants	. . . in these typical industries	. . . from these manufacturing sources	. . . cause these damaging effects
Color	Pulp and paper, steel mills, textiles, slaughterhouses.	Spent cooling liquor, mill scale particles, dye processes, waste blood.	Esthetically objectionable.
Solids, floating and suspended	Canning, packing, slaughterhouses, steel mills.	Foods and animal process wastes, metal process wastes.	Damage to river banks and shorelines.
Oil and grease	Petrochemical, steel mills.	Refinery wastes, coolant and lubricant waste of rolling mills.	Forms floating scums, affects bathing and industrial water.
Organic wastes	Food, slaughterhouse, pulp and paper.	Animal, food washing wastes, wood pulp processing.	Similar to raw sewage, forms floating scums.
Inorganic wastes:			
Metals	Metal fabrication.	Metal fabrication (metal dust particles).	Detrimental to other industries.
Alkaline salts	Petrochemical, metal fabrication.	Industrial cleaning process.	Forms hard water, toxic to fish.
Acids	Chemicals, steel mills.	Chemical process, pickling steel.	Toxic, deteriorates boats and structures in water.
Chemical wastes	Chemical, petrochemical, steel mills.	Various chemical (synthetic dyes, plastics, coatings, solvents, phenols), coke plant wastes.	Taste and odors, toxic to fish and aquatic life; phenols persist in streams for long duration.
Cyanides	Metal fabrication, steel mills petrochemicals.	Metal finishing and plating, blast furnace and coke waste, refinery process.	Toxic effects.
Heat	All process and fabrication plants.	Cooling water discharge.	Diminishes amount of oxygen which water can hold in solution.

AGRICULTURAL WASTES

Farming practices can also contribute to water pollution. The pollutants may be soil particles, phosphate, nitrogen, pesticides, and intestinal organisms from animals.

Careless and excessive applications of fertilizer containing phosphate, ammonia, and/or nitrite, and of pesticides can lead to direct contamination of water and excessive residuals in the soil. With careful and reasonable application, these nutrients and pesticides are generally tightly adherent to the soil particles. With good soil conservation practices, the transfer of such soil particles to the water by sheet erosion during heavy runoff periods is minimized. Where soil conservation is neglected, the transfer is significant. The nutrients and minerals are transferred in part from the suspended and settled soil particles to the water, and the suspended soil particles themselves contribute to sedimentation of lakes and reservoirs and cause a cumulative loss in the storage capacity of these water bodies.

Unless provided with adequate collection and treatment, livestock and fowl feeding areas are points of concentrated waste products which accumulate in dry periods and are transferred to the nearest watercourse during runoff periods. This can become a serious source of pollution during a spring thaw after freezing weather conditions.

It must be said that minimal study has been given to agricultural pollution in Illinois, and it is an important area for intensified study and research.

OIL AND GAS WASTES

In the past, surface waste of minerals and the resulting pollution of water resources were caused by unrestricted and uncontrolled flow of oil, gas, and salt water, which frequently accompanies the production of oil and gas. Many years ago, before modern drilling methods, tools, and safety equipment existed, the wild and uncontrolled flow of gusher wells was not uncommon. Gas wells blow out from time to time, and large volumes of gas are lost before wells can be brought under control. Advances in the technology have done much to prevent surface waste of oil and blowouts of gas wells.

Subsurface chokes installed in wells in potentially dangerous areas have reduced the frequency of uncontrolled flows of large volumes of oil and gas when surface production facilities fail. Preventing salt water contamination of either land or fresh water resources is the major pollution problem in oil production. Separate problems are involved in preventing the pollution of surface and ground waters.

When an oil or gas well is drilled, the bit usually penetrates fresh water strata at relatively shallow depths. Water wells may take water from these ground-water zones for irrigation or for animal and human consumption. Mineralized water may enter the fresh water strata, if improperly cased wells penetrate them. Regulations controlling drilling and casing of oil and gas wells do not apply to water wells. In many oil and gas producing areas the mineralization of subsurface water increases with depth.

Illinois requires that all fresh water strata be protected by cementing the casing of the oil or gas well to a point below the deepest fresh water strata. Practices in the abandonment of wells or dry holes are now regulated to prevent contamination of fresh water zones, although many oil wells were abandoned before proper technology and regulations were in effect.

Some oil reservoirs produce large quantities of salt water along with the oil and gas. Surface fresh water supplies can be protected by proper disposal of the salt water, commonly called oil field brine. The necessity of protecting fresh water resources and soils was recognized as early as 1905 by the United States Geological Survey. It was then common practice to allow salt water to flow into streams and rivers, but the relatively small volumes were diluted enough so that no appreciable pollution occurred.

A more satisfactory way to dispose of salt water is by injecting it into one or more permeable subsurface formations that do not contain fresh water. An increasing volume of salt water is used in water-flooding, the secondary recovery procedure of injecting water into a depleted or nearly depleted oil reservoir to flush out a secondary "crop" of oil. The practice of injecting salt water into relatively flush reservoirs to maintain pressure and increase the ultimate oil recovery also is becoming a common procedure for suitable reservoirs. These two procedures are a beneficial use of produced salt water. Most of the salt water they dispose of is injected into salt-water-bearing formations.

Salt water disposal by injection is expensive. Suitable aquifers must be located in formations with sufficient permeability to receive large volumes at reasonable pressures. Frequently, new disposal wells are drilled, unless existing oil wells can be used for disposal. Pumping equipment and distribution lines must be installed, and most important, the produced salt water must be analyzed and treated after collection to prevent scale from forming and plugging the lines. Formation water produced with oil is characterized primarily by its high content of sodium chloride, but it also may contain varying amounts of minerals and substances such as sulphates, bicarbonates, suspended solids, and bacteria.

Since World War II, the rapidly expanding population and economy have created simultaneously the need for greater resources of fresh water and increasing volumes of salt water which must be disposed of. Illinois has strengthened and added regulations to control salt water disposal. In many areas concentrated salt solutions escaped or leached into fresh water sands or streams from old evaporation pits. State regulations specify that pits must be impervious, or lined with an impervious material. Storage is permitted only in approved pits. Samples are collected from streams and rivers to locate sources of pollution, and appropriate action is taken to prevent further pollution.

In 1964 the Department of Mines and Minerals, Division of Oil and Gas, adopted new regulations for the specific purpose of protecting fresh water resources from contamination from oil field operations. These rules outline drilling procedures, casing programs, requirements for obtaining permits to construct salt water pits, time limits for cleaning up well sites after plugging, and rules for abandoning wells. The State thus strengthened its program to combat pollution.

Additional protection of fresh water sources is required. The regulations stipulate that pits used to retain salt water produced in oil field operations must meet standards of construction and location before they can be approved for use. All pits are inspected yearly, or more frequently. If any evidence of seepage is found, the pits are immediately condemned and required to be filled and leveled. This system of issuing permits and maintaining surveillance of operations has enabled the Oil and Gas Division to require hundreds of pits to be abandoned, filled, and leveled during the past two years. Also, it has necessitated the drilling of wells or conversion of numerous abandoned holes to disposal wells for the disposition of salt water into underground formations. The underground formation chosen for disposal is reviewed by the Oil and Gas Division. Casing and cementing is required to prevent escape of salt water to other formations. This method of disposal is expensive, but reliable, and is accepted by all the oil producing states.

In addition to pit inspection and the permit program, drilling procedures are regulated. All wells drilled must have surface casing permanently cemented in the well. Such casings cannot be removed after the well is completed or after it is abandoned. When a well is abandoned, a 50-foot cement plug must be placed opposite the fresh water table to avoid water contamination. These procedures give added protection to fresh water resources.

The Oil and Gas Act stipulates that each oil well must be covered with a surety bond in the amount of $1000, or $2500 in the case of blanket bonds, payable to the State. Posting of bond guarantees proper plugging of the well and restoration of the site when the well is no longer used. Plugging and restoration work is done under the direction of the Department of Mines and Minerals.

Oil well inspectors are trained in testing procedures, which enables them to detect sources of salt water contamination by testing at various check points in streams. This has enabled the Department to maintain closer surveillance of possible sources of pollution. Oil well inspectors are certified under the personnel code to insure a continued program of law enforcement by qualified personnel.

RURAL COMMUNITIES

About thirteen small communities with average populations of 1000 currently have partial sewer systems but no treatment works. All of these communities have prepared plans for needed facilities, but construction has been delayed, primarily by problems of financing and site acquisition. It is expected that all of these facilities will be completed by 1968.

Approximately 600 incorporated communities have no sanitary sewer systems. These municipalities have average populations of from 500 to 600 and rely on individual home septic tank systems for sewage disposal. Many of these septic tank systems fail or are inefficient because of tight or wet soils and residential lots of inadequate size. To relieve local nuisance conditions, overflow connections have often been made to farm drainage tile systems and to storm drain systems. In a number of small communities such practice has resulted in nuisance conditions and minor stream pollution on farms or other private property below the point of drainage. Occasionally, such situations come to the attention of the Sanitary Water Board through complaints from property owners. This system of small communities without sewage disposal facilities has not been studied, but such a study should be part of the systems analysis recommended in this water resources plan.

In the fall of 1965, Congress established additional Federal grant programs to help communities develop or improve sewerage works. As a result, more than 100 small Illinois communities have filed inquiry forms, as a preliminary to filing grant applications. Almost all of these inquiries stress the need for sewers and sewage treatment to eliminate pollution nuisances and solve public health problems. Many communities admit that they are now polluting local streams. Some communities want sewer systems in order to attract small industry and commercial establishments, although small communities generally provide only domestic sewage treatment. Industries with large volumes of liquid wastes must provide their own treatment facilities, or the municipality must expand its sewerage system to handle the increased load.

POLLUTION INDICATORS

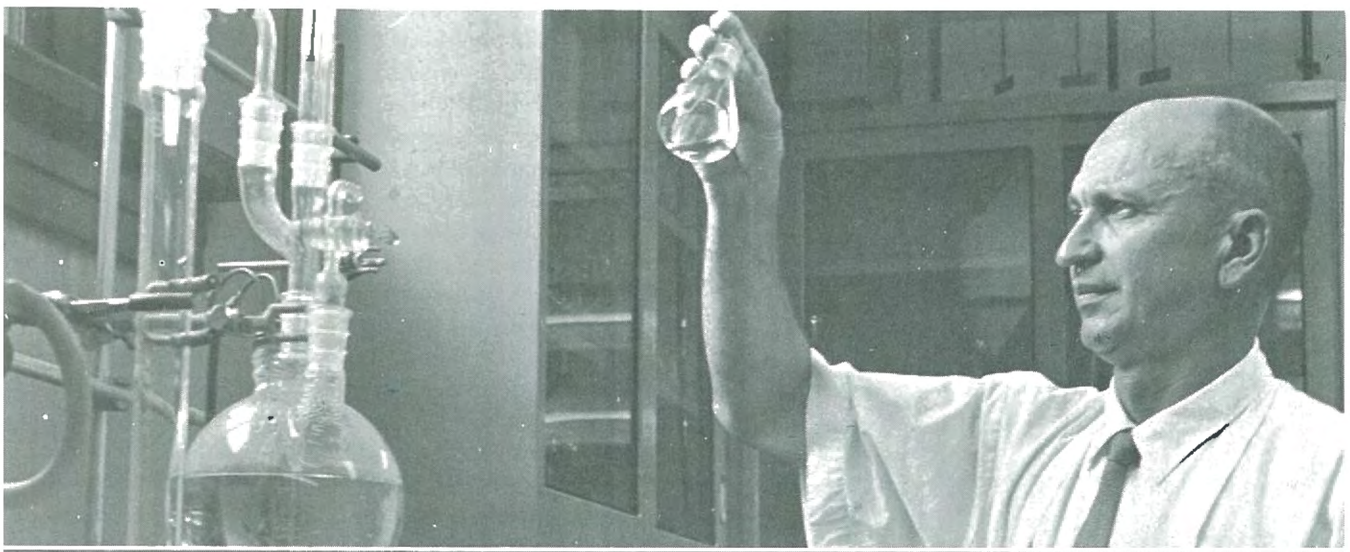
Parameters are measures of pollution characteristics of importance in the identification and control of water pollution. The parameters used to analyze municipal wastes cannot be applied to industrial wastes without an understanding of their limitations, or without supplementary tests to determine the properties of specific industrial wastes.

All such tests are designed to evaluate the most detrimental, or pollutional, characteristics of wastes. These characteristics of municipal wastes are a) unhealthy concentrations of disease-producing bacteria; b) low dissolved oxygen content in the receiving stream; c) unsightly floating solids, turbidity, and accumulations of solids; d) obnoxious odors; e) nutrients which cause undesirable stimulation of aquatic plant growth; and f) high biochemical oxygen demand. Industrial wastes normally do not carry significant concentrations of disease-producing bacteria, but they often have the other detrimental characteristics listed above, as well as those which disrupt treatment processes or are toxic to desirable plants and animals.

These parameters are used, not only in analyzing and defining the nature and composition of wastes, but also in prescribing methods of waste treatment and pollution control. The parameters which are currently significant in water pollution control are:

Dissolved Oxygen (DO) is one of the most important indicators of water quality. Adequate DO levels are necessary to support desirable fish and aquatic life. Introducing significant amounts of organic wastes, coupled with inadequate DO levels, degrades the stream, creates odor nuisance, and eliminates fish and aquatic life. Dissolved Oxygen is easily measured by chemical and instrument tests and provides the basis for the BOD test.

Biochemical Oxygen Demand (BOD) is a measure of the quantity of dissolved oxygen consumed by bacteria during the process of reducing organic waste materials to a simpler and less harmful form. The BOD test measures the change in DO during a specific in-



cubation period, commonly five days, under standard environmental conditions. When used alone, the BOD test serves as one measure (in terms of oxygen-consuming ability) of the organic pollution present in a stream. BOD measurements, together with DO values, are used to evaluate the self-purification capacity of a stream.

Population Equivalent is an expression of the relative strength of a waste (usually industrial) in terms of its equivalent in domestic waste, expressed as the population that would produce the equivalent domestic waste. The term as used here relates to BOD, suspended solids, and quantity of waste flow.

Hydrogen-Ion Concentration (pH) is defined as the logarithm of the reciprocal of the hydrogen-ion concentration. The instrument test for pH indicates whether waters are acidic, neutral, or basic. A value of 7.0 is the neutral point; values less than 7.0 indicate an acid condition. Low pH or acidic conditions tend to accelerate pipe corrosion, decompose concrete, and intensify the toxic action of sulfides and cyanides. High pH values disrupt biological activity and precipitate iron as hydroxides. For biological reduction of organic wastes, a pH in the 5 to 9 range is most desirable.

Coliform Bacteria—The coliform group embraces several varieties of bacteria which differ in biochemical characteristics, as well as in natural sources and habitats. Coliform bacteria are found in the fecal matter of all warm-blooded animals, including man. Some varieties abound in nature, i.e., in solids and on plants. Enteric pathogens, or disease-producing organisms of intestinal origin, may also be present in fecal matter. Therefore, the presence of the coliform group has long been used to indicate the possible presence of pathogenic bacteria. However, other supplementary tests increase the certainty of detecting recent fecal contamination. Among the supplementary tests are those for enterococci and fecal streptococci. In addition, confirmation tests at an elevated temperature more precisely indicate coliform bacteria of fecal origin.

Turbidity is primarily a measure of the amount of suspended inorganic sediment in water. Turbidity is significant in industrial process water and public water supplies. Certain industrial uses are impaired by high turbidity, and the public tends to associate turbid water with possible pollution. The degree of turbidity substantially affects the amount of treatment required for water that is to be consumed. High turbidity restricts passage of light to photosynthetic plants and animals and thus is deleterious to the stream environment.

Temperature has a marked effect on the sanitary and ecological characteristics of a stream. The solubility of oxygen in water is inversely proportional to water temperature. Temperature increase also accelerates the rate at which biological life uses oxygen. Abnormally high temperatures are detrimental to fish and aquatic life. The efficiency of industrial cooling processes decreases as temperature increases.

Dissolved Solids are the total amount of dissolved material, organic and inorganic, contained in water or wastes. For certain industrial uses, a limited amount of total dissolved solids (TDS) can be present in the water supply. Excessive dissolved solids in water can make the water unpalatable and, in certain cases, cathartic. Increased treatment costs are also a consequence of excessive dissolved solids. Potable water supplies often have total solids contents ranging from 20 to 1000 mg/l. The U. S. Public Health Service Drinking Water Standards recommend the rejection of sources which have more than 500 mg/l of TDS, if a better source can be reasonably developed.

Color in water indicates the presence of suspended or dissolved material, or both. Color is often leached from organic debris and consists chiefly of vegetable extracts such as tannin and humic acid. Textile and paper industries can contribute substantial amounts of highly colored liquids which may be resistant to biological attack. Color is considered undesirable in municipal and certain industrial water supplies, and it can indicate the presence of harmful wastes.

Phenols are significant primarily because they cause taste and color in drinking water. The presence of as little as 1 microgram per liter (1 part per billion) of chlorinated phenols can be tasted in drinking water. Phenols in a body of water can taint fish flesh. The test for phenol also detects certain aromatic compounds, which in significant concentrations usually indicate industrial pollution.

Chlorides (Cl) are often found in natural waters, but sewage or waste waters usually contain much higher concentrations than those occurring naturally in this part of the country. The chloride content of water is not altered in passage over or through the ground, but addition of liquid human wastes builds up the chloride content above the normal or background levels of natural water. As chloride concentration increases, palatability is affected, corrosiveness increases, and irrigation usage is impaired. The Public Health Service Standards for Drinking Water recommend that a limit of 250 mg/l be established for supplies intended for public use.

Ammonia (NH_3) and Organic Nitrogen are indicators of the freshness of sewage. Waters in which most of the nitrogen is in the form of organic and ammonia nitrogen are often considered to have been recently polluted. The presence of ammonia in municipal water sources is particularly significant because of its marked effect on the amount of chlorine needed to disinfect water properly. Ammonia is also capable of exerting a significant oxygen demand in surface waters. The toxic effect of ammonia on aquatic life increases with increasing pH.

Nitrate Nitrogen (NO_3) is generally present in relatively small quantities in unpolluted surface waters. Any significant increase in its concentration indicates that the water characteristics have been altered by industrial, domestic, and agricultural wastes. Nitrate nitrogen is the most highly oxidized form of ammonia; consequently, it is the most stable state in the nitrogen cycle. Organic nitrogen is converted to ammonia nitrogen, which is then oxidized to nitrite and subsequently to nitrate. When a stream is depleted of dissolved oxygen, it uses the nitrate as an alternate source of oxygen. High concentrations of nitrate nitrogen are reported to cause methemoglobinemia in infants (commonly called "blue babies"). A limit of 45 mg/l of nitrate is recommended in the Drinking Water Standards.

Nitrates are necessary to complete the normal cycle of aquatic life, which is of particular significance in natural waters. If nitrates are present with phosphorus in optimum amounts, massive growths of algae and plankton can result. Certain types of these growths can be troublesome to municipal water plant operation and can also cause taste and odor problems. Others can cause unsightly conditions in streams and along shorelines.

Phosphate (PO_4)—Biological activity requires the presence of phosphate. The predominant sources of phosphate are animal and human waste matter and synthetic detergents. Detergents often contribute as much as two to three times more phosphate than waste matter does. Runoff from fertilized fields and industrial wastes also contains phosphate. The bacteriological mechanism of stream purification requires phosphate to permit the purification process to proceed at an optimum rate; phosphate is not considered harmful to human health. Phosphate in optimum quantities, in the presence of sufficient nitrogen, sunlight, and food, can promote massive growths of algae and plankton, which affect water use as nitrates do.

Chemical Oxygen Demand (COD)—indicates the total amount of oxidizable organic load present in water. When considered with BOD, the COD will indicate whether contaminants are resistant to biological degradation and may indicate toxicity. If both parameters are low, the water is considered relatively unpolluted. A low BOD and high COD would indicate a waste not readily subject to biological degradation or the presence of toxic materials; a high BOD and COD indicate heavy organic contamination. The average domestic sewage has a COD/BOD ratio between 1.5 and 2.0.

Detergents—Until recently, the presence of detergents in streams containing municipal wastes frequently caused foaming in the streams and occasionally in water supplies. Through industrial research, an effective new detergent formulation was developed and introduced in 1965. This new detergent is biologically degradable; its use has led to a dramatic reduction in stream concentrations, and this pollution problem appears to have been solved.

Other Parameters—Many other parameters, significant in varying degrees, are not included above. Among these are the presence of organics (CCE), and toxic metals, and measures of hardness, sulfates (SO_4), taste, and odor.

POLLUTION CONDITIONS IN ILLINOIS STREAMS

With few exceptions, average levels of turbidity, total dissolved solids, chlorides, and sulfates in Illinois streams are satisfactory. This assessment is based on analysis of data from the State network of water quality stations and data in a special report by the Fisheries Division of the Department of Conservation.

However, it is the exceptional, or non-average, condition which is usually responsible for fish kills, nuisance complaints, or pollution. Notable exceptions are found on the Saline River, which is subject to pollution from mine waste; on the Big Muddy River, which is polluted by coal mining and oil recovery operations; and on Indian Creek in Lawrence County, which is polluted by petroleum waste. Chloride and sulfate levels increase periodically on certain reaches of the Kaskaskia River and the Embarras River. Phosphate and fluoride levels in the middle and upper reaches of the Illinois River increase periodically and are consistently higher than desirable.

Periodic low oxygen levels have been recorded in the Fox, DuPage, upper DesPlaines, Illinois, Vermilion, Embarras, and Little Wabash Rivers. These lows are generally due to a combination of minimum streamflow, coinciding with the oxygen demand of waste treatment plant effluents. Low oxygen levels generally occur downstream from major municipalities.

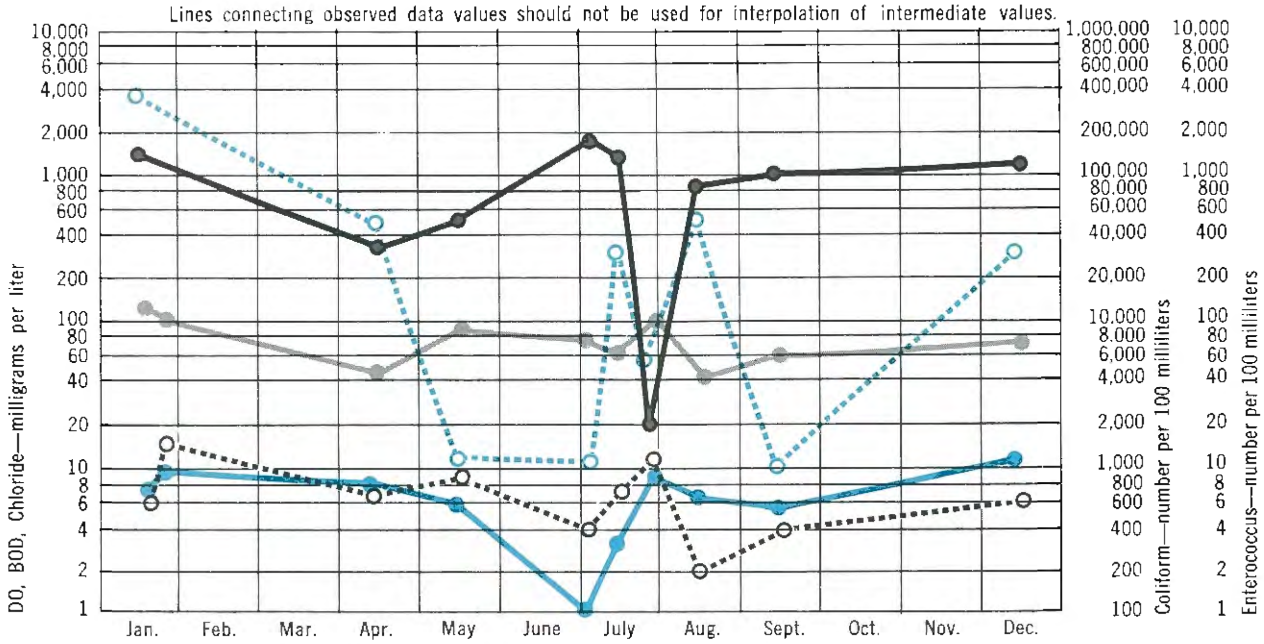
Excessive pollution exists in some areas in Illinois, but in no cases has pollution completely destroyed the resource. Fish kills have occurred from excessive or slug discharges of toxic materials from industrial operations. The more common pollutants include ammonia, cyanide, acid, whey, and high-strength waste or effluents from various food processing industries. The Saline River Basin and parts of the Big Muddy Basin have no fish or aquatic life because of the discharges from coal mining. This is true of a few other streams or sections of streams in other areas of the State.

The conditions that cause water pollution in streams are variable and often transient. Depending upon the sources of pollution and the physical characteristics of the watercourse, a particular reach of a stream may be severely degraded at one time and appear to have recovered at a later date; or pollution may be observed in one reach and downstream reaches will show no evidence of it; or the effects of pollution may be so long-lasting and slow-moving that they appear only in the downstream reaches. Certain types of wastes may not exert any pollutional effect, but instead may stimulate the overgrowth of plant and animal life, which eventually produces a secondary pollutional effect. Thus, the true measure of pollution can be taken only by continuous and regular observation of stream conditions in many locations.

More than 280 sampling locations have been established on Illinois streams by the State Sanitary Water Board. The stream sampling programs are aimed at determining surface-water quality and the degree of pollution resulting from waste discharges to the streams. The data in Figures 1 through 19 have been drawn from these sampling programs, to show some existing conditions in selected streams in 1965, and to compare them with conditions observed from 1958 to 1965. Space does not permit showing values for all the characteristics analyzed, therefore only those are shown which are considered to be the most characteristic parameters of pollution conditions. These serve only as indicators of stream conditions; only an evaluation of results of all the analyses made could give a complete picture of pollution conditions in Illinois streams.

Since criteria for water quality control may differ from stream to stream, or for various locations on one stream, each figure is accompanied by a short commentary.

OBSERVATIONS OF STREAM CONDITIONS DES PLAINES RIVER • CHANNAHON • 1965

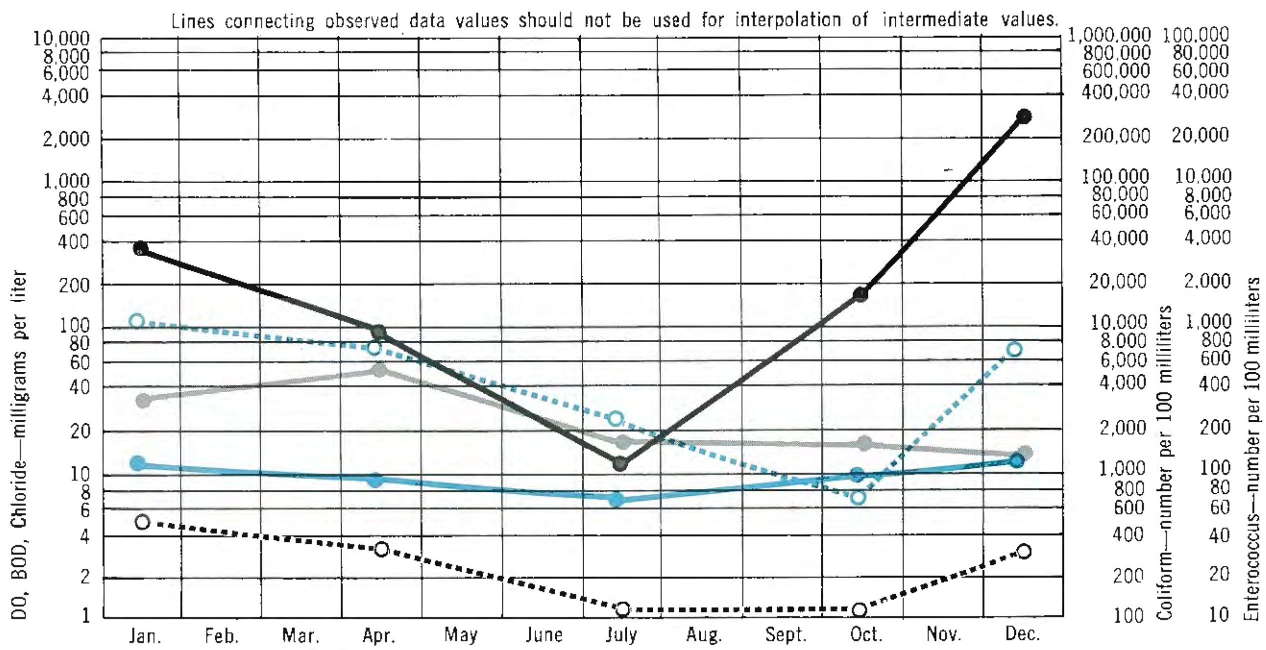


SUMMARY OF OBSERVED STREAM CONDITIONS—DES PLAINES RIVER—CHANNAHON, 1959 THROUGH 1965

FIGURE 1

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Radioactivity Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	17	20	21	21	20	20	21	20	20	21	21
Observed Maximum —	86	10.8	22.0	114	348	8.0	14	10	130	180,000	3,700
Observed Minimum —	34	1.0	6	24	144	7.2	2	—	—	—	—
Average (Median*) —	62	5.5	39	63	239	7.6*	6	2	21	55,500	262

OBSERVATIONS OF STREAM CONDITIONS KANKAKEE RIVER • JOLIET ARSENAL • 1965

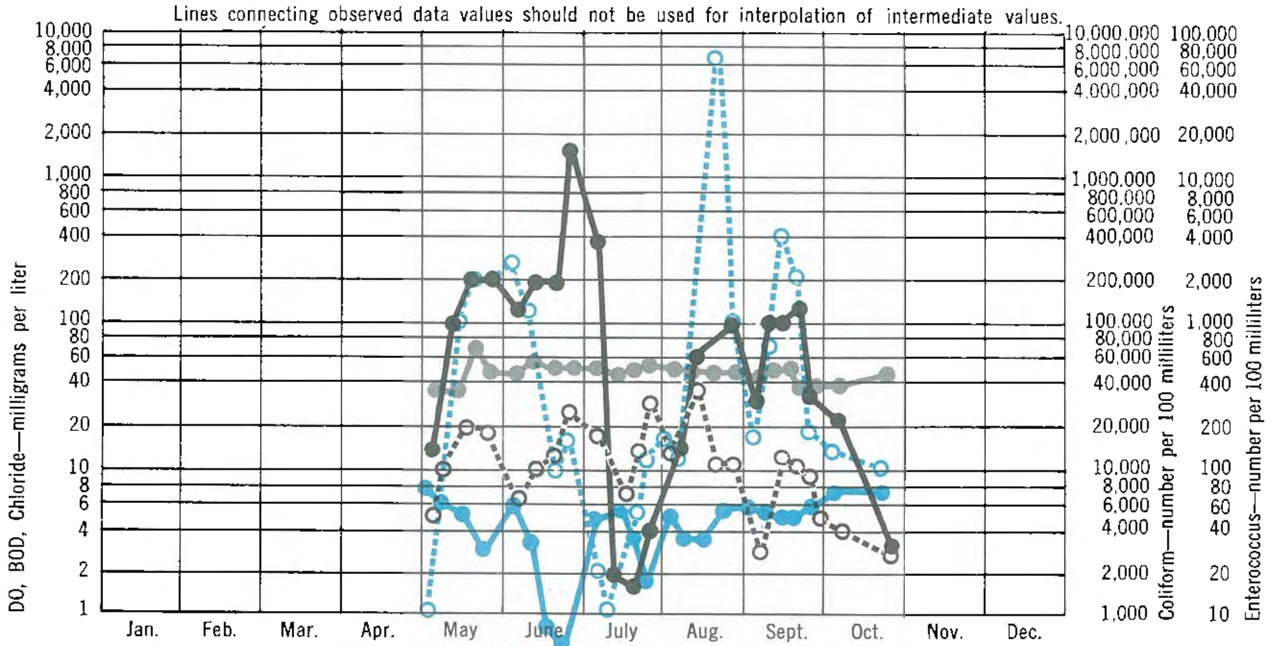


SUMMARY OF OBSERVED STREAM CONDITIONS—KANKAKEE RIVER—JOLIET, 1959 THROUGH 1965

FIGURE 2

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Radioactivity Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	17	19	20	20	20	20	20	19	19	20	20
Observed Maximum —	86	13.8	375	56	576	8.7	30	10	68	260,000	1,000
Observed Minimum —	32	5.6	5	9	200	7.3	1	—	—	50	—
Average (Median*) —	59	9.5	82	18	306	7.6*	3	2	19	25,176	180

OBSERVATIONS OF STREAM CONDITIONS
ILLINOIS RIVER • OTTAWA • 1965



SUMMARY OF OBSERVED STREAM CONDITIONS—ILLINOIS RIVER—OTTAWA, 1965

FIGURE 3

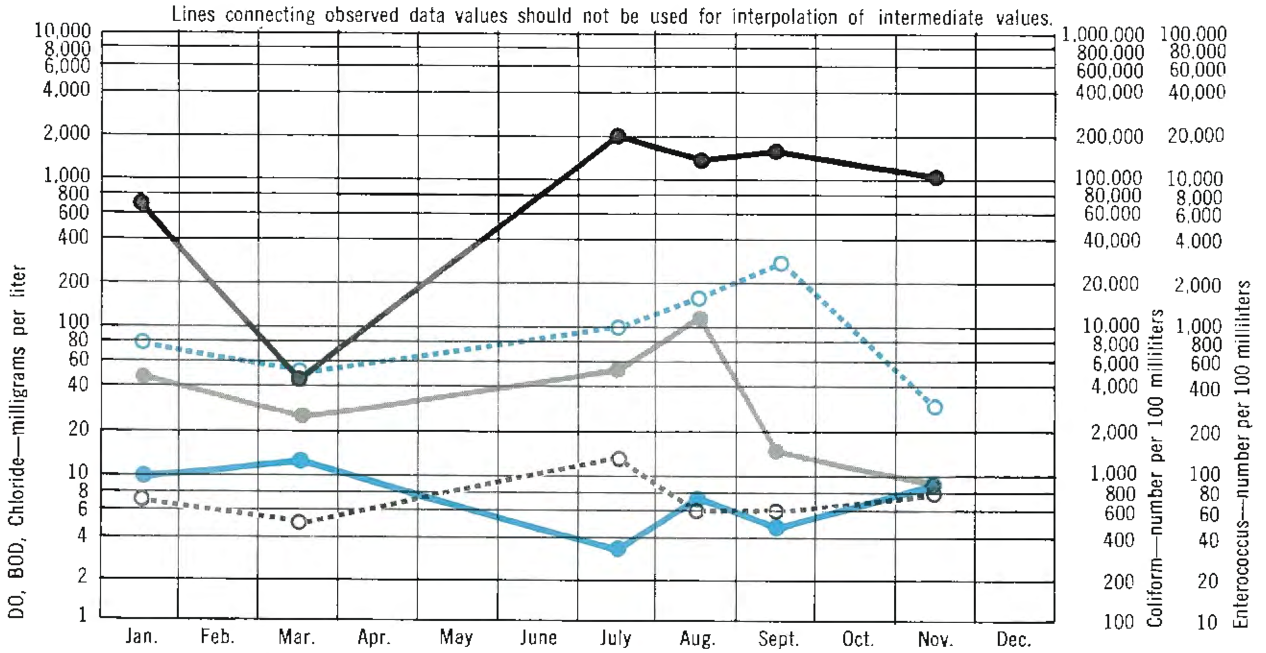
	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses	— —	23	23	23	23	23	23	23	23	22	23
Observed Maximum	— —	7.1	305	69	320	8.0	36	5	20	1,700,000	61,000
Observed Minimum	— —	0.6	5	34	200	7.4	3	—	3	1,700	10
Average (Median*)	— —	4.4	38	45	260	7.6*	12	1	9	168,395	3,420

Figure 1. DesPlaines River at Route 66 Bridge near Channahon— Dissolved oxygen concentrations, which were measured between 10 a.m. and 3 p.m., ranged from 1.0 to 10.8 mg/l during 1965. Twice in July 1965, concentrations of dissolved oxygen were below 5 mg/l. Experience indicates that the hour at which samples are taken strongly influences the results obtained, and that DO concentrations are low in the early morning hours. For example, a study made by the Illinois Natural History Survey found DO concentrations of about 1.5 mg/l at River Mile Point 278 (Route 66 Bridge over the DesPlaines) in July 1965 between 8:35 a.m. and 10:35 a.m. The BOD values in 1965 ranged from 2 to 14 mg/l. The numbers of bacteria of the coliform group were generally sufficiently high to preclude any use of the River for recreation.

Figure 2. Kankakee River near Joliet Arsenal— Conditions generally are good in this stream, with the exception that high coliform bacteria levels were found in the January, April, October, and December 1965 samples.

Figure 3. Illinois River at Ottawa— Dissolved oxygen concentrations were below 5 mg/l twelve times and below 3 mg/l four times in 1965. Again, as on the DesPlaines near Channahon, all observations were taken at 3 or 4 p.m., when dissolved oxygen concentrations in the stream could be expected to be at a maximum. A study by the Natural History Survey in July 1965, in which observations were made between 7:25 and 10:13 a.m., showed no DO concentrations higher than about 3.3. mg/l in the Starved Rock Pool and a concentration of 2.5 mg/l at Ottawa. Coliform bacteria levels are generally higher than that permitted for recreational use of the water.

OBSERVATIONS OF STREAM CONDITIONS ILLINOIS RIVER • PEKIN • 1965

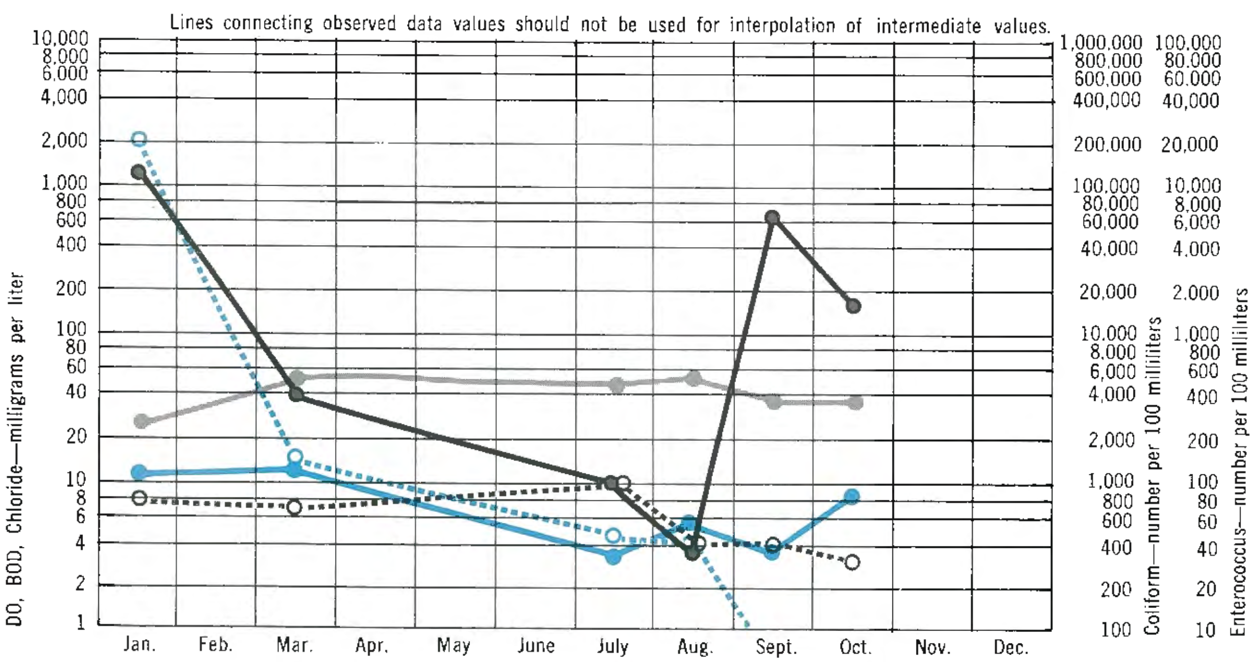


SUMMARY OF OBSERVED STREAM CONDITIONS—ILLINOIS RIVER—PEKIN, 1959 THROUGH 1965

FIGURE 4

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	19	17	18	18	18	19	18	18	18	17	7
Observed Maximum —	80	12.8	800	110	352	8.6	13	11	118	210,000	2,800
Observed Minimum —	32	3.2	55	8	172	7.3	2	—	—	60	92
Average (Median*) —	56	8.3	158	44	266	7.6*	6	3	18	71,115	709

OBSERVATIONS OF STREAM CONDITIONS ILLINOIS RIVER • MEREDOSIA • 1965



SUMMARY OF OBSERVED STREAM CONDITIONS—ILLINOIS RIVER—MEREDOSIA, 1959 THROUGH 1965

FIGURE 5

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	19	19	19	19	19	19	19	19	19	19	19
Observed Maximum —	80	12.1	1500	52	320	8.2	16	23	183	120,000	20,000
Observed Minimum —	32	3.1	7	5	166	7.2	3	—	—	100	2
Average (Median*) —	61	6.8	275	30	243	7.6*	6	5	37	21,794	2,732

OBSERVATIONS OF STREAM CONDITIONS
DU PAGE RIVER • PLAINFIELD • 1965

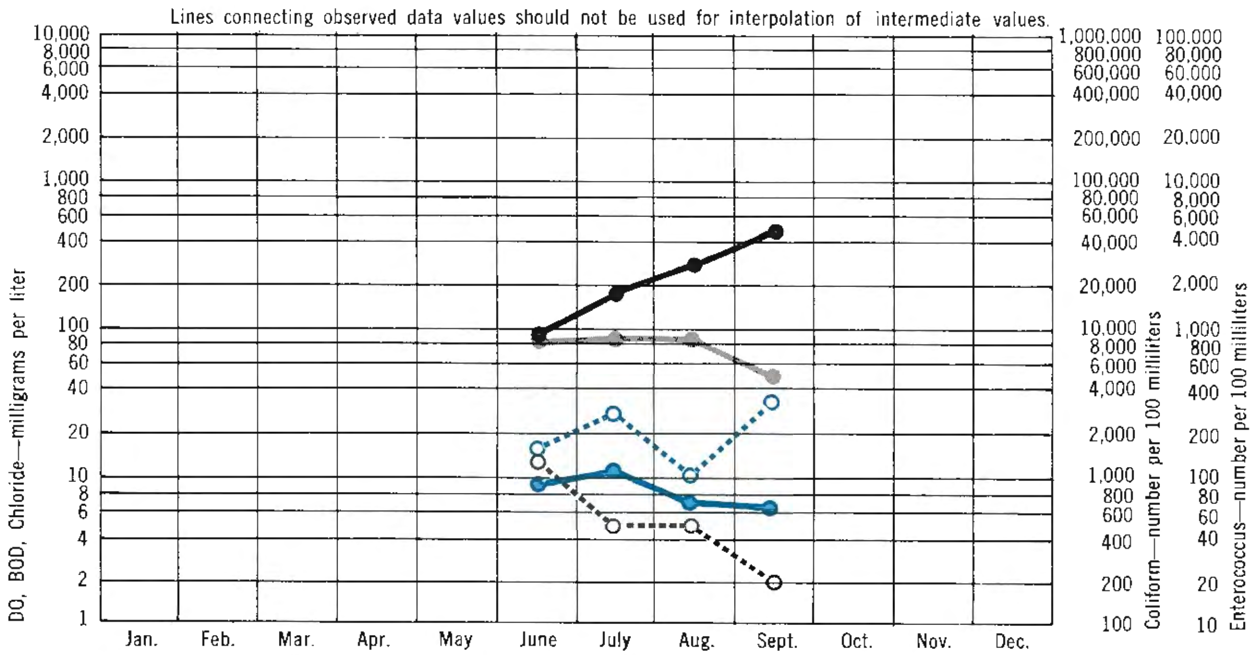


FIGURE 6

SUMMARY OF OBSERVED STREAM CONDITIONS—DU PAGE RIVER—PLAINFIELD, 1964 THROUGH 1965

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	9	10	6	8	6	10	10	8	8	8	8
Observed Maximum —	85	10.6	120	113	448	8.7	12	2	20	43,000	1,400
Observed Minimum —	65	3.6	15	36	320	7.5	2	—	—	1,000	100
Average (Median*) —	74	7.1	38	79	391	8.4*	4	—	11	17,250	393

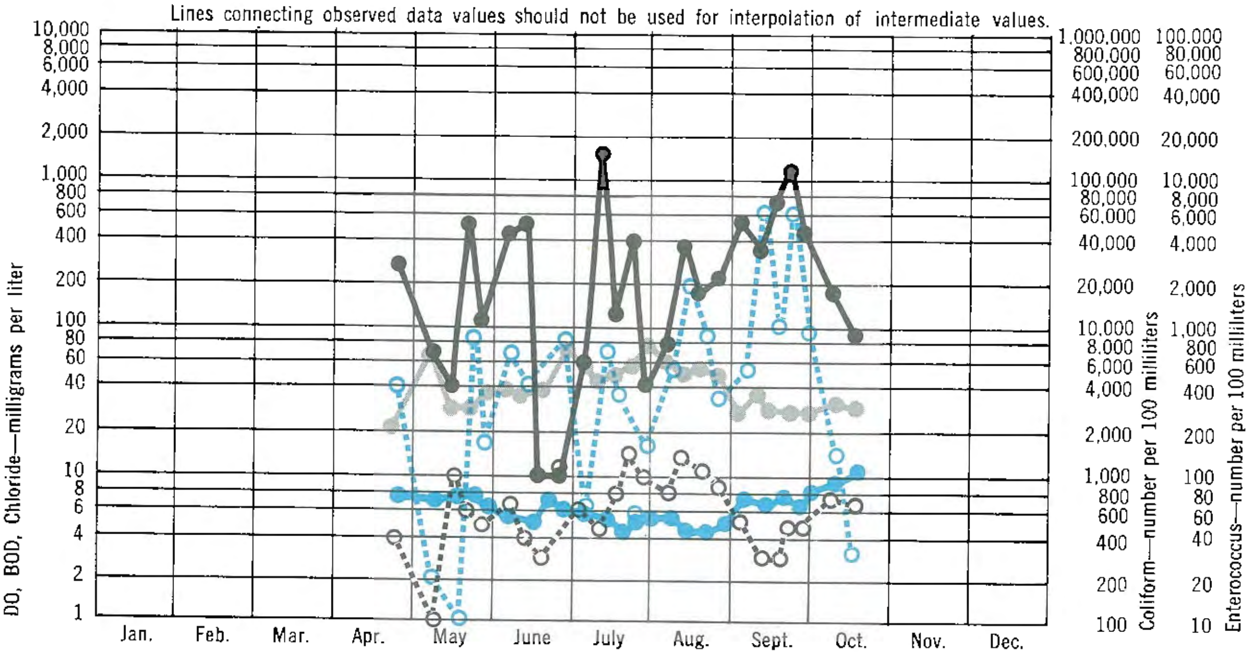
Figure 4. Illinois River at Pekin (Above Pekin industrial and municipal discharges, but below discharges from Peoria and East Peoria)—Some of the burden of wastes imposed on the Illinois River in its upper reaches is overcome by the time it reaches Peoria, but additional industrial and treated municipal wastes are discharged to the River in the Peoria-Pekin area. In 1965, dissolved oxygen concentrations ranged from 3.2 to 12.3, and the value was less than 5 mg/l in July and September. A study by the Natural History Survey showed an average DO of 4.8 mg/l for early morning samplings.

Coliform counts, even though reduced from the levels observed at Ottawa, were still higher than desirable. This undoubtedly is due to discharges of treated municipal wastes in the Peoria area.

Figure 5. Illinois River at Meredosia—From Pekin to Meredosia, there is little improvement in the condition of the River. In 1965, DO ranged from 3.5 to 10.1 and averaged 6.9, as compared to the Pekin average of 7.7 mg/l. Lowest observed DO in the 1959 through 1965 period was 3.1 mg/l, but again this is representative only of afternoon sampling periods. A Natural History Survey study in 1964 showed 3.8 mg/l average DO at Meredosia. The dissolved oxygen concentration in the entire lower Illinois River was less than 4.0 mg/l, when samples were taken in early morning hours. Coliform counts at Meredosia were much lower than upstream at Ottawa and Pekin, but were higher than desirable in January, March, September, and October 1965. Dilution from high runoff may have been partially responsible for the lower count. Turbidity values are generally higher at Meredosia than at Pekin.

Figure 6. DuPage River near Plainfield—Biochemical oxygen demand in the River at this location is generally low; it ranged from 2 to 12 mg/l and averaged 6 in 1965. This, compared with the 1964 through 1965 summary, indicates very little change with respect to this characteristic in the two-year period. The same is generally true of other characteristics such as dissolved oxygen, coliforms, and enterococci. A 1964 study of the bottom fauna showed balanced conditions from below Plainfield to the DesPlaines River.

OBSERVATIONS OF STREAM CONDITIONS
FOX RIVER SHERIDAN 1965



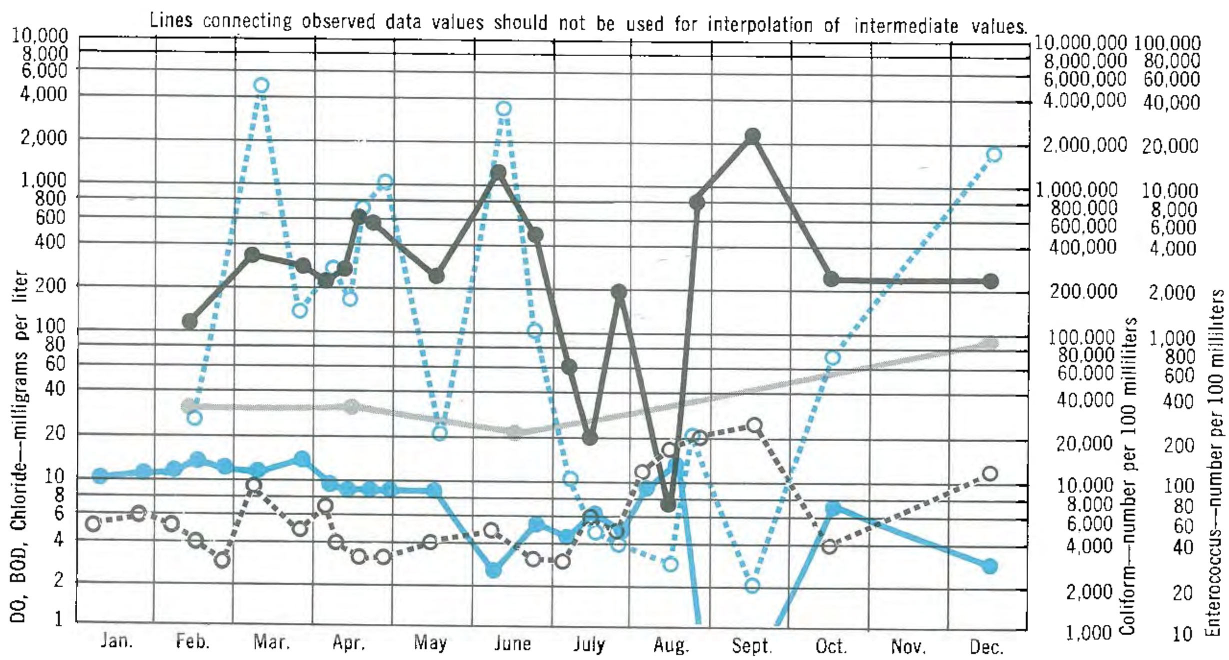
SUMMARY OF OBSERVED STREAM CONDITIONS—FOX RIVER—SHERIDAN, 1959 THROUGH 1965

FIGURE 7

COLIFORM
CHLORIDE
ENTEROCOCCUS
DO
BOD

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	85	200	200	201	201	201	201	201	201	200	199
Observed Maximum —	79	17.5	600	80	420	9.6	81	17	264	240,000	24,000
Observed Minimum —	32	1.6	5	8	231	5.5	1	—	—	0	0
Average (Median*) —	55	7.2	42	37	316	8.4*	10	1	28	22,990	757

OBSERVATIONS OF STREAM CONDITIONS
SANGAMON RIVER
SOUTHEAST OF NIANTIC 1965

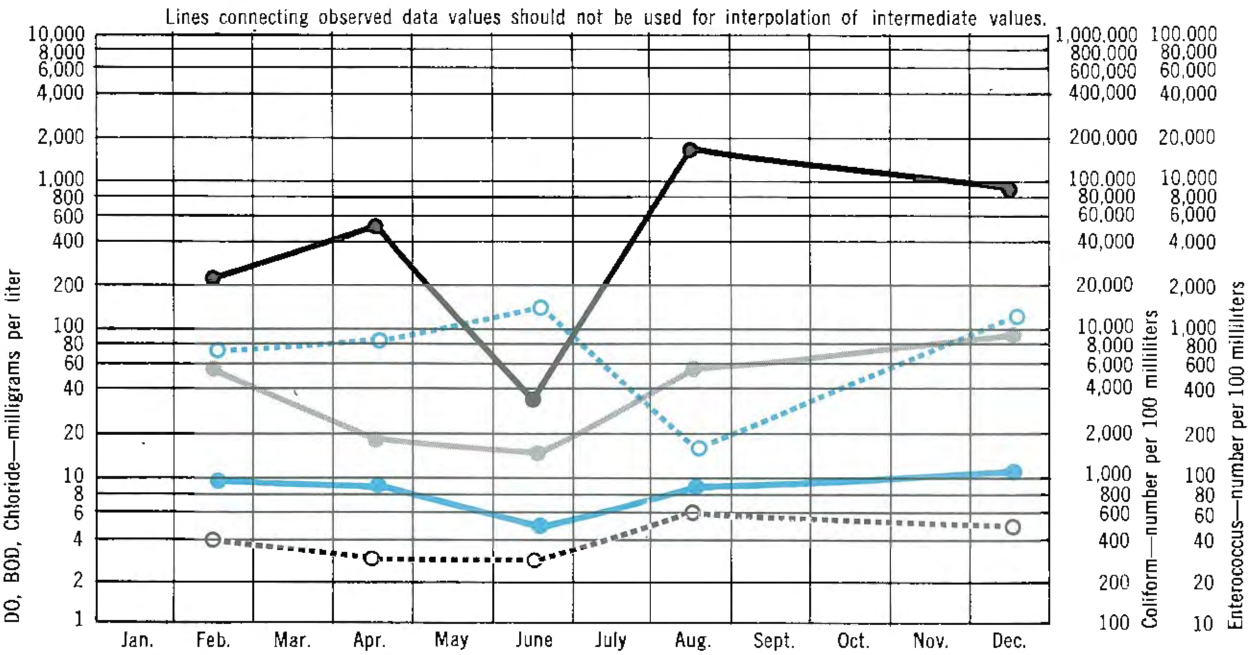


SUMMARY OF OBSERVED STREAM CONDITIONS—SANGAMON RIVER—NIANTIC, 1958 THROUGH 1965

FIGURE 8

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	38	38	18	16	17	25	36	16	16	31	31
Observed Maximum —	86	12.6	75	250	890	8.3	35	7	60	2,100,000	44,000
Observed Minimum —	32	0.0	4	8	156	7.4	3	—	—	6,000	20
Average (Median*) —	58	6.8	29	82	311	7.8*	8	1	16	332,109	5,269

OBSERVATIONS OF STREAM CONDITIONS
SANGAMON RIVER • SPRINGFIELD • 1965



SUMMARY OF OBSERVED STREAM CONDITIONS—SANGAMON RIVER—SPRINGFIELD, 1958 THROUGH 1965

FIGURE 9

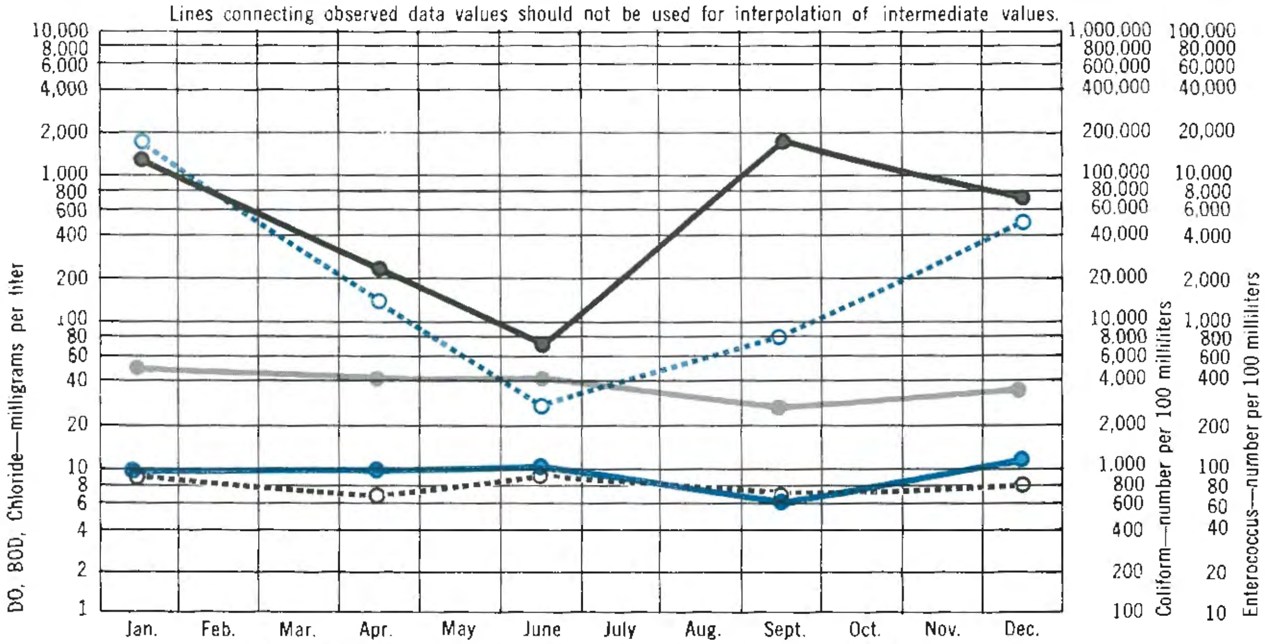
	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses	18	17	19	18	18	18	18	18	18	18	18
Observed Maximum	84	13.5	600	122	390	8.0	13	12	572	740,000	25,000
Observed Minimum	—	0.0	5	13	184	7.1	1	—	—	570	30
Average (Median*)	56	7.4	94	57	262	7.6*	5	1	50	134,231	3,262

Figure 7. Fox River near Sheridan—In May, June, July, and August 1965, BOD levels higher than 10 mg/l were observed in the River, although DO levels were consistently higher than 4 mg/l. This may have been partially due to high plankton levels. The average BOD for 1959 through 1965 was 10 mg/l. For much of 1965, the number of coliform bacteria observed was higher than the level desired for recreational use.

Figure 8. Sangamon River near Niantic—Although DO levels in 1965 were generally above 3 mg/l, on two occasions in August and September when streamflows undoubtedly were low, dissolved oxygen was completely depleted from the stream. In the same period, BOD values between 11 and 23 mg/l were observed. Very high counts of both coliform and enterococcus organisms were found consistently.

Figure 9. Sangamon River near Springfield—The quality of the River improves somewhat from Decatur to Springfield. The number of coliforms observed drops by approximately one order of magnitude. No DO concentrations of less than 4 mg/l and no BOD higher than 6 mg/l were observed in 1965.

OBSERVATIONS OF STREAM CONDITIONS
ROCK RIVER • ROCKFORD • 1965

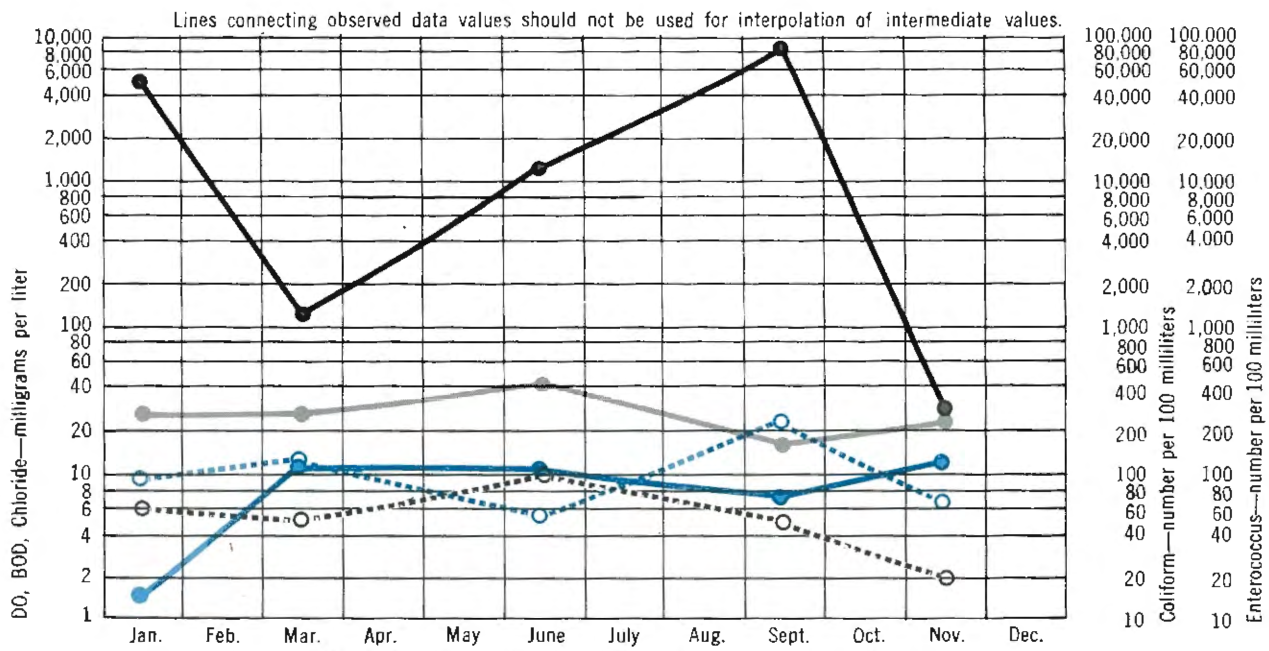


SUMMARY OF OBSERVED STREAM CONDITIONS—ROCK RIVER—ROCKFORD, 1959 THROUGH 1965

FIGURE 10

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha pc/l	Beta	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	12	12	12	12	12	12	12	12	12	12	12
Observed Maximum —	80	13.4	170	48	348	8.7	11	8	43	190,000	18,000
Observed Minimum —	40	5.7	15	1	31	7.6	3	—	—	7,400	68
Average (Median*) —	60	9.3	79	24	256	8.0*	7	2	17	85,950	2,847

OBSERVATIONS OF STREAM CONDITIONS
ROCK RIVER • ROCK FALLS • 1965

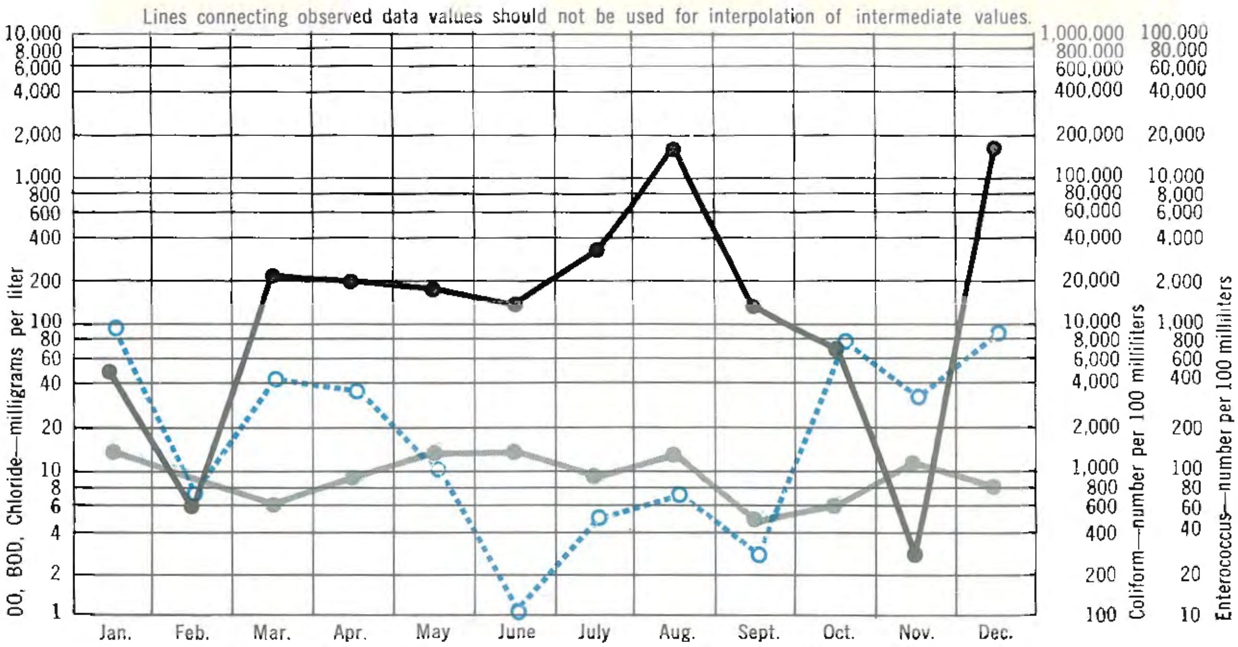


SUMMARY OF OBSERVED STREAM CONDITIONS—ROCK RIVER—ROCK FALLS, 1959 THROUGH 1965

FIGURE 11

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha pc/l	Beta	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	24	24	18	12	12	24	17	12	12	18	13
Observed Maximum —	78	16.2	120	40	332	8.8	10	5	90	87,000	230
Observed Minimum —	33	1.5	5	11	224	7.5	2	—	—	200	28
Average (Median*) —	62	8.8	52	20	276	7.6*	5	1	23	25,264	89

OBSERVATIONS OF STREAM CONDITIONS MISSISSIPPI RIVER • CANTON, MISSOURI 1965



SUMMARY OF OBSERVED STREAM CONDITIONS—MISSISSIPPI RIVER—CANTON, MISSOURI, 1964 THROUGH 1965

FIGURE 12

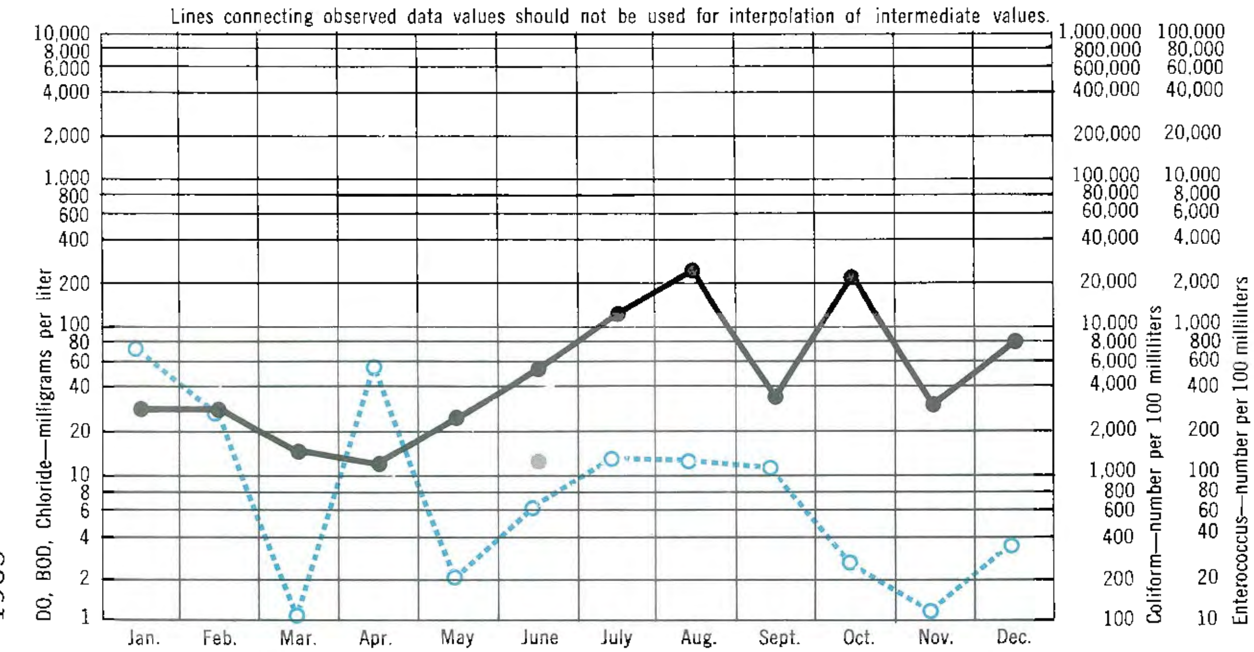
		Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses	—	15	—	17	16	—	17	—	16	16	17	17
Observed Maximum	—	84	—	700	26	—	8.4	—	13	48	380,000	950
Observed Minimum	—	34	—	8	6	—	7.3	—	1	0	200	2
Average (Median*)	—	58.6	—	206	11	—	7.7*	—	4.8	17.5	56,700	238

Figure 10. Rock River below Rockford-East Channel—In the east channel, which is immediately below the Rockford Sanitary District's treatment plant, DO and BOD concentrations were within reasonable limits in 1965. Coliform organisms ranged from 7400 to 190,000 per 100 ml, which is more or less to be expected below effluent outfalls. However, these levels exceed the limits desirable for recreational use.

Figure 11. Rock River below Rock Falls—The water quality changes only slightly between Rockford and Rock Falls. Coliforms, chlorides, and BOD were lower at Rock Falls in 1965, and DO values about the same, except that the values were higher for the January observation at Rock Falls, which was 1.5 mg/l.

Figure 12. Mississippi River at Canton, Missouri—Relatively little data on water quality are available at this station for comparison with other stations on the Mississippi or on other rivers. However, data for 1965 are presented to serve as a basis for future comparisons. Chlorides ranged from 5 to 15 mg/l, coliforms from 280 to 160,000 per 100 ml., and enterococci from 10 to 950 per 100 ml. The magnitude and range of these observations indicate the tremendous volume of dilution water in the River.

OBSERVATIONS OF STREAM CONDITIONS MISSISSIPPI RIVER • EAST ST. LOUIS 1965



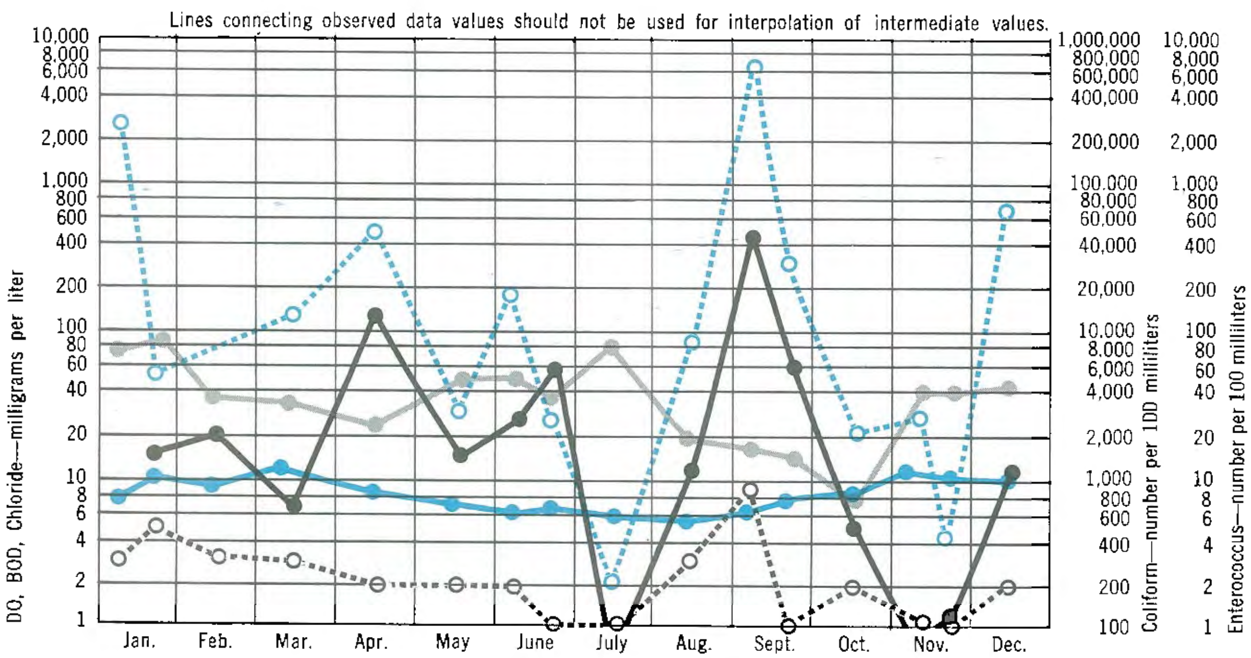
SUMMARY OF OBSERVED STREAM CONDITIONS—MISSISSIPPI RIVER—EAST ST. LOUIS, 1964 THROUGH 1965

COLIFORM
CHLORIDE
ENTEROCOCCUS
DO
BOD

FIGURE 13

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha pc/l	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses	15	—	3	2	—	6	—	3	3	17	17
Observed Maximum	80	—	280	14	—	8.4	—	4	25	27,000	700
Observed Minimum	36	—	130	14	—	7.3	—	4	21	1,200	10
Average (Median*)	59	—	203	14	—	7.6*	—	4	23	8,829	162

OBSERVATIONS OF STREAM CONDITIONS KASKASKIA RIVER • SHELBYVILLE • 1965

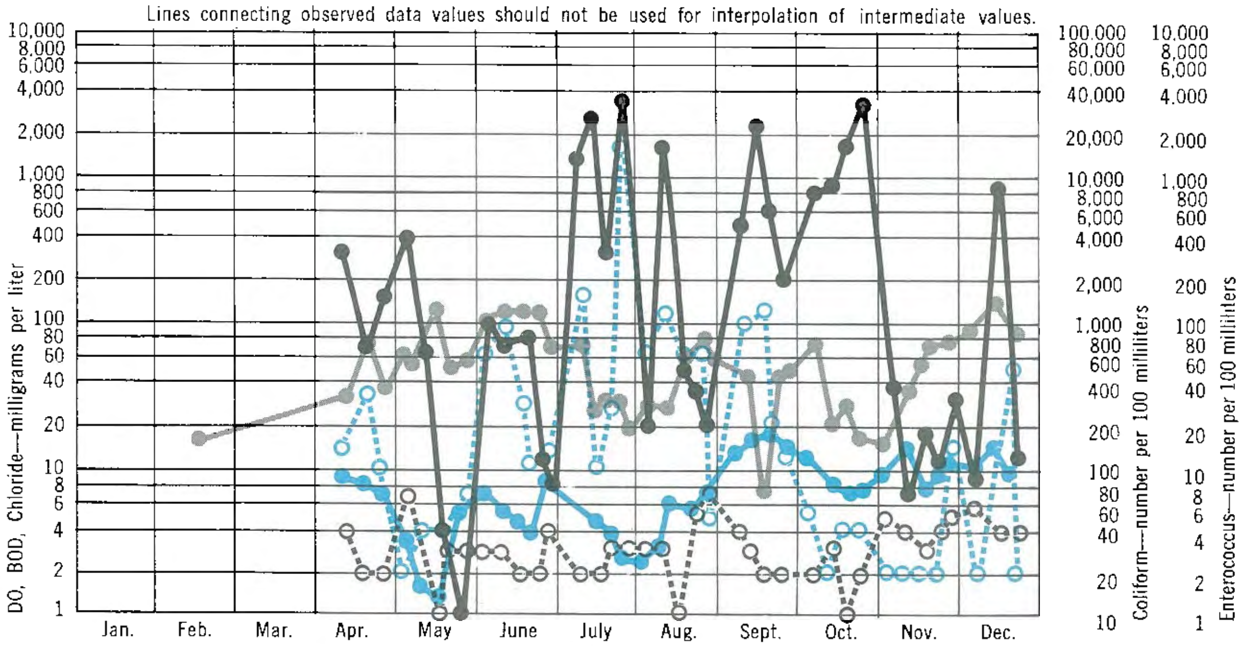


SUMMARY OF OBSERVED STREAM CONDITIONS—KASKASKIA RIVER—1959 THROUGH 1965

FIGURE 14

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha pc/l	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses	66	56	10	163	164	164	38	4	4	20	20
Observed Maximum	85	14.6	180	480	640	8.5	9	7	—	44,000	6,100
Observed Minimum	33	3.2	9	4	80	6.4	—	—	—	2	2
Average (Median*)	61	7.7	32	53	339	7.6*	2	2	—	4,035	502

OBSERVATIONS OF STREAM CONDITIONS
BIG MUDDY RIVER • MURPHYSBORO
1965



SUMMARY OF OBSERVED STREAM CONDITIONS—BIG MUDDY RIVER—MURPHYSBORO, 1964 THROUGH 1965

FIGURE 15

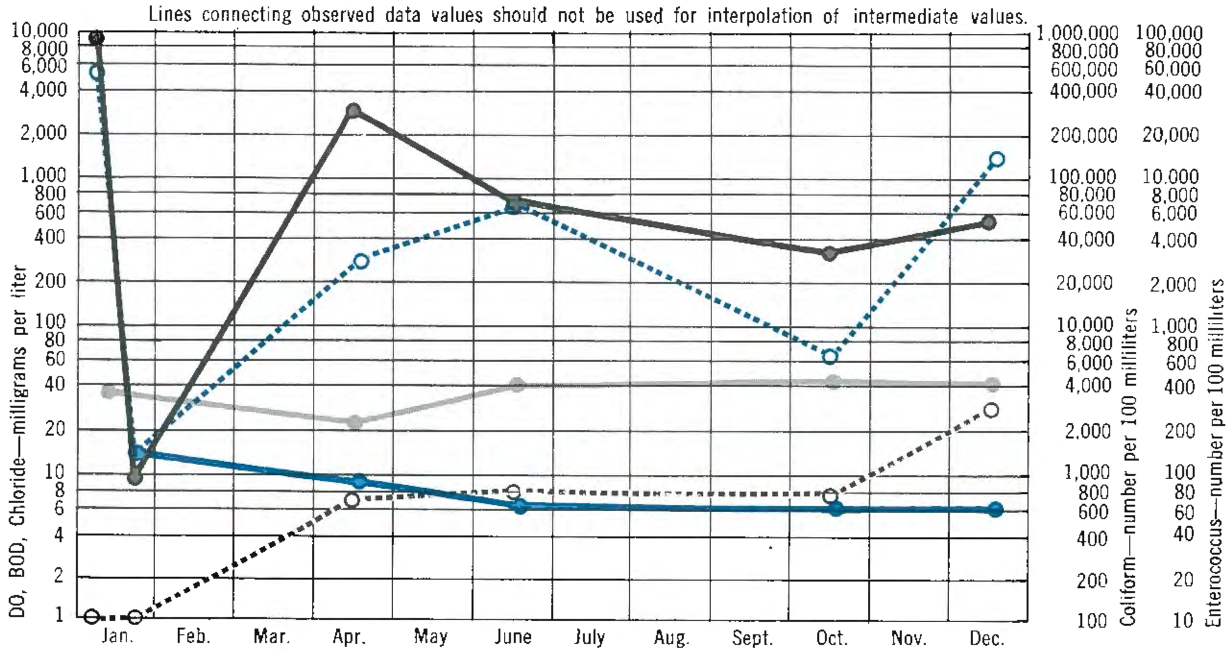
	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses	— —	36	47	45	50	48	41	43	43	40	40
Observed Maximum	— —	16.5	650	310	770	8.5	8	6	37	34,000	1,700
Observed Minimum	— —	1.2	5	7	84	6.7	1	—	—	10	2
Average (Median*)	— —	7.6	81	67	323	7.2*	3	1	12	5,545	75

Figure 13. Mississippi River at East St. Louis— As the Mississippi flows from Canton, Missouri, to East St. Louis, it undoubtedly picks up significant waste loads. However, its volume of flow is also increased, with the result that the quality is also improved, as measured by comparable characteristics at the two sampling locations. At East St. Louis, coliform levels in March, April, and May 1965 were 2400 per 100 ml or less.

Figure 14. Kaskaskia River at Shelbyville— In 1965, dissolved oxygen levels in the River were consistently within a narrow range, from 5.2 to 10.8 mg/l, and BOD values were less than 5 mg/l, with the exception of September, when they reached 9.0 mg/l. The stability of these characteristics is evident from the summary of 1959 to 1965 conditions, which shows that DO and BOD values have averaged 7.7 and 2 mg/l, respectively. Coliform counts are not significantly excessive; they ranged from 60 to 44,000 per 100 ml in 1965, and averaged 4035 per 100 ml during the 1959 through 1965 period.

Figure 15. Big Muddy River at Murphysboro— Dissolved oxygen in the Big Muddy fell below 4 mg/l in May, June, July, and August 1965. This was well below the two-year average of 7.6 mg/l. BOD was not excessive; it ranged from 1 to 8 mg/l. The number of coliforms observed was highest in July, August, September, and October 1965, and reached a maximum of 35,000 per 100 ml. Chloride levels generally were high, ranging from 7 to 140 mg/l.

OBSERVATIONS OF STREAM CONDITIONS SALT FORK OF THE VERMILION RIVER, URBANA • 1965

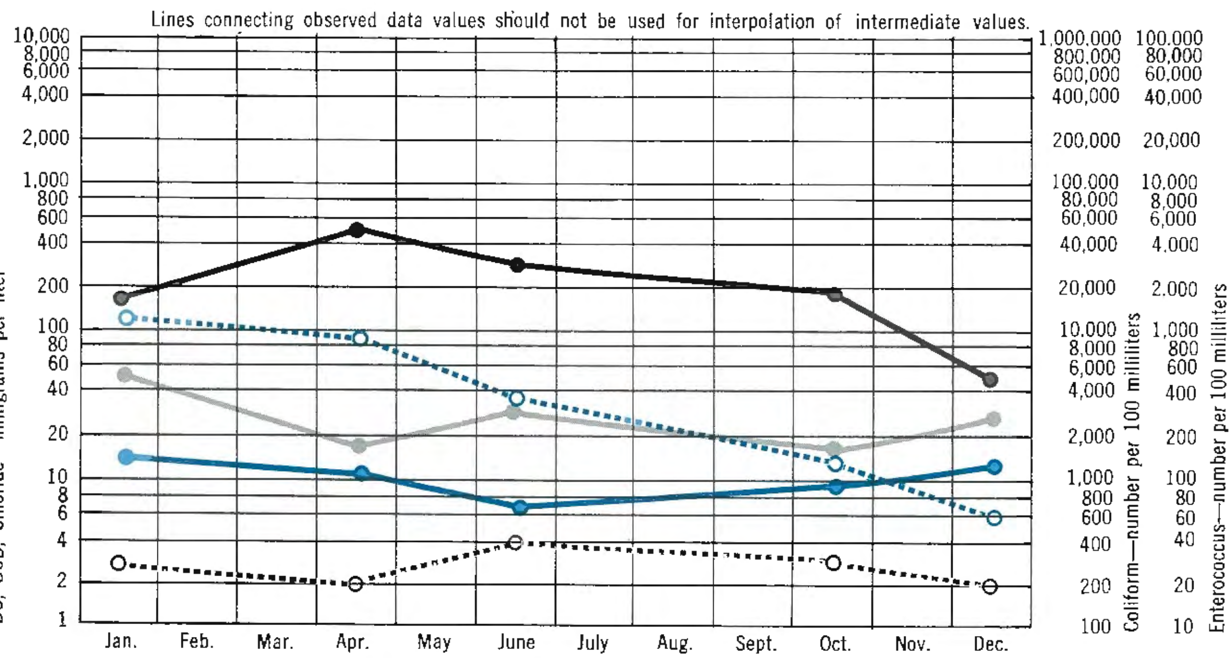


SUMMARY OF OBSERVED STREAM CONDITIONS—SALT FORK RIVER—URBANA, 1964 THROUGH 1965

FIGURE 16

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	6	7	6	6	6	6	9	6	6	9	9
Observed Maximum —	74	13.6	50	50	328	8.2	71	3	19	14,000,000	1,500,000
Observed Minimum —	34	2.8	10	21	200	7.4	1	—	—	940	150
Average (Median*) —	55	7.2	32	38	264	7.6*	19	—	10	2,519,215	188,032

OBSERVATIONS OF STREAM CONDITIONS VERMILION RIVER • DANVILLE • 1965

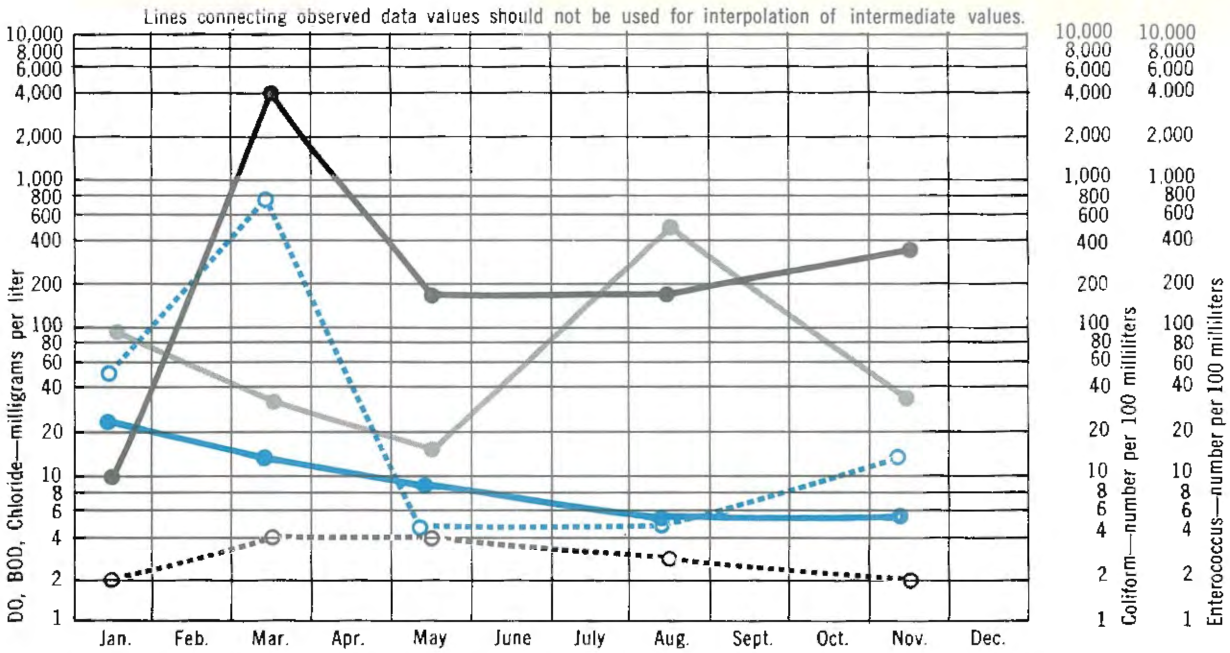


SUMMARY OF OBSERVED STREAM CONDITIONS—VERMILION RIVER—DANVILLE, 1958 THROUGH 1965

FIGURE 17

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	17	16	17	17	17	17	14	17	17	16	16
Observed Maximum —	82	13.8	950	68	470	8.5	10	22	430	440,000	15,000
Observed Minimum —	34	4.6	6	10	140	6.8	2	—	—	390	6
Average (Median*) —	56	8.9	121	30	311	7.6*	4	4	34	82,167	3,137

OBSERVATIONS OF STREAM CONDITIONS
LITTLE WABASH RIVER • LOUISVILLE
1965



SUMMARY OF OBSERVED STREAM CONDITIONS—LITTLE WABASH RIVER—LOUISVILLE, 1958 THROUGH 1965

FIGURE 18

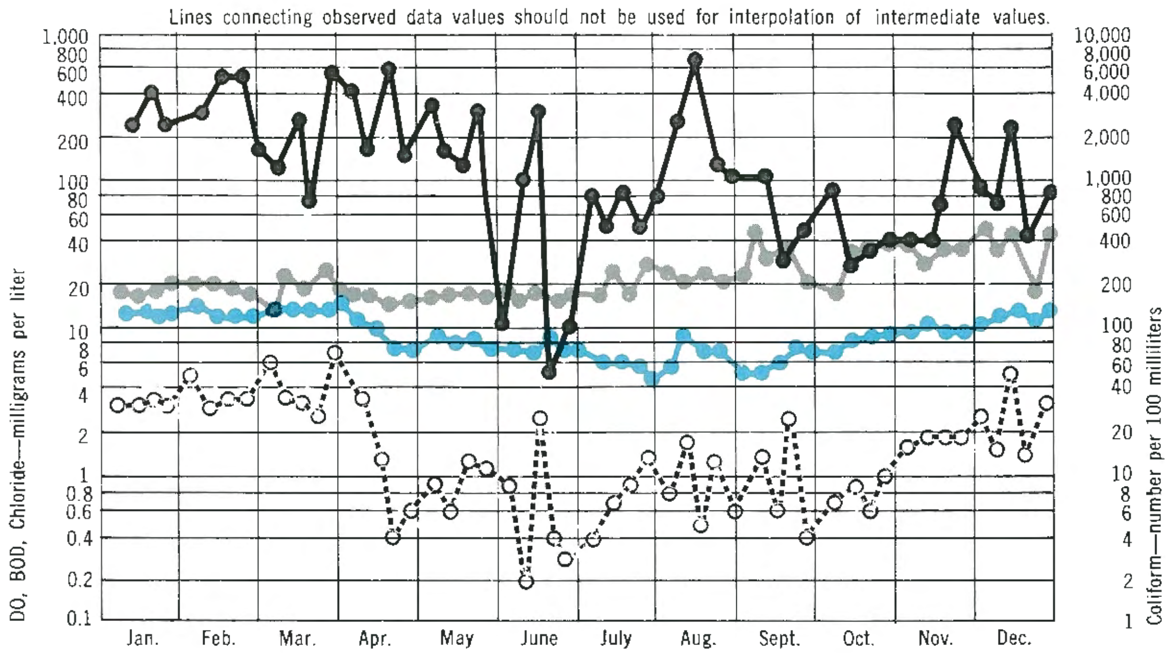
	Temp. Deg F	OD mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha pc/l	Radioactivity Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses —	14	14	15	14	15	15	13	14	14	14	14
Observed Maximum —	82	—	450	500	308	8.5	5	15	493	26,000	1,800
Observed Minimum —	40	3.0	11	7	—	6.9	—	—	—	10	—
Average (Median*) —	63	9.5	108	62	173	7.2*	2	3	66	3,110	209

Figure 16. Salt Fork of the Vermilion River at Urbana— Dissolved oxygen concentrations in 1965 ranged from 6.4 to 13.6 mg/l and averaged 8.5 mg/l, which exceeds the 1964 through 1965 average. However, BOD values of 28 and 71 mg/l were observed in January and December. In general coliform levels are high; they ranged from 940 to 960,000 per 100 ml in 1965, and averaged 2,519,000 for the 1964 through 1965 period. This station is located near the headwaters of the stream, where the volume of water available for carrying wastes is often critically low.

Figure 17. Vermilion River at Danville— Biochemical oxygen demand values for 1965 were consistently lower than the 1958 through 1965 average of 4 mg/l, and DO concentrations ranged from 7.2 to 13.8 mg/l. Coliform and enterococci levels were much reduced from those observed in the tributary Salt Fork at Urbana. Coliforms ranged from 5000 to 47,000 per 100 ml, all of which are higher than desirable for water intended for recreational use, and some of which are higher than the limits for water supply use.

Figure 18. Little Wabash River at Louisville— The observations show the Little Wabash to be generally in good condition with respect to pollution. The highest coliform level observed in 1965 was 4100 per 100 ml, and 26,000 was the maximum for the 1958 through 1965 period. The average coliform count from 1958 through 1965 was 3110. Dissolved oxygen concentrations were satisfactory, as were BOD levels. Chloride content was the only observed characteristic that was excessive; it reached 340 in January and 231 mg/l in May 1965.

OBSERVATIONS OF STREAM CONDITIONS
OHIO RIVER • CAIRO • 1965



SUMMARY OF OBSERVED STREAM CONDITIONS—OHIO RIVER—CAIRO, 1964 THROUGH 1965

FIGURE 19

	Temp. Deg F	DO mg/l	Turbidity	Chloride mg/l	Hardness mg/l	pH	BOD mg/l	Radioactivity Alpha	Beta pc/l	Coliform No. per 100 ml.	Enterococcus No. per 100 ml.
No. of Analyses	265	258	257	261	257	—	256	76	142	177	—
Observed Maximum	86	18.4	800	57	220	—	7.4	59	771	2,600,000	—
Observed Minimum	32.3	1.3	12	4	75	—	0.1	0	0	20	—
Average	60.2	9.8	132	19	129	—	1.9	4.4	41.7	22,589	—

Figure 19. Ohio River at Cairo—Long-term data on stream conditions at Cairo are not available; data presented are much less conclusive than information for other stations. Coliform, enterococcus, chloride, and BOD levels are relatively low in comparison to other streams. Undoubtedly, the volume of water flowing is large in comparison to waste loads carried, and this dilution accounts for the low levels of the observed characteristics.

THE ILLINOIS RIVER SYSTEM

At present, the quality of the water in the Illinois River system ranges from good to severely degraded; the degree of pollution and the consequent impairment of water use varies from place to place and with the seasons of the year.

The Illinois River system consists of the main stem of the River and its tributaries, including the canal system in the Chicago area. Specifically, the upper system consists of the North and South Branches of the Chicago River, the canal from Wilmette to the Chicago River, the Chicago Sanitary and Ship Canal, the Calumet-Sag Channel, and the DesPlaines and DuPage Rivers to their confluence with the Kankakee. The lower system consists of the Kankakee, Fox, Vermilion, Spoon, Sangamon, and their tributaries.

Organic waste loads imposed on the upper tributary system above the Kankakee River junction exceed the River's natural capacity for waste assimilation, despite the dilution water diverted from Lake Michigan. Waste loads seriously deplete oxygen reserves in several critical reaches of the Chicago Sanitary and Ship Canal system. In warm weather, the oxygen (DO) levels reach zero and remain at or near zero for extended periods. The resulting septic condition is offensive, and even coarse fish cannot live in these waters.

Until these conditions are corrected, use of the Illinois River and the upper system will be limited largely to carrying wastes, for navigation, and as a floodway. Man may desire to use the River for a number of other purposes, but this is impossible under present conditions. For example, at Joliet, the DesPlaines River flows through the city, but the quality of the water is too poor for it to be used for water supply or for recreation.

In the canal system through the Chicago area, an artificial temperature rise of 15 to 18 degrees Fahrenheit, in addition to the normal seasonal variations, is caused by inputs of heat from cooling water discharged by power generation plants and from sewage treatment plant effluents. This temperature rise reduces the oxygen capacity of the canals, increases the rate of oxygen consumption, upsets the cycle of aquatic life, and reduces the efficiency of the water for re-use for industrial cooling.

The canal system also contains significant quantities of settleable organic and inorganic solids, which cause deposits and exert a heavy and continuous demand on the oxygen resources of the stream.

Biological degradation is especially evident in the upper tributaries, such as the Fox, DuPage, and DesPlaines Rivers, and in the main canal system above the Kankakee River. Over-enrichment of the aquatic environment has caused prolific nuisance growths of algae in some sectors; oxygen depletion and other detrimental effects have inhibited the establishment of well-balanced aquatic life in the upper river system. Gradual recovery takes place downstream, and a more-balanced aquatic life is found in the extreme lower Illinois River and in downstream tributaries.

Although they are treated to a high degree by conventional methods, the massive waste loads discharged by the Chicago Metropolitan Area create both a primary degrading effect in local waters and secondary effects as far as 200 miles downstream.

After initial recovery of dissolved oxygen in the main stem below the Kankakee River junction, a second major zone of oxygen depletion begins above Peoria and extends for several miles below the City. A part of this oxygen sag is waste input from the Peoria-Pekin area. By the time they reach Peoria, the wastes originating in Chicago are in the second, or nitrogenous, stage of the decomposition reaction and are believed to be a contributing cause of the downriver oxygen depletion.

Bacterial pollution is evidenced by high coliform and fecal streptococcus organisms. Although highest concentrations are found near the cities, concentrations throughout most of the Illinois River system are so high that they are a danger to the health of people who use the streams for body contact sports such as swimming and water skiing. Indeed, swimming or water skiing in any of the streams and rivers of Illinois is not recommended.

Varying degrees of stream pollution have been accepted because it has been considered necessary for watercourses to carry away wastes. The degree of pollution permitted should be defined by the present and potential uses of the particular section of the watercourse. The Illinois River system is polluted to a high degree for some uses and to a low, or tolerable, degree for others. It is polluted to the degree that, in its present condition, much of it is unsuitable for water skiing and swimming and not good for commercial or sport fishing. Paradoxically, the water from the Illinois can still be used for drinking, if properly treated, and can be used to artificially recharge the ground water. The Illinois River also moves a great deal of shipping tonnage, and carries away great volumes of waste materials.

The water resources of the Illinois River system are presently used for municipal and industrial water supply, navigation, as fish and wildlife habitat, for recreation, stock watering, irrigation, power generation, and for the assimilation and transport of water-borne wastes. Sport fishing is extensive in the main stem of the River below Ottawa and in its tributaries. Commercial fishing, although not as extensive as in former years, is still important below Starved Rock Pool. The many flood-plain lakes of the Illinois Basin are famed

waterfowl shooting areas and important stopover points for birds on the Mississippi Flyway migration route. More than 5 million visitors use the recreational areas in the Illinois River Basin each year.

WASTE LOADS

In 1960, the river system's total combined domestic and industrial waste load before treatment was equivalent in biochemical oxygen demand (BOD) to the untreated wastes of 10.5 million people, of which a 9.1 million population equivalent (PE) is from the upper Illinois River system, above the junctions of the Kankakee and DesPlaines Rivers. Sources of municipal wastes in the upper Illinois River system are shown in Figure 20.

Treatment reduces the waste load discharged from municipal plants from a population equivalent of 10.5 million to 1.4 million. Industries with separate sewer systems discharge an additional waste load of 946,000 PE to the Illinois system. No increase in discharged waste loads is foreseen by 1980, because increased levels of treatment will offset the increase in population. However, reduction in current effluent load will be offset by increased industrial and population effluents between Morris and Peoria. By 2020, the total waste load to streams in the system is expected to be a BOD population equivalent of 4 to 4.5 million after treatment. The largest concentration of industry is in the Chicago area. These industries produce metals, food, paper, chemicals, and related products. There is also a sizeable industrial development between Morris and the Peoria-Pekin area.

Using the population equivalent of the organic load discharged to the stream as a baseline, the physical and biological conditions of the Illinois River are not as severely degraded today as they were 40 years ago. To demonstrate this, a 1922 Public Health Service study can be compared with a more recent study made in 1960 through 1962.

In 1922, the domestic organic load discharged to the main stem of the Illinois Waterway was approximately 253 tons, or a population equivalent of about 3,020,000 persons. For similar domestic loadings in 1960 through 1962, the tonnage was approximately 82, with a corresponding population equivalent of 1 million persons, about a 66 percent reduction.

In 1922, the industrial waste load discharged to the main stem of the Illinois River was about 267 tons, or a population equivalent of 3,200,000 persons. In 1960 through 1962, the industrial contribution was 74 tons or a population equivalent of approximately 900,000, about a 72 percent reduction.

In summary, during the past 40 years, the organic loading of waste discharges to the Illinois River is estimated to have been reduced 70 percent—from a population equivalent of 6,220,000 to 1,900,000. But even as this dramatic reduction in waste loadings has been taking place, equally important changes have occurred in the characteristics of the wastes and of the River, and in the needs for and uses of the River's resources. Many of these changes negate the importance of quality, as measured by the criteria of waste loadings, and generate other criteria requiring much higher quality.

Peoria now depends on the Illinois River for its water supply; hence, bacterial concentrations, taste and odor producing organisms, and chemical quality are important considerations. The average daily pumpage by industry for cooling and process water on the Illinois River today is approximately 1.4 billion gallons—much more than 20 to 30 years ago, when Chicago was allowed to divert 4.2 billion gallons of Lake Michigan water per day to the River, as compared to the present 0.97 billion gallons. Chemical plants whose waste products contain phosphates, fluorides, exotic organics, and toxic materials did not exist 20 to 30 years ago.

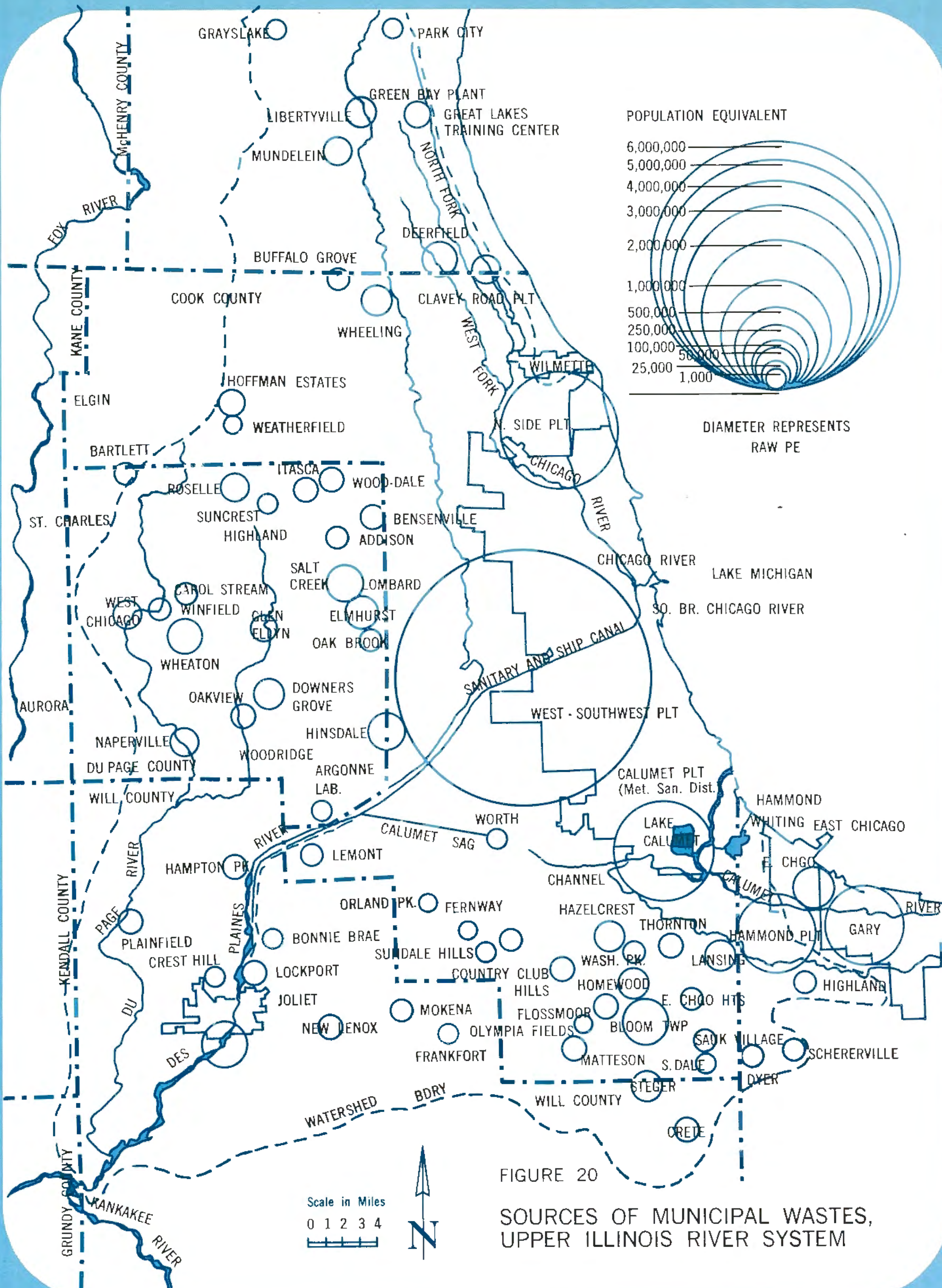


FIGURE 20

SOURCES OF MUNICIPAL WASTES, UPPER ILLINOIS RIVER SYSTEM

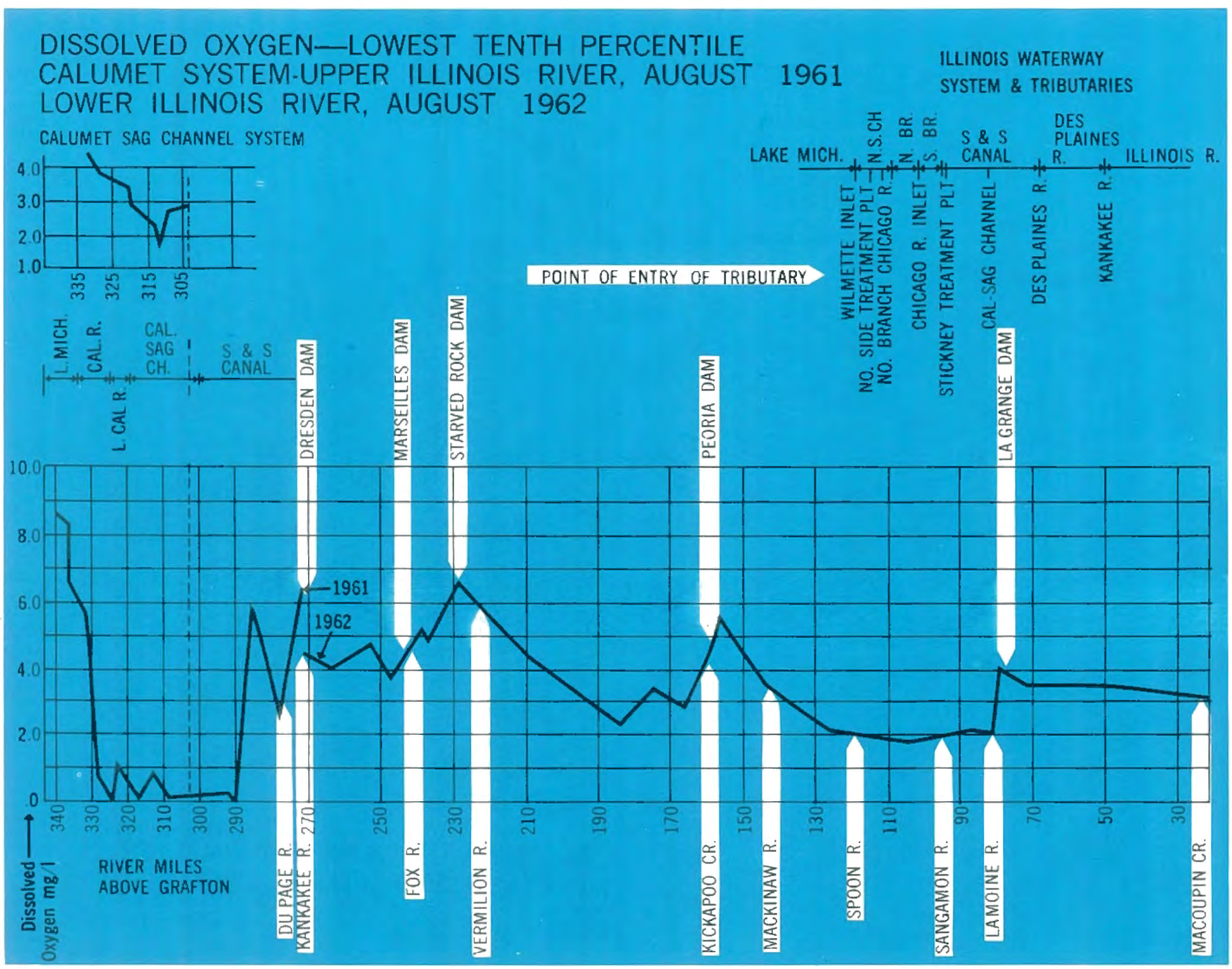
Boating enthusiasts, swimmers, water-skiers, fishermen, and conservationists challenge other users for their share of the stream. Each use dictates its own criteria for quantity and quality. Proposed standards of quality for the Illinois are given in a later section of this chapter.

Coupled with the increasing need for greater quantities of better quality water is a need to determine, for selected sectors of the Illinois River, its capacity to assimilate and dilute wastes of municipal and industrial origin. Physically, the Illinois River is no longer the flowing stream of 40 years ago. Construction of a system of locks and dams has transformed it into a series of seven navigational pools, in which the dry-weather streamflows are about 40 percent less than they were twenty years ago.

In the lower Illinois in one period of study, serious oxygen depletion was observed from Mile Point 230 at Starved Rock Dam to Mile Point 161 at the Peoria Dam, and from Peoria Dam downstream as far as Mile Point 24 at Macoupin Creek. In the first zone, oxygen levels decreased from about 8 mg/l to 2 mg/l; in the second zone, after some recovery by re-aeration at Peoria Dam, levels again declined. These findings are the lowest tenth percentile levels from the data collected during that period, as illustrated in Figure 21. This severe depletion of oxygen in the downstream portion of a large river like the Illinois was unexpected, since there are no known sources of waste of sufficient magnitude to cause such depletion below Chicago. However, in reviewing the other chemical data obtained concurrently, it was observed that the DO decline was paralleled by a marked reduction in ammonia nitrogen and a corresponding rise in nitrate nitrogen. Since ammonia nitrogen is known to exert a sizeable oxygen demand, it is concluded that the downstream oxygen depletion was the result of oxidation of the ammonia to nitrate. Depletion in the zone below Peoria Dam is partially attributed to additional waste discharges from the Peoria-Pekin area, but such load inputs are not large enough to account for the total oxygen demand that was exhibited.

With the exception of the Sangamon River below

FIGURE 21



Decatur, no serious depletions of dissolved oxygen were observed in the major tributary streams of the Illinois River.

Biochemical Oxygen Demand (BOD)

The biochemical oxygen demand, as measured by the standard five-day procedure, indicated numerous points of input of oxygen-demanding wastes into the Illinois River system. The effects of these inputs were revealed in the DO levels found in these streams, as well as in the residual BOD which was observed.

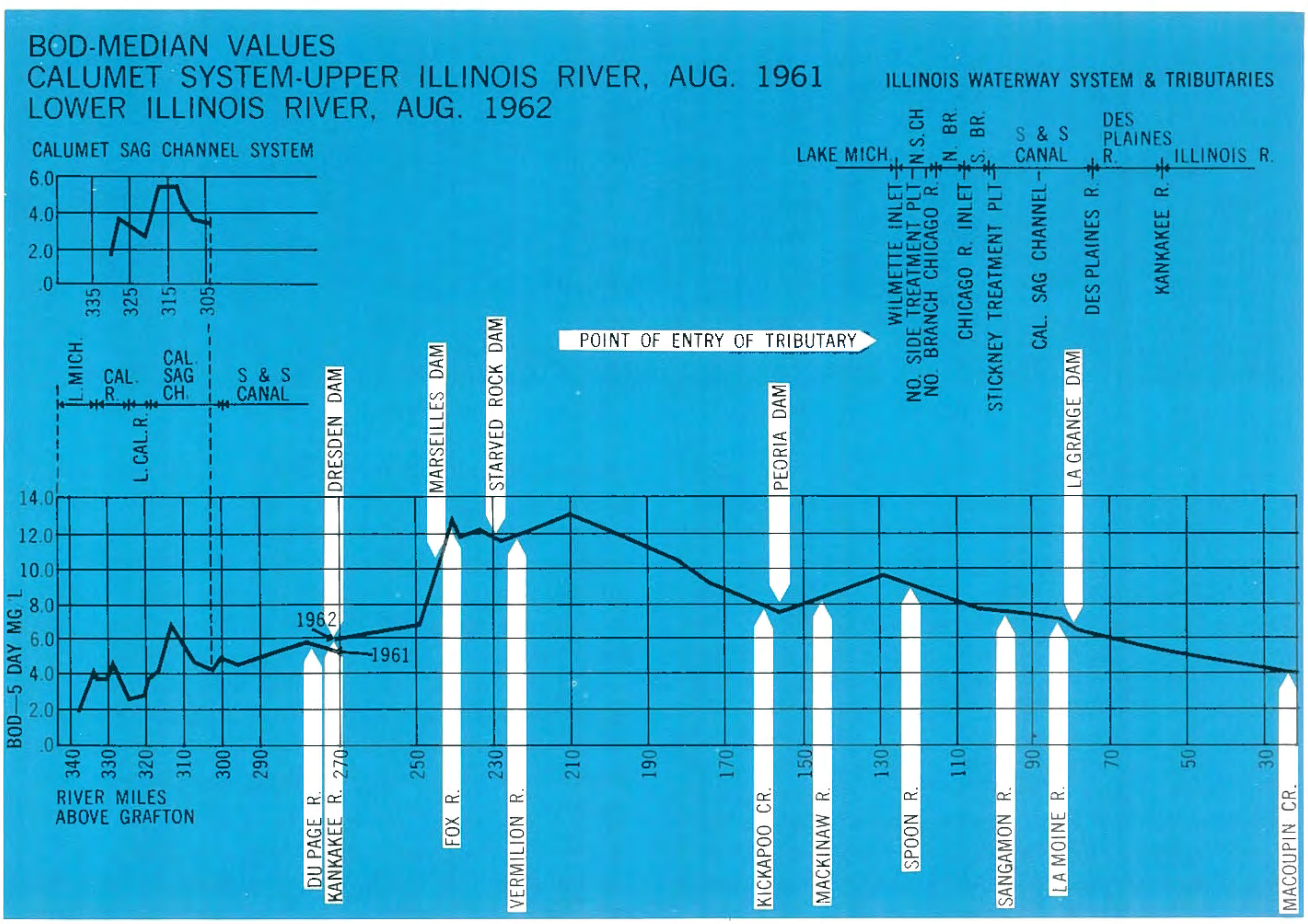
The Lake Michigan waters that entered the upper part of the River carried a natural BOD ranging from 1.0 to 4.0 mg/l, which was rapidly increased by waste discharges from the Chicago Metropolitan Sanitary District treatment plants, storm overflows, industrial outfalls and miscellaneous sources. This resulted in a significant rise in BOD levels throughout the length of the upper River. (Figure 22).

In the lower Illinois, the BOD resulting from the Chicago area wastes appears at first to gradually diminish, as would be expected in the normal process of stream assimilation. However, a sharp rise in BOD observed during the summer study period in the reach between Dresden and Peoria was unexpected. From these observations, it was concluded that the secondary oxygen demand resulting from the nitrogenous phase of the BOD reaction is the probable cause of the increase in BOD and the corresponding drop in DO. Serious consideration must be given to ways and means of excluding or treating the sizeable ammonia loads now being contributed by the Chicago wastes. Below Peoria, further increases in BOD result from the waste discharged from that area, with corresponding influence on the DO levels found in this stretch of stream.

These findings clearly show that the waste discharges of the Metropolitan Chicago Area are a major source of BOD entering the main stem, and their influence extends through the entire length of the Illinois River. These wastes, with the wastes from all municipal and industrial areas along the River, are the principal sources of BOD in the Illinois River.

With the exception of the Fox River, the BOD levels of the tributaries discharging to the Illinois River were significantly below the levels found in the main stem, which indicates that the wastes discharged to these tributaries were assimilated satisfactorily within the tributary limits.

FIGURE 22



POLLUTION CONTROL

East St. Louis treatment plant under construction.

Water pollution control in Illinois is administered under the 1951 Sanitary Water Board Act. (A description of the powers and functions of the Board is given in Chapter IX.) The Sanitary Water Board Act declared it to be the public policy of the State to maintain reasonable standards of purity of the waters of the State consistent with their use, including their use in the final distribution of the water-borne wastes of the economy.

METHODS OF WASTE TREATMENT

The Sanitary Water Board Act provides that no wastes be discharged into any waters of the State without first being given the degree of treatment necessary to prevent the pollution of such waters. The Board establishes regulations, largely based on fundamental sanitary engineering knowledge, for planning and design of waste treatment facilities, and reviews and evaluates design proposals. Each proposed facility is considered individually in relation to the type, strength, and volume of waste to be treated; in relation to the character, size, and waste-assimilation capacity of the waterway receiving the wastes; and in relation to the immediate and projected needs of the community to be served. The regulations provide criteria for the methods and degree of sewage treatment. Methods of sewage treatment are:

Primary treatment usually consists of screening devices and settling tanks to remove floating debris and settleable solid materials. Also included are facilities for the de-watering and disposal of settled solids. Aeration or mechanical agitation may be included to improve settling characteristics. The principal objective of primary treatment is the reduction in the amount of suspended inorganic and organic solids. Primary treatment methods are relatively ineffective in reducing dissolved organic materials commonly related to the "strength" of sewage, as measured by the BOD test. Generally, the efficiency required of primary treatment is such that it reduces suspended solids by about 50 percent and BOD by about 35 percent.

Intermediate treatment results when any additional method, such as aeration or chemical treatment, is added to primary treatment. Substantial percentages of very finely divided particulate matter are removed, in addition to the suspended solids removed by primary treatment. Efficiency improves so that about 60 percent of both BOD and suspended solids is removed.

Secondary treatment includes those methods, usually biologic in nature and aimed at purification of dissolved organic wastes, which are added to primary treatment and result in removals of 85 to 95 percent of the BOD and suspended solids. The efficiency of the removal is dependent upon design factors and the type or combination of facilities provided. Secondary treatment methods include trickling filters and several modifications of the activated sludge process.

Trickling filters consist of an artificial bed of coarse material, such as broken stone, clinkers, slate, slats, or brush. Sewage is distributed over the filters and applied in drops, films, or spray from troughs, drippers, moving distributors, or fixed nozzles. It trickles through the filters to the underdrains. This gives opportunity for the formation of biological growths or slimes on the surfaces of the filter bed material, which clarify and oxidize the sewage by utilizing some of the waste materials for growth and energy. Settling tanks follow trickling filters to capture the solid materials escaping from the trickling filter with the treated sewage.

The activated sludge process is a method of biological sewage treatment in which a mixture of sewage and activated sludge is agitated and aerated. The activated sludge, upon which the organisms responsible for clarifying and oxidizing the sewage are developed and supported, is subsequently separated from the treated sewage by sedimentation and wasted or returned to the process as needed. The treated sewage overflows the weir of the final settling tank in which separation from the sludge takes place. Several modifications of the activated sludge process have been developed which add significantly to its flexibility and efficiency.

Trickling filters and activated sludge are comparable to the extent that both make use of biological organisms in an environment containing oxygen to clarify and oxidize organic waste materials.

Tertiary treatment—Historically, secondary treatment has often been called complete. This is a misnomer since none of the methods of secondary treatment have been 100 percent efficient. The growing need for treatment exceeding the capabilities of existing secondary methods has forced the development of tertiary, or third-stage treatment. Tertiary treatment may consist of extensions or modifications of secondary treatment, additional forms of chemical treatment, electro-chemical methods, carbon filtration, and others. The criteria for determining required methods and degrees of waste treatment are given in Table 2.

TABLE 2
CRITERIA FOR DETERMINING REQUIRED METHODS AND DEGREES OF WASTE TREATMENT

Degree of Treatment Required	Criteria Used Since the 1951 Sanitary Water Board Act: BOD Removal Required	BOD Concentration Permitted in Treated Effluent	Remarks	Criteria Proposed for Adoption in 1967
Primary	35%	130 mg/l	—	Same—but use will be permitted only along Mississippi and Ohio Rivers.
Secondary	85%	30 mg/l	For trickling filter treatment plants	Same—but ratio of minimum volume of streamflow must be 3 times the volume of effluent from treatment plant. (i.e. Dilution Ratio (DR) — 3:1.
Secondary	90%	20 mg/l	For activated sludge treatment plants	Same—but minimum DR must be no less than 2:1.
Secondary	95%	10 mg/l	For modified activated sludge plants	Same—DR may be less than 1:1.
Chlorination (Disinfection)	—	—	Required in special cases only	Generally required of all sewage treatment works.
Tertiary (for BOD reduction)	—	—	Required in special cases only	Continue as special requirement where stream conditions warrant.
Tertiary (for Suspended Solids Reduction)	—	—	Required in special cases only	Required where maximum suspended solids removal is required.

MUNICIPAL AND INDUSTRIAL SEWAGE TREATMENT

About half of the more than 10 million people in Illinois live within the boundaries of the Metropolitan Sanitary District of Greater Chicago. A population equivalent of more than 3 million is reflected by additional industrial wastes originating in the District. These combined wastes are treated in three major and several smaller treatment plants with organic removal efficiencies in excess of 90 percent. The Lake County communities bordering Lake Michigan obtain their water supplies from and discharge treated sewage effluent to Lake Michigan.

Of the 1258 incorporated municipalities in Illinois, 650 have comprehensive sewer systems, and about 637 of these are served by sewage treatment works. Almost all of the larger municipalities which were without treatment facilities until recently are in the East St. Louis Metropolitan Area, where wastes are discharged to the Mississippi River. All of these communities now have sewage treatment facilities under construction or in operation. Although 608 incorporated towns have no sewer systems, 427 of these have populations of less than 500. The remaining 181 municipalities have an average population of 860, and nearly all need sewer systems to correct local nuisances and, in some instances, to correct minor stream pollution.

About 1.5 billion gallons of municipal sewage is treated each day; another 2 billion gallons a day is industrial process water. With a combined streamflow of 23 billion gallons a day in the interior streams, a fair degree of dilution appears to be available in an average situation. However, adequate dilution may not be available at the particular point of discharge, especially during periods of low precipitation. When waste quantities are proportionately large, stream pollution results.

Illinois industry uses a total of about 14.4 billion gallons of water per day. Thirteen billion gallons of this is used for cooling at thermal power stations and for similar uses in industrial processes that do not contaminate the water, which is then available for re-use. The other 1.4 billion gallons is process water, which needs varying degrees of treatment. As Illinois industry grows, the competition for water will be greater, but the demand has not yet become critical, except in localized instances.

Industrial pollution will continue to be concentrated in certain areas. The northern part of the State has a heavy density of metal finishing plants which discharge wastes that have severe toxic effects on fish and wildlife. Canning industries, generally located in the central and northern part of the State, cause seasonal pollution problems. Chemical oil refining and food processing wastes are near the top of the list as potential sources of pollution. In southern Illinois and some other sections of the State, acid wastes from coal mining operations and brine from petroleum production are chronic and serious sources of pollution. A summary of the development of municipal sewer and sewage treatment systems in relation to population growth is given in Table 3.

The method and degree of waste treatment required in Illinois depends upon the strength and volume of the wastes, and upon the character and capacity of the receiving stream.

TABLE 3 ILLINOIS SEWAGE SUMMARY, 1880 THROUGH 1965

Year	Total Illinois Population	Total Illinois Population Tributary to Municipal Sewers	Total Illinois Population Tributary to Municipal Sewage Treatment Works	Percent Total Population Sewered	Percent Total Population Tributary to Sewage Treatment Works	Percent Sewered Population Tributary to Sewage Treatment Works
1880	3,077,871	671,831	0	21.8	0	0
1890	3,826,352	1,499,327	0	39.2	0	0
1900	4,821,550	2,480,785	21,877	51.5	0.45	0.88
1910	5,638,591	3,413,120	165,781	60.6	2.94	4.86
1920	6,485,280	4,481,602	424,706	69.2	6.55	9.48
1930	7,630,654	5,837,511	2,582,898	76.5	33.80	44.30
1940	7,897,241	6,065,726	5,461,756	76.8	69.20	90.20
1950	8,712,176	6,708,545	6,196,777	77.0	71.20	92.40
1960	10,012,612	7,659,473	7,388,658	76.5	73.80	96.50
	Total Population (estimated)	*Tributary to Sewer Systems—Public & Private	*Tributary to Sewer Treatment Works—Public and Private			
1965	10,650,000	8,629,000	8,607,000	81.0	80.8	99.7

*Includes populations in 1) unincorporated areas of sanitary districts, subdivisions, housing, apartments, nursing homes, and trailer parks; 2) State institutions with their own sewage works or connected to municipal systems.

DILUTION AND STREAM PURIFICATION

Legitimate uses of streams change as the economy and affluence of the State change. The increase in recreational use of streams and lakes for boating and fishing has had the greatest impact on pollution control measures. Impoundment of streams in reservoirs as a source of public water supply also increases the need for higher degrees of sewage treatment. Policy and administrative changes have been made to adjust pollution control measures to changing stream usage.

Basically, secondary or biologic treatment is now required for all sewage works, except for those on the Mississippi and Ohio Rivers. These Rivers provide enormous quantities of water for dilution; primary treatment consisting of screening and sedimentation for suspended solids removal is considered adequate. In many areas of the State supplementary treatment and disinfection of the effluent is required. Each new or expanded facility is evaluated as to its effect on stream quality in relation to stream use.

It is evident that many small streams in heavily populated areas cannot be maintained for all possible uses. Therefore, limited pollution will exist. These streams will be maintained so as not to create a nuisance, or obnoxious or otherwise esthetically objectionable conditions. Such streams will not be useable for water supply, for fishing, or for other recreation. Should the public demand that these streams be made adequate for these uses, treated effluents must be removed completely from them, or the degree of treatment must be increased.

The Sanitary Water Board has not previously classified Illinois streams according to degrees of permissible pollution, but has administered the statutes with flexibility, depending upon the particular circumstances, including downstream uses of receiving streams. However, certain desirable limits of pollution have been generally applied.

In most cases, the dissolved oxygen content is the control in determining pollution, and the goal is to maintain stream quality that will support fish and aquatic life. Water that meets this standard is also protected for other uses, because dissolved oxygen helps maintain the waste assimilation, or self-purification, capacity of streams. Streams which meet this standard are suitable for use for water supply, recreation with partial body contact, fish and aquatic life, and for wildlife or livestock watering.

Water for dilution of effluents from sewage and industrial waste treatment plants is a natural and essential use of the resource. The present concept of treatment does not require that water be returned to the stream unimpaired in quality, and in most cases it is not economically feasible to do so. Water requirements for dilution of treated wastes vary with the character of the receiving stream and with downstream water use. More dilution is required in sluggish streams with many deep pools than in fast-moving streams with frequent riffles. The usual ratio for dilution ranges from 1 to 5 or more gallons of streamflow to each gallon of treated effluent.

Discharge of wastes, even when treated, will cause an unsatisfactory quality in receiving waters whose waste assimilation capacity is exceeded. This condition usually, but not always, occurs during periods of warm weather and low flow. The need for adequate flows in receiving streams must be recognized, if the water quality is to be maintained at acceptable levels. If sufficient dilution is not available, a higher degree of treatment or restriction on the amount of treated effluent which is allowed to be discharged to the stream is required.

At times of low streamflow, sufficient water is not available at present for dilution of the effluent from sewerage works at Decatur, Champaign-Urbana, Danville, and Aurora, and from all facilities on the DuPage River, Salt Creek, DesPlaines River, Chicago Sanitary and Ship Canal, and Calumet-Sag Channel. Population growth and anticipated industrial expansion will extend this problem to other areas. Thus, development of additional water supply for dilution, an advanced degree of treatment, or restriction on further increases in discharge to a specific stream may be required to maintain satisfactory conditions in receiving streams.

Surveillance of streams is carried on under a water quality program. Routine samplings are taken at more than 280 selected stream stations and analyzed for a variety of physical, chemical, biological, bacteriological, and radiological qualities. In addition, the Federal Water Pollution Control Administration maintains water quality sampling stations at critical points on interstate streams. Other surveillance data are gathered by inspections, from reports on treatment works operation, and by cooperative efforts of voluntary groups such as sportsmen's clubs, clean stream committees, and sewerage works operators' organizations.

WATER QUALITY STANDARDS

The Federal Government has recently focused attention on the condition of interstate streams. The Federal Water Pollution Control Act, as amended in 1965, places the responsibility on individual states for establishing water quality criteria in interstate waters which will "protect the public health or welfare and enhance the quality of water." If the states do not establish such criteria by June 30, 1967, the Federal Government, through the Pollution Control Administration, will do so. Illinois will propose criteria for interstate streams and forward them to the Pollution Control Administration for approval.

The following criteria apply in Illinois. The criteria under development for interstate streams in Illinois, although more detailed, are generally consistent with these.

General criteria which apply to all Illinois streams:

1. Free from substances attributable to municipal, industrial, or other discharges that will settle to form putrescent or otherwise objectionable sludge deposits;

2. Free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial, or other discharges in amounts sufficient to be unsightly or deleterious;

3. Free from materials attributable to municipal, industrial, or other discharges producing color, odor, or other conditions in such degree as to create a nuisance;

4. Free from substances attributable to municipal, industrial, or other discharges in concentrations or combinations which are toxic or harmful to human, animal, plant, or aquatic life.

Further criteria apply, depending upon the use to be made of stream water as follows:

For a Potable Supply

1. **Bacteria:** Coliform group not to exceed 5000 ml as a monthly average value, nor exceed this number in more than 20 percent of the samples examined during any month, nor exceed 20,000/100 ml in more than 5 percent of such samples;

2. **Threshold-odor number:** Not to exceed 24 (at 60 degrees Centigrade) as a daily average;

3. **Dissolved solids:** Not to exceed 500 mg/l as a monthly average value, nor exceed 750 mg/l at any time. For Ohio River water, values of specific conductance of 800 and 1200 micromhos/cm (at 25 degrees Centigrade) may be considered equivalent to dissolved-solids concentrations of 500 and 750 mg/l;

4. **Radioactive substances:** Gross beta activity (in the known absence of Strontium-90 and alpha emitters) not to exceed 1000 micro-microcuries per liter at any time;

5. **Chemical constituents:** Not to exceed the following specified concentrations at any time:

Constituent	Concentration (mg/l)
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium (hexavalent)	0.05
Cyanide	0.025
Fluoride	1.00
Lead	0.05
Selenium	0.01
Silver	0.05

For Industrial Water Supply Use

The following criteria are applicable to stream water at the point at which the water is withdrawn for use (either with or without treatment) for industrial cooling and processing:

1. **Dissolved oxygen:** Not less than 3.0 mg/l as a daily average value, nor less than 2.0 mg/l at any time;

2. **pH:** Not less than 6.0 nor greater than 9.0 at any time;

3. **Temperature:** Not to exceed 95 degrees Fahrenheit at any time;

4. **Dissolved solids:** Not to exceed 750 mg/l as a monthly average value, nor exceed 1000 mg/l at any time. Values of specific conductance of 1200 and 1600 micromhos/cm (at 25 degrees Centigrade) may be considered equivalent to dissolved-solids concentrations of 750 and 1000 mg/l.

For Aquatic Life

The following criteria are for evaluation of conditions for the maintenance of a well-balanced, warm-water fish population. They are applicable at any point in the stream, except for areas immediately adjacent to sewer outfalls. In such areas, cognizance will be given to opportunities for the admixture of waste effluents with river water.

1. **Dissolved oxygen:** Not less than 5.0 mg/l during at least 16 hours of any 24-hour period, nor less than 3.0 mg/l at any time;

2. **pH:** No values below 6.0 nor above 9.0 and daily average values preferably between 6.5 and 8.5;

3. **Temperature:** Not to exceed 93 degrees Fahrenheit at any time during the months of May through November, and not to exceed 73 degrees Fahrenheit at any time during the months of December through April.

4. **Toxic substances:** Not to exceed one-tenth of the 48-hour median tolerance limit, except that other limiting concentrations may be used in specific cases, when justified on the basis of available evidence and approved by the appropriate regulatory agency.

For Recreation

The following criterion is for evaluation of conditions at any point in water designated to be used for recreational purposes, including such water-contact activities as swimming and water skiing:

1. **Bacteria:** Coliform group not to exceed 1000 per 100 ml as a monthly average value, nor exceed this number in more than 20 percent of the samples examined during any month, nor exceed 2400 per 100 ml on any day.

Future Criteria and Use

With few exceptions, the objective and trend will be toward a water of suitable quality for aquatic life and recreational purposes, but at all times these various water quality use criteria may be applied to various areas of different streams in the State and on an ever-changing basis, dependent upon the local requirements, economic factors, and the change in the environmental character of a particular area of a stream or river basin.

The criteria for interstate waters will be set forth in detail in the State's proposals to the Federal Pollution Control Administration. If approved, these criteria will be declared in effect and will be enforced.

Since the existing conditions, the present and potential use, and the value of the stream for its intended use must all be considered for each body of water, no single standard or set of standards can be established for all Illinois streams. Therefore, the proposed criteria are separated and are different for each body of water. The standards proposed by Illinois vary from the highest possible quality to the lowest acceptable quality.

The water quality criteria have been developed to remedy existing pollution and to provide for future water needs for municipal and industrial supplies, recreation, irrigation, livestock watering, power production, navigation, waste-water assimilation, and esthetic enjoyment.

It is the intention, particularly as related to the Federal grant mechanism, to apply such standards progressively to all streams in Illinois, streams within the state as well as interstate waters.

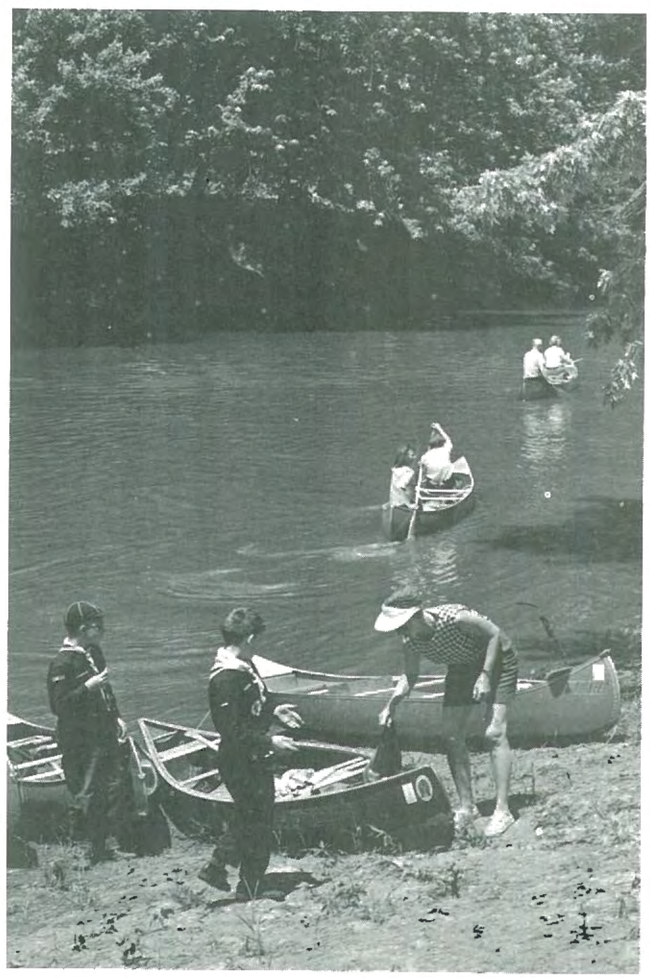
The criteria for upper and lower Lake Michigan as far as the Wisconsin line and for the Calumet River system have already been adopted by Illinois, Indiana, and the Federal Water Pollution Control Administration. They are in effect and will be enforced.

Proposed criteria for the Illinois River system are for recreation standards below Hennepin and in the Peoria Lakes. At various points, standards for industrial and public water supply are proposed, according to the present use of the River. Aquatic life criteria are proposed for the entire River, except for areas immediately adjacent to outfalls.

Recreation standards are proposed for the Mississippi River from the Wisconsin state line to the Alton Lock and Dam Number 26. From Alton Lock to the Ohio River, public water supply standards will apply.

Standards are also proposed for the Ohio and Wabash and their tributaries. The standard for the Ohio and tributary streams between Cairo and Old Shawneetown is for wildlife, fish, and aquatic life. Public water supply criteria are proposed for the Ohio at Elizabethtown, Golconda, and Cairo; for the Wabash at Mt. Carmel; and for the Lower Cache River, Massac Creek, Cache-Post Creek Cutoff, and Seven Mile Creek. That standard is proposed for Sugar Creek, Clear Creek, Brouillettes Creek, and the Little Vermilion and Vermilion Rivers.

Criteria are also proposed for other streams that cross state boundaries—the DesPlaines, Fox, Rock, Kankakee, Iroquois, and their tributaries. These streams will be required to meet standards according to their present use at various points.



CASE STUDIES

Expansion and improvement of sewers and treatment facilities in Illinois municipalities is continuous in a few cities and at ten to twenty year intervals in others. Because of the difficulties in financing capital improvements and the time required for design and construction of facilities, quite often sewerage works are at design capacity or are overloaded before new facilities can be completed. Overloads are caused by unexpected industrial and population growth, higher than estimated peak flows, or excessive infiltration of storm water to the sewer system.

The following case studies describe measures taken by municipalities, sanitary districts, and industries to correct existing water pollution conditions and give estimates of future needs and steps necessary to meet those needs in accordance with the water quality criteria which are established or are being developed. With few exceptions, Illinois communities have a basic plan for development of sewerage systems; it is a responsibility of the Sanitary Water Board to see that such plans are implemented.

CASE STUDY 1. METROPOLITAN SANITARY DISTRICT OF GREATER CHICAGO

The Metropolitan Sanitary District of Greater Chicago has unique problems in disposing of the waste products from a huge urban area without polluting the streams or Lake Michigan. The District has only partially solved the problem, but has proposed a revolutionary engineering solution.

The District (formerly The Sanitary District of Chicago) was organized on May 29, 1889, with the primary responsibility of protecting the water supply from Lake Michigan against pollution. The District then covered 185 square miles (Chicago plus some western suburbs) and served a population of about 750,000. After some 45 annexations, the District now covers 858 square miles, including nearly all of Cook County and serves Chicago, 115 other cities and villages, and 25 smaller local sanitary districts. The District serves a population of 5.5 million, plus an industrial waste load equivalent to an additional 3 million population.

The legislative act that established the District, with subsequent amendments, gave it the powers of taxing, policing, and the right of eminent domain for pollution control, flood control and navigation. Subsequent enactment of the Sanitary Water Board laws, which exempt all sanitary districts with populations of one million or more from Sanitary Water Board jurisdiction, have left the powers of the Metropolitan Sanitary District intact.

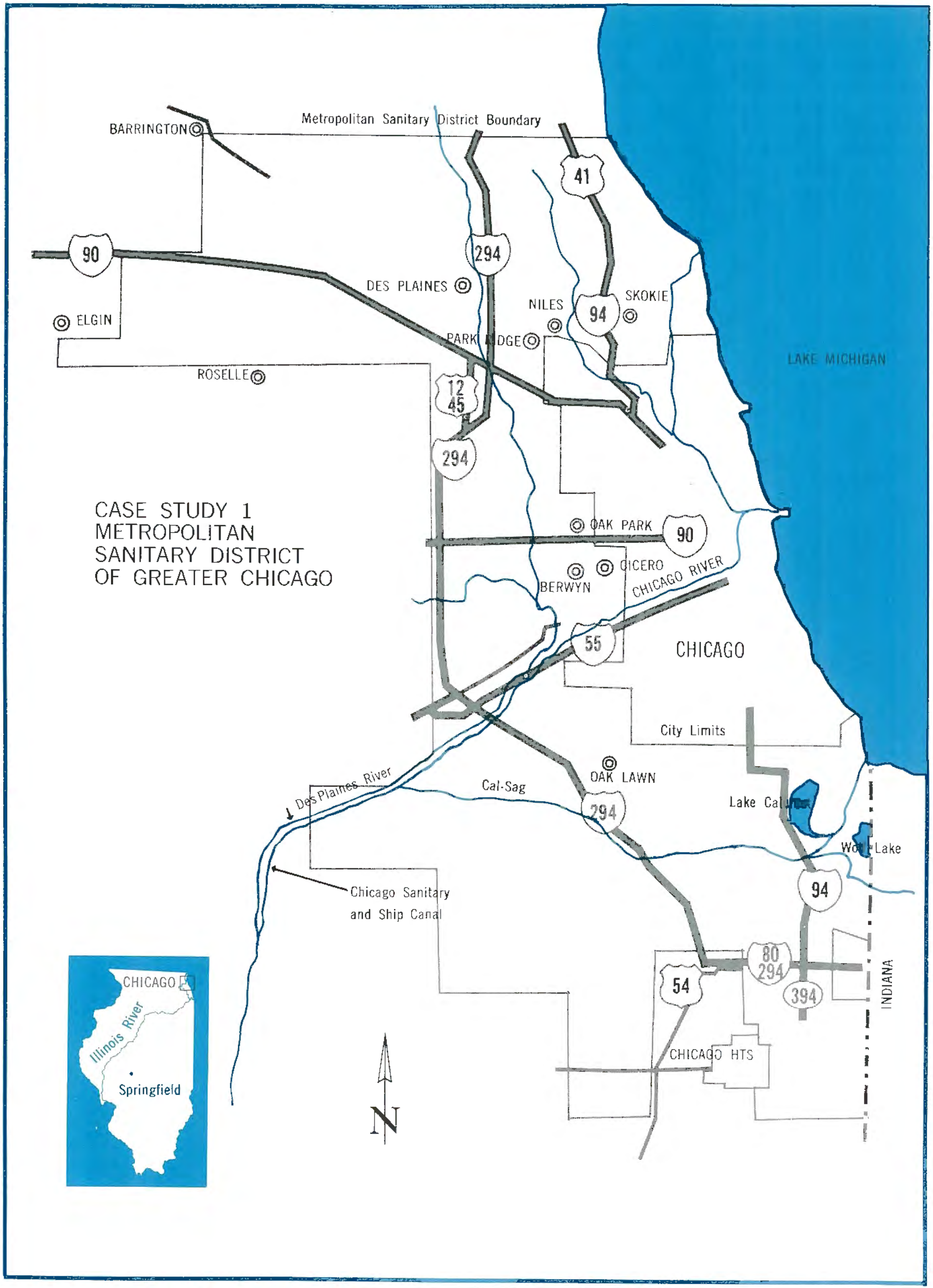
The District maintains and operates a massive sewage collection and treatment system. About 350 miles of intercepting sewers collect and convey wastes to three large sewage treatment works. Many of these interceptors serve combined systems (sewers that are used for both sanitary waste and storm water). During periods of moderate storms, these interceptors are allowed to discharge some of their flow directly into the waterway system. Whenever the treatment works approach capacity, certain amounts of diluted untreated wastes are necessarily discharged to the waterways. The District has instituted a firm policy that all newly constructed sanitary and storm sewers must be separated.

In order to protect Lake Michigan water from pollution, the District reversed the flow of the natural rivers away from the Lake into a drainage system flowing to the west. The entire waterway system today consists of 71 miles of canals, channels, and rivers. Water from Lake Michigan enters this waterway system via the North Shore Channel, the Chicago River, and the Calumet River. The flow of water is controlled by sluice gates and locks at the Wilmette Harbor Pumping Station, the Chicago River Controlling Works, and the Thomas J. O'Brien Lock and Controlling Works. Occasionally during the later stages of unusual major storms, it has been necessary to open the gates and allow some highly diluted wastes to discharge to Lake Michigan in order to prevent extreme damage by flooding. This has occurred only seven times since 1954. The recreational use of the waterway system has been restricted to boating.

Most of the Chicagoland area is composed of extremely flat topography. One of the proposed solutions for flood protection is the use of reservoirs, preferably located in the upstream reaches, where the floodwaters can be slowly and harmlessly released after a storm. A flood storage reservoir will also permit preliminary treatment before discharging effluent to the waterways.

DEEP TUNNEL PLAN

The Metropolitan Sanitary District is investigating a plan proposed by the Harza and Bauer Engineering Companies. A totally new concept called the Deep Tunnel Plan for Flood and Pollution Control is being explored. This plan offers a solution to the problems of flooding and pollution by providing a deep underground reservoir. The key element in the operation of the plan


CASE STUDY 1
METROPOLITAN
SANITARY DISTRICT
OF GREATER CHICAGO
Metropolitan Sanitary District Boundary
BARRINGTON
ELGIN
ROSELLE
DES PLAINES
NILES
SKOKIE
PARK RIDGE
LAKE MICHIGAN
OAK PARK
CICERO
BERWYN
CHICAGO RIVER
CHICAGO
City Limits
OAK LAWN
Cal-Sag
Des Plaines River
Lake Calumet
Wolf Lake
Chicago Sanitary
and Ship Canal
INDIANA
CHICAGO HTS
CHICAGO
Illinois River
Springfield
N
90
294
41
94
12
45
55
54
80
394

is to intercept the storm water overflows from new and existing main sewers and channel it into vertical drains. The vertical drains would discharge into a huge underground reservoir excavated in solid rock approximately 800 feet below the surface. After temporary storage underground, the storm water overflows would be pumped to a surface reservoir. By adding generating facilities to the required pumping equipment, the upper and lower reservoirs could be used for a hydroelectric pumped-storage operation. Also included in this plan will be treatment of the polluted storm water overflows before they are discharged to the waterway system at controlled rates.

If this system were expanded to include the entire Chicagoland area, it would eliminate basement and underpass flooding and prevent polluted overflows from being discharged into the rivers and channels or Lake Michigan. The proposed system could handle 100-year frequency storms.

The District's consulting engineers have completed a preliminary feasibility engineering study of the Deep Tunnel Plan. The general conclusion derived from the report was that the plan offered sufficient promise to justify detailed engineering investigations. A feasibility study of the Deep Tunnel Plan is expected to be started in the near future. This could develop a new solution to a vital problem that affects not only Chicago but other urban areas as well. A pioneering effort toward this engineering achievement would reflect the Sanitary District's tradition of technical leadership.

The Sanitary District operates three major sewage treatment works, which now have a combined capacity of approximately 1300 mgd. These treatment works are the North Side, Calumet, and the West-Southwest (Stickney); the latter is the largest of its kind in the world. All three plants employ the activated sludge process. In addition, the District maintains several small plants at Bartlett, Streamwood, Hanover Park, Barrington Woods, Lemont, Orland Park, Hazel Crest, and East Chicago Heights. However, the population served by these plants is small in comparison to the total District population.

SLUDGE DISPOSAL

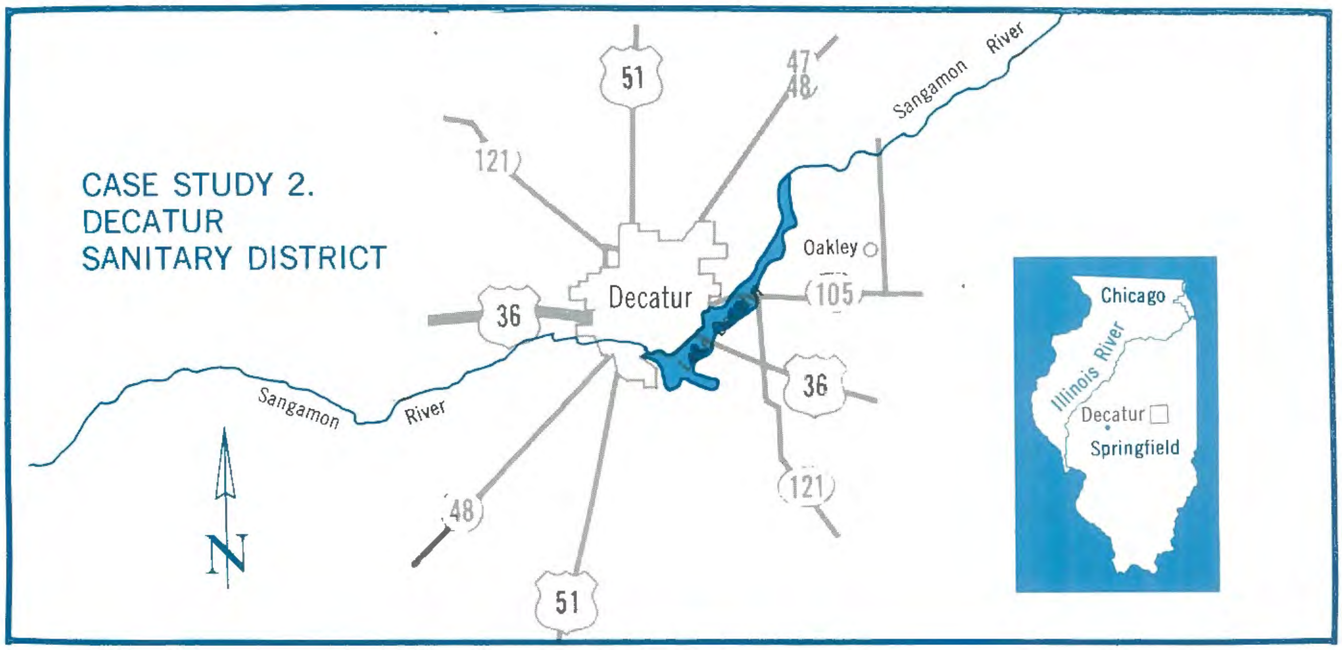
Disposal of the solids removed from sewage has always been a problem associated with sewage treatment. The Sanitary District has for years used part of its waste sludge in the manufacture of commercial fertilizer. Also used, in addition to heated digesters, is a wet air oxidation method of disposal known as the Zimmerman Process. Four 50-ton units were installed at the Southwest Treatment Works and are currently being modified to increase the plant's capacity. It is estimated that these units will then be able to handle up to 300 tons of solids a day.

The disposal of sludge is currently the District's most critical problem. The Engineering Department has started an extensive engineering investigation and study into the possibility of transporting digested sludge by pumping through pipelines to a reservoir where the sludge can then safely be distributed onto marginal farmlands or strip mines. It is proposed that the Agronomy Department of the University of Illinois will concurrently conduct research and studies, primarily to insure that the public health will be completely protected. This system would provide 1) a means of solving the problem into perpetuity, 2) an economical method of disposal, and 3) a beneficial development of poor farmlands and/or recreational parks at the strip mines.

The degree of treatment accomplished at the District's works is more than 90 percent efficient. Even with this high degree of treatment, effluents discharged to the waterway system carry a BOD equivalent of a population of about 900,000. Using the same percentage of treatment efficiency, the combined domestic and industrial waste loads reaching the stream system will be equivalent to that for a population of 1.1 million in 1980 and 2.7 million in 2020. However, the District has inaugurated a program to obtain the highest degree of treatment possible. It is anticipated that the amount of BOD discharged to the waterway system 50 years from now will be less than it is today.

Calumet Treatment Plant.

CASE STUDY 2. DECATUR SANITARY DISTRICT



Decatur industries contribute a variety of wastes to the sewerage system. Treated sewage effluent is discharged to the Sangamon River downstream from the City water supply lake and dam. During low-flow periods no dilution water is available. This puts a premium on maximum treatment of the combined municipal and industrial wastes. Shock loads and occasional overloads have an adverse effect on the stream. The possibility of streamflow augmentation is being studied by the Corps of Engineers in its study of the proposed Oakley Reservoir.

Decatur, a city of 78,004 in 1960, has several industries which use water, including a corn processing plant and a soybean processing plant. The two industries discharge organic wastes that create special problems in treating the wastes from the Decatur Metropolitan Area.

The Sanitary District of Decatur was formed in 1917. The District's treatment plant is in southwest Decatur on the Sangamon River. The first treatment facilities, in operation since 1924, were originally designed to treat the waste from a population equivalent of 60,000 at an average flow of 8 mgd, which was increased to 150,000 PE at 10 mgd average flow. Since the basic facilities were installed, several additions to the plant and process changes have been made. The last major expansion of the treatment facilities was the addition of a primary settling tank, several new aeration tanks, a final settling tank, additional blowers, and associated changes in existing plant units and flow channels to bring the total plant capacity up to 250,000 population equivalent per day at a flow of 18 mgd. This project was completed in 1964.

The present plant is essentially two plants in parallel operation. One is the original Imhoff tank-trickling filter plant, the other an activated sludge plant. Each has a separate outlet to the River. Incoming raw sewage is split and sent to each plant in proportion to its capacity.

ORGANIC WASTE LOAD

The highly variable organic load received at the treatment plant from the local industries has been a serious problem, because the load periodically exceeds the present design capacity of the facilities. The facilities are capable of providing 90 percent reduction of the incoming organic load, if the design capacity of the plant is not exceeded by shock loads of organic industrial wastes. Thus, at optimum efficiency of 90 percent removal of BOD and at the design load of 250,000 population equivalent (42,500 pounds of BOD per day), 4250 pounds of BOD per day will be discharged to the Sangamon River.

To permit assimilation of the effluent organic load without degrading the stream below the outlet, the load should not exceed 50 pounds of BOD per day per cfs of streamflow. Using this criterion, a minimum upstream flow of 63 cfs is required in the Sangamon River when 4250 pounds of BOD per day is discharged in the plant effluent.

During the dry months of the year, all flow in the Sangamon River is retained in Lake Decatur, the water supply reservoir for the City. During these periods when there is no flow released for dilution of the waste treatment plant effluent, the stream below the plant outlets is degraded for several miles. The stream becomes black, its odor is offensive, and dissolved oxygen is depleted. Such conditions were observed during a two-day sampling survey made by the U. S. Public Health Service in August 1964, and again on two days in October 1964. The latter survey was made just prior to the opening of the new treatment facilities, which were finished in 1964.

The Sanitary Water Board began routine sampling of the Sangamon River below the treatment plants in December 1964, shortly after the new treatment facilities were in operation. The sampling continued every two weeks into the summer of 1965. During this period, the Decatur Sanitary District had difficulty obtaining satisfactory efficiency from the new treatment facilities because of excessive industrial waste loads. The sampling survey showed that the downstream conditions were unsatisfactory when there was no flow in the River above the Sanitary District's plant. Dissolved oxygen levels during the sampling period were as low as zero as far as 12 miles below the plant outlets. Depressed dissolved oxygen levels were observed as far as 25 miles downstream from the plant outlets. In the spring and early summer of 1965, when there was flow over the dam from Lake Decatur, the downstream conditions were generally satisfactory.

On August 4 and 5, 1965, an extensive fish kill in the River extended 14.5 miles below the District's plant. The kill was attributed to a lack of dissolved oxygen. The stream conditions observed there indicate the immediate need for flow augmentation to maintain the required minimum flow of dilution water and the need for additional stages of treatment to provide increased BOD removal.

OAKLEY RESERVOIR

Plans for the Oakley Reservoir project include allocation of water for flow augmentation to maintain acceptable stream conditions below the District's treatment facilities. The District plans to convert an unused sludge lagoon into a tertiary treatment lagoon for the effluent from the trickling filter portion of the treatment plant. Pilot studies indicate that this tertiary treatment lagoon will remove up to 55 percent of the load remaining in the flow from the trickling filter side of the plant. This will account for the additional removal of 1300 pounds of BOD per day at the plant design load. A tertiary treatment lagoon may also be required for the activated sludge side of the plant to remove additional waste load from the effluent prior to discharge.

The 1965 Public Health Service Report on Oakley Reservoir projected the population of Decatur at 185,000 in 2020, and estimated that the waste flow would be 41.8 mgd by that time. The report made no projection of the total organic load from the Decatur area for 2020.

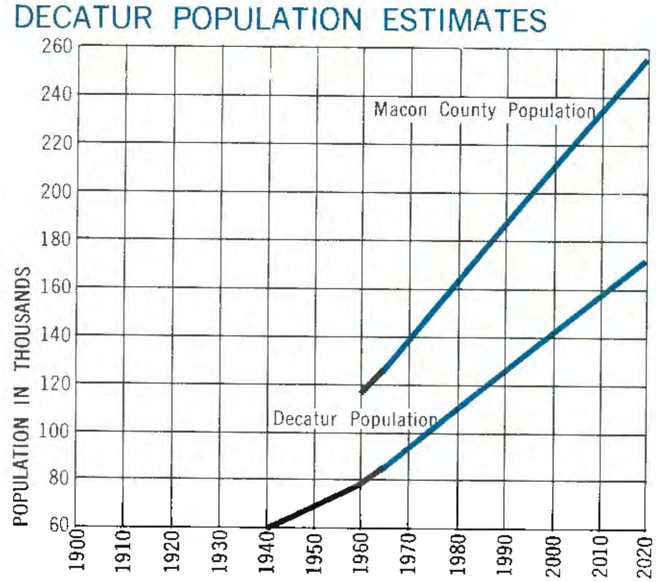
The Sanitary Water Board estimates the population of Decatur at approximately 175,000 for 2020 (Figure 23). It is not possible to make a realistic projection of the organic or hydraulic industrial load in 2020. For planning purposes, a 100 percent increase in the present industrial load has been assumed. Existing total industrial load is reported to be approximately 130,000 PE at 4.5 mgd. The projected 2020 industrial load will then be 260,000 PE and 9 mgd. Treatment facilities designed to treat the combined domestic and industrial waste load from 435,000 population equivalent at a flow of approximately 30 mgd will be required by 2020.

Assuming that by 2020 three-stage treatment facilities that will provide 95 percent overall reduction of BOD will be in general use, 3700 pounds of BOD per day will be discharged to the Sangamon River. At a maximum of 50 pounds BOD per day per cfs, a minimum upstream flow of approximately 30 cfs will be required for dilution of the treated effluent.

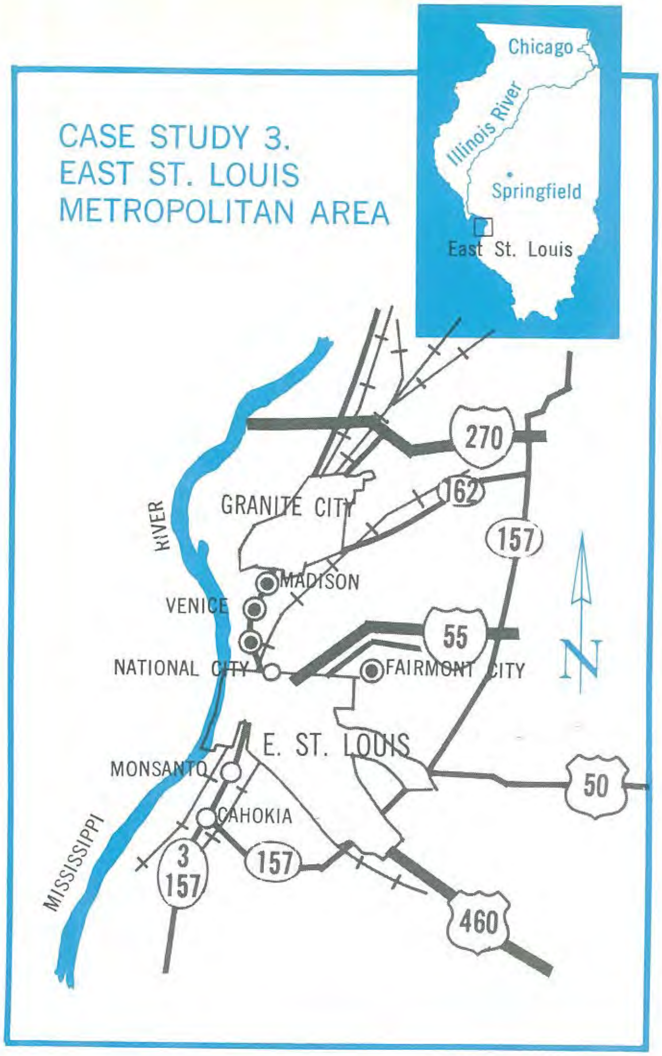
The Decatur Sanitary District has long-range plans to build a complete new treatment plant a few miles west of the present plant to provide for continued growth of the community. It is conceivable that the population of Decatur, including the industrial waste load, may reach a point at which it is not economically feasible to provide the degree of treatment necessary to prevent degradation of the receiving stream, using the amount of water allotted for flow augmentation from the proposed Oakley Reservoir project. When this occurs, Decatur will have reached the point beyond which further development will be restricted by the water resources available for flow augmentation and public water supply needs. Growth beyond this point will depend entirely upon auxiliary sources of flow augmentation and/or methods of waste treatment refined beyond those presently available.

FIGURE 23

DECATUR POPULATION ESTIMATES



CASE STUDY 3. EAST ST. LOUIS METROPOLITAN AREA



The East St. Louis Area, including Monsanto, Madison, Venice, and Granite City, is both residential and industrial, with much of the riverfront occupied by railroad yards and industrial property. Because of the vast amount of dilution water available in the Mississippi, sewage and industrial wastes were not treated prior to 1956. Now waste treatment works are in operation or under construction for the entire area, including St. Louis, Missouri.

The East St. Louis area is an industrial complex including Granite City on the north and the residential village of Cahokia on the south, and is generally bounded on the east by Illinois 157. Most of this area is served by the East Side Levee and Sanitary District, which was authorized by the Legislature in 1907, primarily to protect the locality from floods and to construct interior drainage works. The District is also authorized to build and operate sewage disposal facilities.

Much of the area has combined storm and sanitary sewers and necessary drainage structures. Sewers constructed in the last twenty years have been separate systems which discharge to out-fall sewers and levee pumping stations owned or operated by the District.

The total population tributary to the seven main outlets to the Mississippi River is expected to increase from 151,000 in 1960, to 304,000 by 1980, with a subsequent area population of 378,000. Low areas in the flood plain and extensive industrial use may preclude population growth beyond the estimate above.

The Illinois Sanitary Water Board directed the East Side Levee and Sanitary District, municipalities, and industries to provide sewage treatment works. The request was made in conjunction with the Bi-State Compact between Illinois and Missouri and in accord with the Federal Water Pollution Control Act. The first preliminary engineering study was of the entire area—for the cities and East Side Levee and Sanitary District jointly. Subsequently, the agencies decided to proceed independently, and separate engineering studies were made.

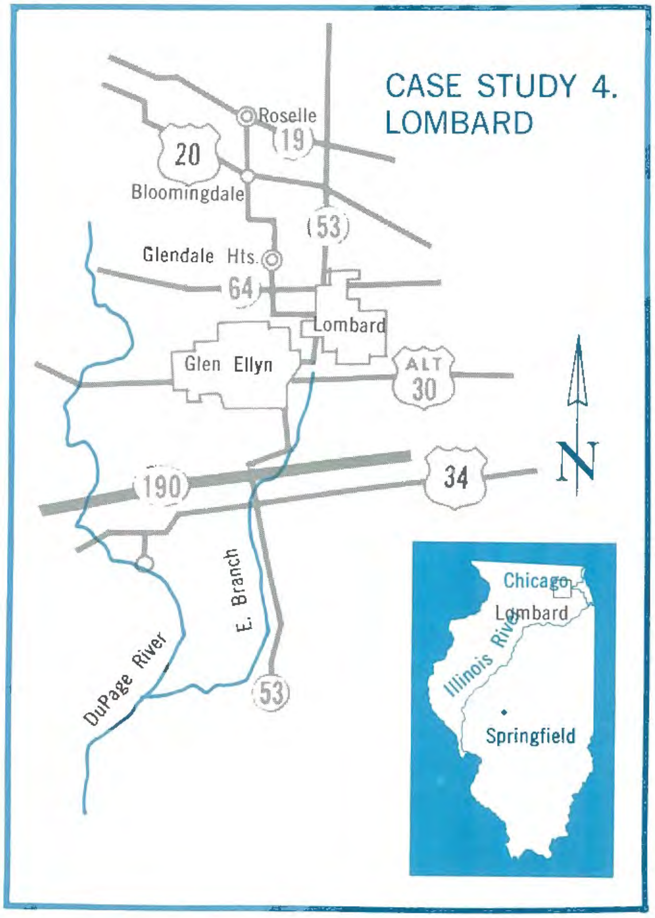
Independent treatment works have been provided by the Granite City Steel Company; the city of Granite City; the East Side Levee and Sanitary District serving Madison, Venice, Fairmont City, and a portion of industry in the area; the city of East St. Louis; the village of Monsanto; and the East Side Levee and Sanitary District for Cahokia and Centreville Township. A group of industries at National City are developing plans for one or more special treatment works. Total expenditure for the area is approximately $12.5 million and provides treatment capacity to the 1980 to 1985 period. With the exception of the special industrial facilities, all sewerage works provide primary treatment. All except the facilities at Cahokia treat industrial wastes as well as domestic sewage.

In 1960 an average of 116 mgd of domestic, commercial, and industrial wastes was discharged to the Mississippi River from the seven outlets within the District. The daily maximum flow was about 140 mgd. The industrial flow was 80 percent of the total. Subsequent in-plant improvements and separation of process water from cooling water permitted a revision to an estimated flow of 98 mgd for 1980 and an ultimate average flow of 140 mgd.

The Mississippi River has adequate flow at the ten-year low-flow frequency to absorb effluents from primary sewerage works. Some industrial wastes now receive special treatment, in-plant pre-treatment, or in-plant separation prior to discharge to municipal facilities. This will continue to be the pattern in the future. All municipalities have a sewer use ordinance and monitor and regulate the character and quantities of wastes discharged to the system. Industrial wastes not amenable to treatment in the municipal facilities, or wastes which interfere with operation of these facilities, will be removed or treated at their source.

The combination of rail and river transportation, a network of interstate highways, practical sites, basic waste disposal facilities, and abundance of water assures the continued industrial development of this area.

CASE STUDY 4. LOMBARD



Lombard is a residential community within a large metropolitan, commercial, and industrial area. Its location near headwaters of a small stream is typical of many communities in the Northeastern Illinois Metropolitan Area. Accelerated population growth and annexation of contiguous areas require continual expansion of the sewer system and frequent enlargement of sewage treatment facilities. There is remote prospect of streamflow augmentation. Therefore, an increased degree of treatment and maximum attention to maintenance and efficient operation are required.

A combined sanitary and storm sewer system in the older part of the community creates a problem by overloading the sewers and the treatment works, and also bypasses diluted sewage to the stream during high intensity or prolonged rainfall. Area plans for DuPage and other counties have given serious consideration to consolidation of small sewerage systems into integrated facilities with effluent discharge to streams of adequate capacity. Effluent impoundment during periods of low streamflow may be necessary to solve the problem.

Lombard, about 20 miles west of downtown Chicago, had a 1960 population of 22,500. The first treatment plant was installed in 1928 and was rebuilt in 1956 for a design flow of 2.2 mgd. Treatment units include primary tanks, separate sludge digesters, and trickling filters. Piping was arranged so that the original primary tank could be used as a settling tank for excess stormwater flow. Treated effluent discharges directly into the East Branch of the DuPage River within 4 miles of the headwaters of the stream. Average BOD of the raw sewage is 128 mg/l and of the final effluent 25 mg/l, or about an 80 percent reduction.

The current sewerage improvement program includes construction of combined relief sewers and expansion of the sewage treatment works. Treatment expansion will provide capacity for a population of 40,000 with average flow of 4.36 mgd, or 6800 pounds of BOD per day. Treatment facilities include chlorination equipment and a tertiary lagoon, necessitated by higher treatment criteria specified by the Sanitary Water Board and by limited streamflow. Because of the rapid rate of population growth, another expansion of facilities will be needed within ten years. The present system has a limited reserve capacity for municipal and wet industry waste treatment. It is anticipated that new facilities will provide at least a 95 percent reduction of waste load BOD from a design basis of 6800 pounds down to 340 pounds. Assuming a permissible stream loading of 50 pounds BOD per cfs of discharge, a minimum streamflow of 6.8 cfs is needed.

Stream sampling during the summer of 1964 revealed an average BOD of 12 mg/l at five stations on the East Branch of the DuPage River. A desirable range of BOD is 4 to 8 mg/l. Dissolved oxygen ranged from 3.6 mg/l at the lower station to zero DO below Lombard, as compared to the desirable range of 2 to 4 mg/l or a minimum of 50 percent saturation. Coliform bacteria counts ranged from 11,000 per 100 ml at the southern station to 2.1 million per 100 ml below Lombard, as compared to a desirable range of 5000 per 100 ml. The biologists' report of visual observations and bottom samples indicated stream pollution at all stations.

Stream discharge at the mouth of the East Branch averaged 57 cfs for the period from 1960 to 1964. The average during the 1964 survey was 63 cfs, with a daily low of 33 cfs. One-third of the low value, or 11.6 cfs, was effluent from sewage treatment works. Flow duration curves show flows of less than 7.5 cfs during 5 percent of the time, reflecting reduction of flow by evaporation and seepage.

Waste treatment capacity at Lombard must be increased 20 to 25 percent by 1980 to serve a population of 48,000 to 50,000, and designed for 8100 to 8500 pounds of BOD. Assuming 95 percent reduction of incoming waste load, 425 pounds of BOD would be discharged daily in the effluent, which would require a minimum streamflow of 8.5 cfs. There is little prospect of obtaining additional dilution through low-flow augmentation. Thus, maximum possible treatment and operational control is necessary. Treatment capacity may be increased somewhat by adding activated sludge facilities, but the practical limits for waste treatment on this stream have been reached, and a new approach to the problems of waste is needed.

COUNTY PLAN

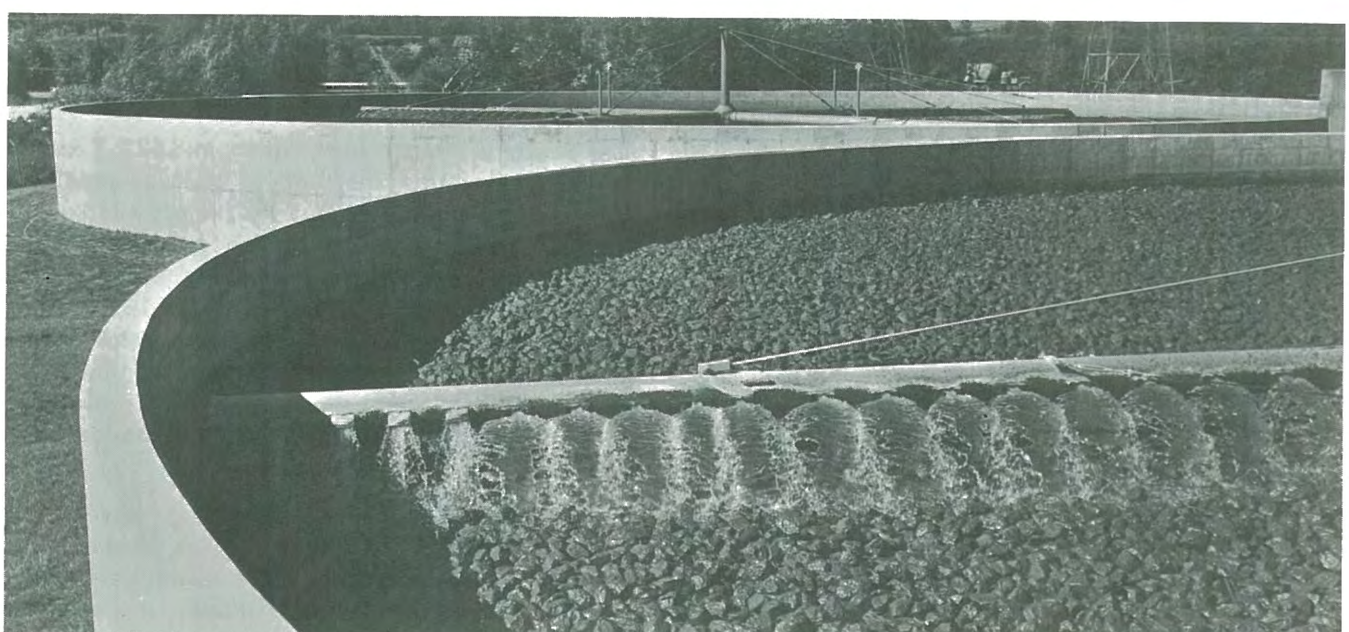
Area plans developed by the DuPage County Department of Public Works indicate the need for a coordinated program involving a minimum number of strategically placed treatment works designed to serve the entire County. Such facilities must provide a maximum degree of treatment and must discharge effluents to streams at points of maximum available or augmented low flow. Some impoundment of upstream storm flow is contemplated to provide some low-flow augmentation. Under this program, all sewerage systems would be connected to the sewage treatment plants by trunk sewers and interceptors. Existing plants would be phased out or retained for partial or standby operation. With this program in full operation, treatment capable of 98 percent removals will be necessary. An additional solution may involve effluent impoundment during periods of low streamflow.

Lombard recently annexed approximately 1000 acres south of the village limits and proposes to construct sewage treatment works there. In discussions with the County Department of Public Works, sewerage works to serve this additional 800 to 1000 acres and all or part of three residential developments in the immediate area were considered. Sewerage works designed to serve a population of 20,000 will be required to serve this area. Three small existing treatment plants can then be abandoned.

If agreement can be reached to proceed under a coordinated County plan, initial sewerage works will have provisions for expansion and consolidation of facilities. The service area would include Roselle, Bloomingdale, Glendale Heights, Lombard, and Glen Ellyn, plus all presently unincorporated areas north of the Illinois Tollway that are tributary to the East Branch of the DuPage River. Current population of the area is 80,000 and is estimated to reach 138,000 by 1980 and 220,000 by 2020. Streamflow of three to five times the low, which is now available 5 percent of the time, would be required to sustain fish life. The plant and interceptors needed by 1980 will cost an estimated $9 to $10 million. Plant expansion to serve the 2020 population would require expenditure of an additional $20 million.

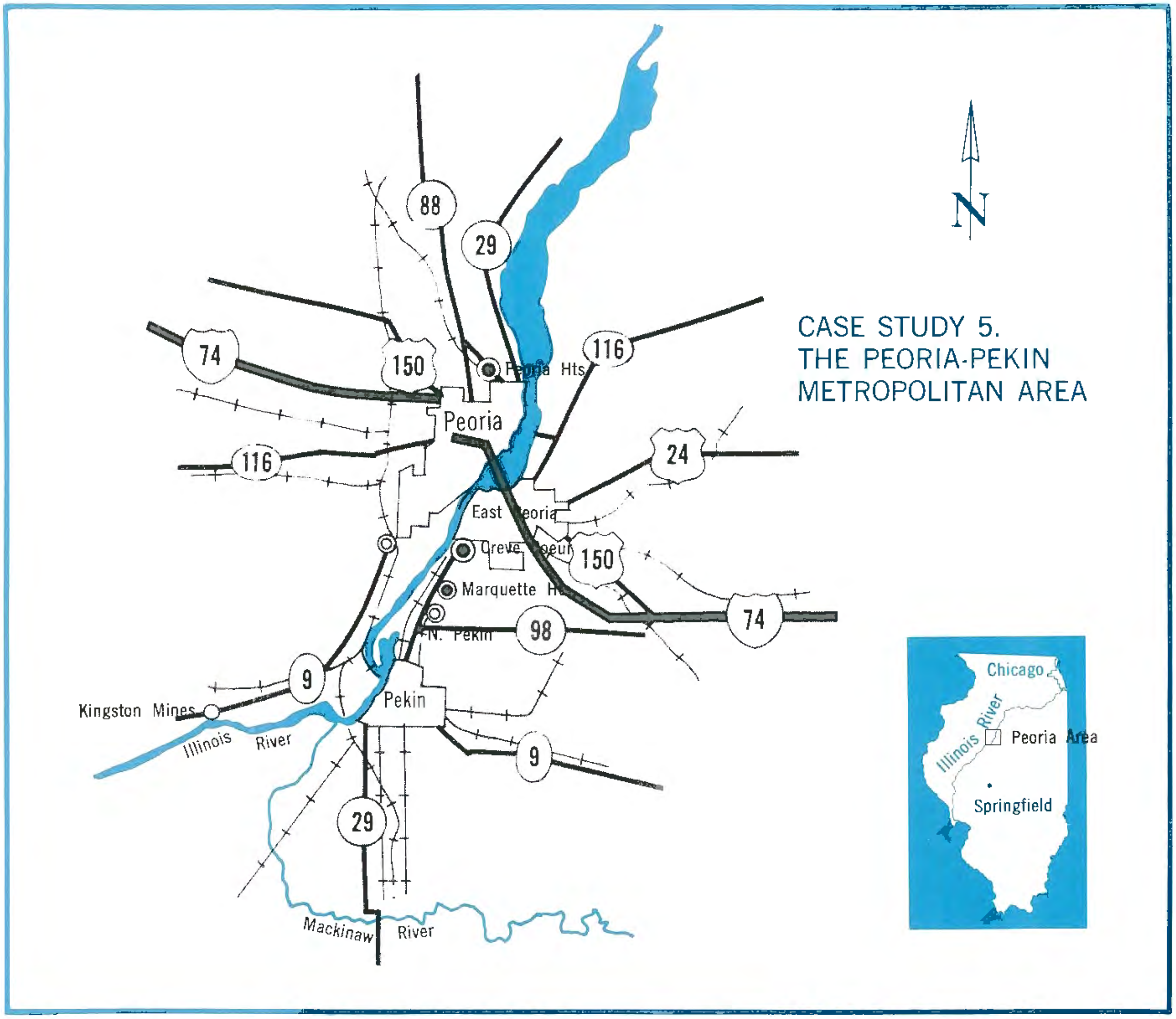
The policy of the State Sanitary Water Board has been to require the maximum practical degree of treatment with disinfection of the effluent, in order to prevent nuisance and visibly objectionable stream conditions. It is not feasible, with the magnitude of the waste load which this and other communities place on the stream, to maintain sufficient oxygen levels to support fish life.

The population of Lombard and surrounding communities may reach its maximum limit by 2020. Even with maximum feasible sewage treatment, the streams will not provide sufficient dilution during low flows that occur 5 percent of the time. A solution to the problem might be to construct outfall sewers, flumes, or channels designed to carry high quality sewage effluent to the Illinois Waterway. Initially, this might be at some point downstream from Joliet. Ultimately, all of the Northeastern Illinois Metropolitan Area may be interconnected to such an effluent channel, in order to relieve natural streams of the oxygen demand and nutrients. Other solutions might be to pump artificially recharged water to augment streamflow for dilution purposes, or to transfer water from the Fox River to augment low flows in the DuPage River.



New rotary distributing arm filters at Lombard.

CASE STUDY 5. THE PEORIA-PEKIN METROPOLITAN AREA



The Peoria-Pekin area has the largest industrial and residential population in the State outside of Chicago, and is also on the Illinois River, the largest intrastate River in the State. Peoria and adjacent communities are served by an efficient Sanitary District. Limited industrial effluents are discharged to the River from the Peoria area. In the Pekin area several industries discharge treated or partially treated industrial effluents, and several municipal sewerage works serve smaller communities for 15 miles north along the east bank of the River. Numerous discharges within a short reach of the River exert a combined effect on the stream in the Havana to Beardstown area and during low-flow periods have a degrading influence on the entire stream to its mouth at Grafton.

The Greater Peoria Sanitary District serves Peoria, Bartonville, Bellevue, Peoria Heights, and several subdivisions outside the City limits. The total 1960 population of these incorporated areas was 119,050. The population of Peoria County was 189,044 in 1960 (Figure 24). Peoria is moderately industrialized and contributes a wide variety of industrial wastes.

The Sanitary District was formed in 1927. The first treatment facilities, installed in 1931 in southwest Peoria on the Illinois River, used the activated sludge process. The first plant was designed to serve a 200,000 population equivalent. The basic treatment units originally installed provided treatment until 1965 with no major plant additions. Numerous process changes and innovations upgraded the treatment capabilities of the original plant units. In 1965 the plant still provided 85 to 90 percent removal of BOD for a waste load for a population equivalent of more than 400,000.

The estimated 1966 domestic population served by the Sanitary District is 130,000 to 140,000. The balance of the 400,000 to 500,000 population equivalent daily load is contributed by a variety of industries served by the District. These include a brewery, distilleries, packing plants, and miscellaneous small industries. Virtually all industrial wastes in Peoria are tributary to the Sanitary District sewers.

The District recently completed a $20 million sewer interceptor system. The new sewers intercept at existing points of discharge of untreated sewage into local streams and extend service to large outlying areas and subdivisions. This major sewer extension program provides for orderly growth of the Peoria area for many years and will assure central treatment of all sewage from new areas as they develop.

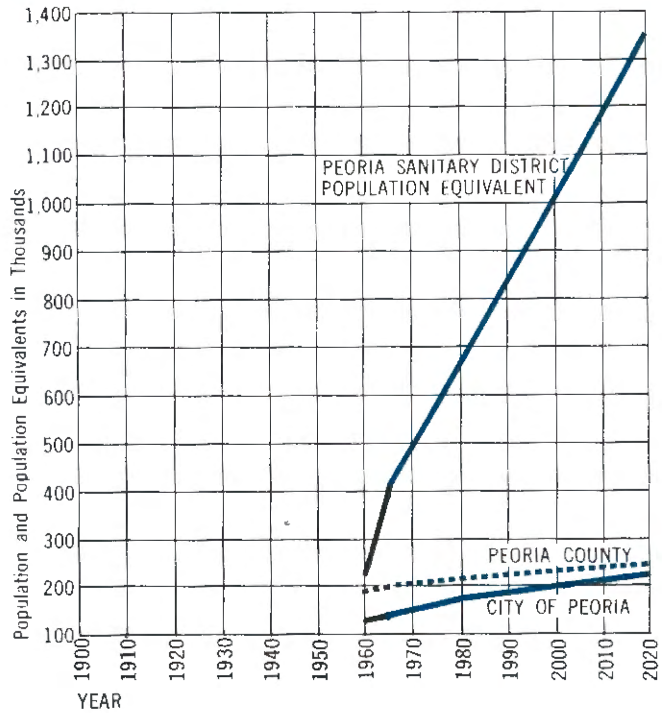
PLANT EXPANSION

Treatment plant expansion completed in 1966 increased the blower capacity and final settling tank capacity and added tertiary treatment facilities and chlorination. The additions were designed to bring the capacity up to 750,000 PE at 35 mgd average design flow, with a peak hydraulic capacity of 70 mgd. It is anticipated that this design load will be reached by 1985. The modified facilities provide 90 percent removal of BOD and 95 percent removal of suspended solids at the design load. This will result in a load of 12,750 pounds of BOD per day discharged to the Illinois River at design capacity in 1985. The Illinois River has a flow equal to or greater than 4080 cfs for about 94 percent of the time at Kingston Mines about 10 miles downstream from Peoria. At a low flow of 4080 cfs, the effluent load from the Greater Peoria Sanitary District plant at design capacity will contribute 3.12 pounds of BOD per day per cfs of streamflow. This is well within the suggested maximum of 50 pounds of BOD per day per cfs.

A projection of the recent load received at the District's plant and the 1985 design of 750,000 PE places the load at approximately 1,350,000 PE by the year 2020. The treatment facilities will have to be enlarged when the 1985 design capacity of 750,000 PE is reached. Assuming facilities will be provided in 2020 that can

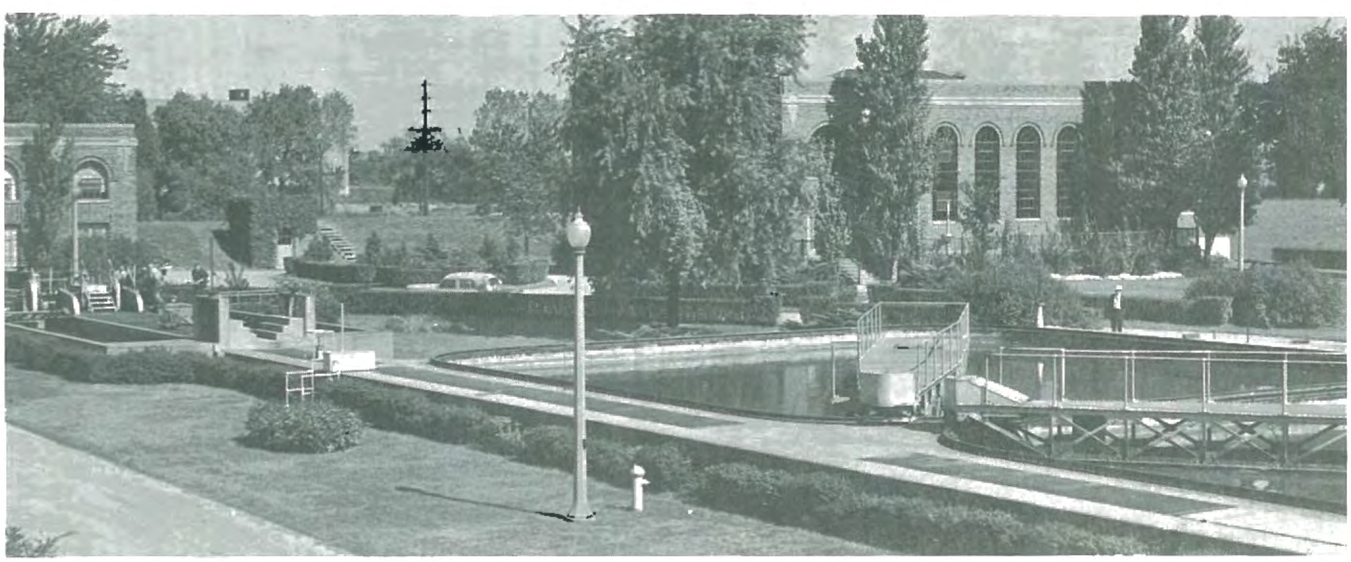
FIGURE 24

PEORIA ESTIMATES OF POPULATION AND DOMESTIC AND INDUSTRIAL WASTE LOADS



produce at least 90 percent removal of BOD for the 1,350,000 PE, 23,000 pounds of BOD per day will be discharged to the Illinois River. At a low flow of 4080 cfs, this will amount to 5.6 pounds of BOD per day per cfs of flow.

There appears to be no problem of possible pollution of the Illinois River in 2020 at low flow from the Peoria Sanitary District's effluent, assuming that a minimum of 90 percent removal of BOD is provided for all waste from the District at all times.



East Peoria

The East Peoria area includes many small subdivisions. The 1960 population of East Peoria was 12,310, and it is highly industrialized for its size. A large crawler-tractor plant is the principal industry.

East Peoria operates a primary sewage treatment plant at the southwest corner of the City near the Illinois River. Discharge is directly to the River. The plant was built in 1940 and was designed to serve 8000 PE. Additions completed in 1962 increased the capacity to 25,000 PE at 2.5 mgd. The treatment units include mechanically equipped primary settling tanks and heated anaerobic digesters.

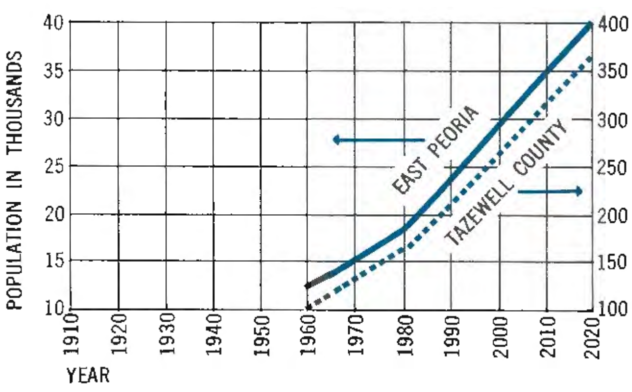
There are no significant industrial wastes tributary to the East Peoria treatment plant, but the large work force of the tractor company contributes an appreciable domestic waste load. The company provides its own treatment of industrial wastes in a new treatment plant completed in 1966, which provides removal of oil and grease from the waste prior to discharge to the Illinois River. Oily material, the only waste of significance from this industry, should be adequately removed by the new plant for many years. Treatment units will be added to remove soluble oils as soon as operating data are available from the new facilities.

East Peoria's existing treatment facilities are presently inadequate to meet the 1965 Sanitary Water Board requirements for the Illinois River. The requirements call for the equivalent of secondary treatment for all wastes discharged to the River, plus chlorination of domestic sewage plant effluents. To comply with these requirements, East Peoria must add secondary treatment units and chlorination equipment.

Estimates indicate that the population of East Peoria will approach 40,000 by 2020 (Figure 25). Assuming that the tractor plant and other local industries will employ 10,000 persons from outside the City limits, sewage treatment facilities will be required by 2020 to serve a population equivalent of approximately 50,000. Assuming that secondary facilities will be provided to remove 90 percent of the BOD, approximately 850 pounds of BOD will be discharged in the effluent to the Illinois River each day. This waste load will have no adverse effect on the River.

FIGURE 25

TAZEWELL COUNTY AND EAST PEORIA POPULATION ESTIMATES



Creve Coeur

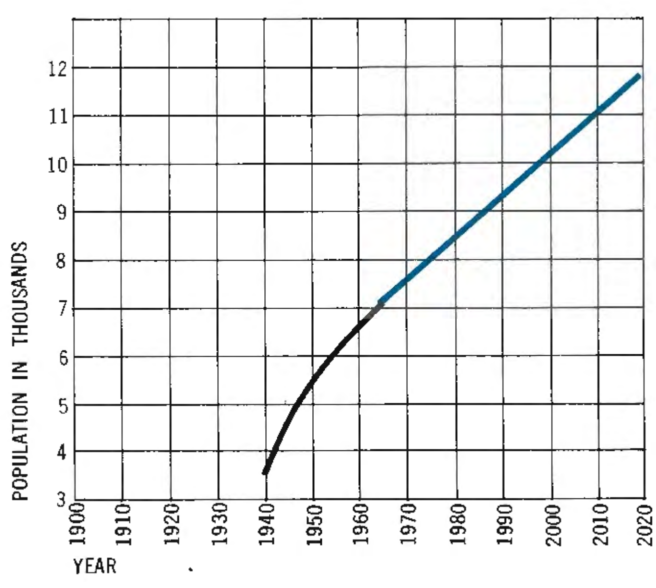
Creve Coeur is primarily a residential community with no significant industrial waste discharges. The 1960 population was 6684. The City recently completed a new primary treatment plant to serve a design population of 11,000 at 1.1 mgd average daily flow. The City had no comprehensive sewer system prior to the construction of the treatment plant and sewer system. Septic tank outlets were connected to any convenient storm drain or tile line. Inadequately treated sewage wastes were discharged at many points, creating nuisances and health hazards.

Because design for the new treatment plant was approved just before the new requirement for secondary treatment on the Illinois River was adopted, only a primary treatment plant was installed. Chlorination facilities were incorporated in the new plant.

It is estimated that the population of Creve Coeur will approach 12,000 by the year 2020 (Figure 26). Secondary treatment with effluent chlorination will be required in the near future to comply with present Sanitary Water Board requirements for the Illinois River. Assuming that 90 percent removal of BOD will be provided, 200 pounds of BOD will remain in the treated effluent in 2020. This load by itself will have no adverse effect on the Illinois River at low flow.

FIGURE 26

CREVE COEUR POPULATION ESTIMATES



Marquette Heights

Marquette Heights, a completely residential community, had a 1960 population of 2517. The City owns and operates a sewage treatment plant which was built in 1949. The plant is an activated sludge plant designed to serve 5000 persons. The secondary treatment units have never been operated since the plant was built, because only primary treatment was required on the Illinois River before the new Sanitary Water Board requirements. The City should take immediate action to place the secondary portion of the plant in operation to provide the highest possible degree of treatment. Improvements in the maintenance and operation of the primary treatment units are also needed to improve the plant's performance.

No figures are available for Marquette Heights population prior to 1960, because the area has built up since 1950. Therefore, it is impossible to project past rates of growth. It is estimated that the population will grow at about the same moderate rate as nearby Creve Coeur to approximately 5000 or 6000 by 2020. If this is the case, the existing plant should be adequate to handle the wastes from the community for some time, if maintenance and operation are good. Chlorination facilities will be required to comply with present Sanitary Water Board requirements.

Pekin

Pekin is a moderately industrialized community which has grown rapidly since 1900. The 1960 population was 28,146. The major industries include a large corn products plant, a distillery, a paper reprocessing plant, and a yeast manufacturing plant.

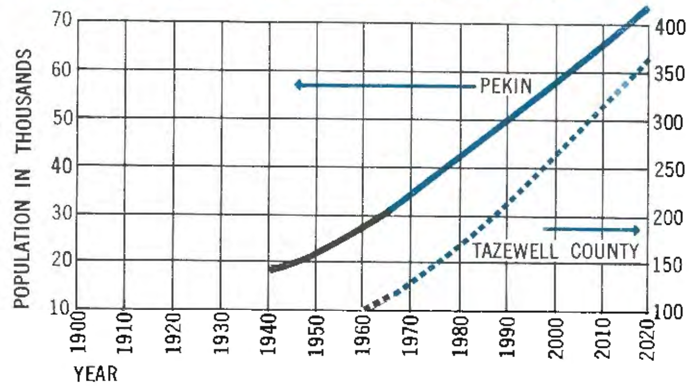
The City operates a primary sewage treatment plant that treats only the domestic waste load from the metropolitan area. All industrial wastes are either treated by the industries or discharged directly to the Illinois River without treatment.

The City treatment plant was built in 1939 to serve a 20,000 population equivalent. The treatment facilities consist of mechanically equipped settling tanks and heated anaerobic digesters. The plant effluent goes directly into the Illinois River. Two settling tanks and one digester were added in 1964 to increase the primary treatment capacity to serve a design population equivalent of 54,000. The City must plan to provide needed secondary treatment facilities within the next few years to meet Sanitary Water Board requirements for the Illinois River.

Figure 27 is an estimate of Pekin's population, based on recent census figures and compared with the County population trend. It is anticipated that the population of Pekin will approach 74,000 by 2020. With secondary treatment providing 90 percent reduction of BOD for a design load of 74,000 PE, 1258 pounds of BOD will

FIGURE 27

TAZEWELL COUNTY AND PEKIN POPULATION ESTIMATES



be discharged to the River each day. At a low flow of 4080 cfs, this will amount to 0.31 pounds of BOD per cfs of upstream flow. This is well below the maximum limit of 50 pounds of BOD per day per cfs streamflow.

The large corn processing plant at Pekin is a major source of pollution of the Illinois River. The plant produces corn starch, corn syrup, corn oil, and associated products. The plant discharges large quantities of waste water—about 10 to 20 mgd. All this waste is discharged directly into the Illinois River without treatment. The population equivalent of this discharge has been observed to be as high as 1.5 million, with the average load from 300,000 to 500,000 PE per day. The deterioration of the quality of the lower Illinois River from the Pekin-Peoria area to its mouth is attributed largely to the organic load from this corn processing plant and other Pekin industries.

In June 1964 oxygen depletion caused a fish kill on the lower Illinois River from Meredosia to the mouth. An area of depressed oxygen concentration has been observed below Pekin-Peoria during the summer months by the staff of the Illinois Sanitary Water Board. The dissolved oxygen concentration generally hits its lowest point in the Beardstown-Meredosia area and remains low from that area to the mouth of the River. The dissolved oxygen concentration frequently drops to 2 ppm or less.

The corn processing plant has retained engineering consultants to study their industrial waste treatment problems and prepare a design for a treatment plant. This engineering work has been completed, but the company has been slow to implement the engineers' recommendations to provide needed waste treatment facilities. The company's action to abate pollution has been confined to in-plant changes to reduce the waste volume and loss of organic material. A minimum of 90 percent removal of BOD from this waste load has been requested by the staff of the Sanitary Water Board.

A second major source of organic pollution in the Pekin area is a yeast manufacturing plant. The plant does have treatment facilities which were installed in the mid-1930s. Treatment facilities consist of six large unheated digesters that provide about five days detention. All the plant's waste is pumped through these digesters, and approximately 60 percent reduction of BOD is achieved. The waste flow ranges from 300,000 gpd to 500,000 gpd, and the strength of the treated effluent still contains a BOD concentration as high as 3000 ppm. This represents a load of up to 200,000 PE per day, or 12,000 pounds of BOD per day, which is discharged to the Illinois River. The Sanitary Water Board has asked the company to provide further treatment of its waste before discharge, for a minimum BOD removal of 90 percent. The company reacted to this request for a higher degree of treatment by retaining consultants to study the plant and prepare recommendations for needed additional facilities.

The distillery at Pekin produces various alcoholic spirits from the fermentation of grain and subsequent distillation. The grain fermentation produces large quantities of organic waste material. This waste is recovered in a drying operation that converts it to dried brewers grain, a valuable animal feed. The drying operation is, in effect, a waste treatment and the discharge from the plant into the Illinois River contains a load of only 15,000 to 20,000 PE.

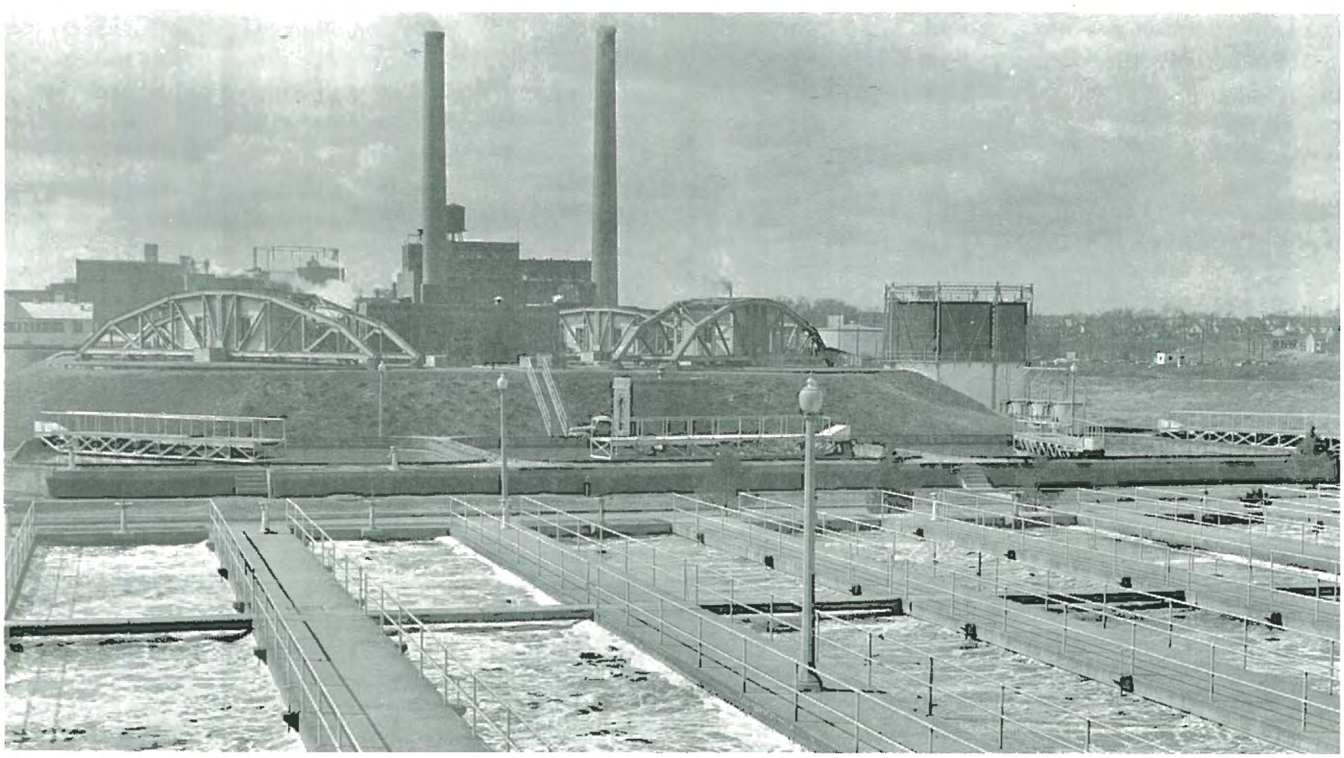
A paper reprocessing plant at Pekin makes paperboard for boxes by reprocessing waste paper. The waste discharges from the plant carry paper solids and exert an oxygen demand on the River. The oxygen-consuming capacity of the waste is equivalent to the waste discharge from a population equivalent of approximately 15,000. The paper solids created unsightly localized floating rafts of black scum.

In 1965 the company installed paper pump recovery units to provide partial removal of suspended paper solids from the waste flow. Secondary treatment facilities are required to provide additional waste treatment prior to discharge. The company currently is investigating methods of providing additional treatment. The company has been advised by the Sanitary Water Board that 90 percent reduction of BOD is required.

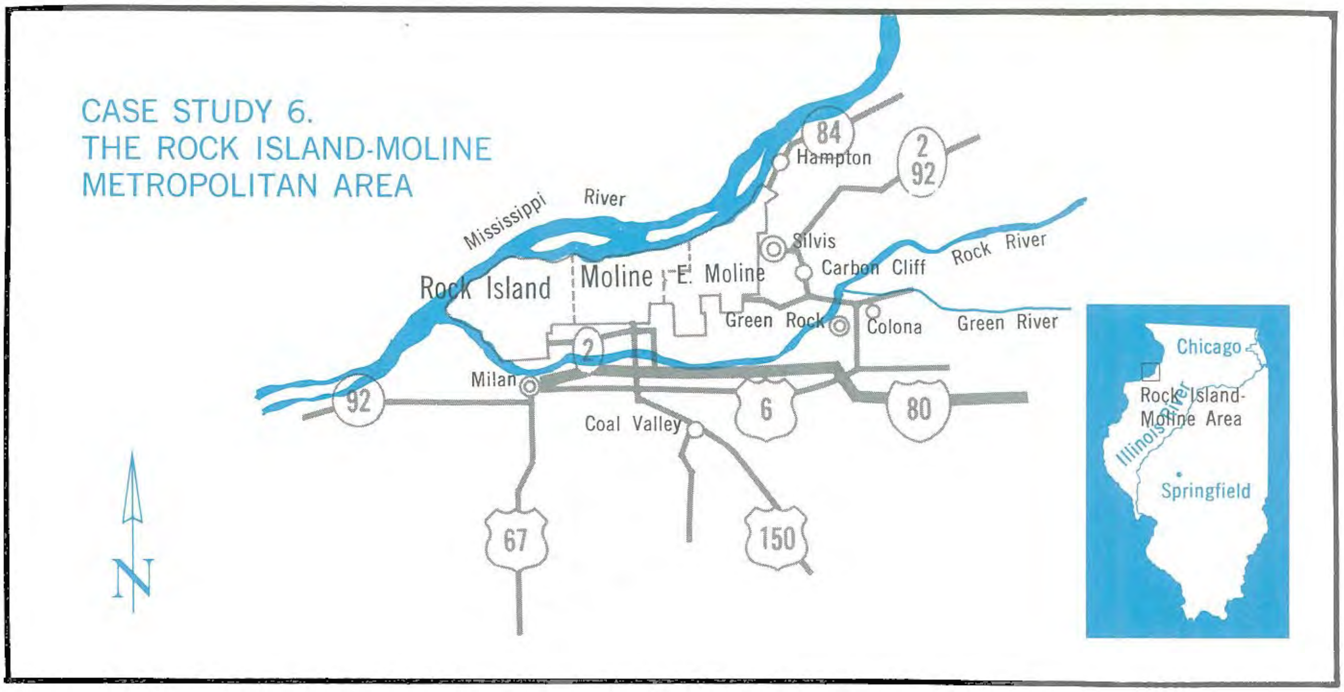
The combined discharges from the Pekin-Peoria area presently have an adverse effect on the Illinois River. At present the most significant contributors of pollutional loads are the corn processing plant and yeast manufacturing plant discussed above. It is hoped that adequate waste treatment facilities will be provided for all the Pekin industries by 1968 and secondary treatment for all domestic waste treatment plants now served by primary plants by 1970.

It is not possible to make a realistic estimate of the industrial waste loads from the area to the year 2020. The staff of the Sanitary Water Board has calculated that the Illinois River can satisfactorily assimilate approximately 140,000 pounds of BOD per day, or 825,000 PE, from the combined Pekin-Peoria area discharges at a low flow of 4080 cfs at 20 degrees Centigrade and still maintain a minimum of 4 ppm of dissolved oxygen.

With secondary treatment of all domestic wastes from the area and 90 percent reduction of BOD for all industrial waste discharges in the Pekin-Peoria area, the Illinois River would be capable of satisfactorily assimilating the treated effluents for many years.



CASE STUDY 6. THE ROCK ISLAND-MOLINE METROPOLITAN AREA



The Tri-Cities, Rock Island, Moline, and East Moline, are residential and industrial communities along the east bank of the Mississippi River. Each community operates its own sewerage system, and a few industries have direct discharges to the River. Because of the high dilution available, the area has only recently provided sewage treatment. Some industrial waste problems have not been completely solved because of the complexity of the sites and area involved.

The Rock Island-Moline Metropolitan Area also includes Silvis, Carbon Cliff, Milan, Coal Valley, Hampton, Green Rock, and Colona. The area is moderately industrialized; the principal industries are farm implement and tractor manufacturers and the Rock Island Arsenal.

The population of Rock Island County was 150,991 in 1960, the majority of it in the Metropolitan Area. Each of the cities in the area elected to construct its own waste treatment plant, rather than to form a Sanitary District served by a central plant.

The region is a unique drainage area. Most of the cities and villages are clustered in a V formed by the confluence of the Rock River on the south and the Mississippi on the north. A north slope drains to the Mississippi and a south slope drains to the Rock. The original development of the cities was on the north slope, on the bank of the Mississippi, and most of the sewers drain that way. The newer areas of the cities are on the south slope on the Rock River watershed. The area on the Mississippi watershed is almost fully developed; future metropolitan growth must be to the east and south, primarily in the Rock River Basin.

Moline had the first waste treatment plant in the area. It consisted of an Imhoff tank built in 1913 for primary treatment and discharged to the Mississippi River. The effluent was chlorinated during the first few years after the plant was built. The plant was abandoned twenty years ago.

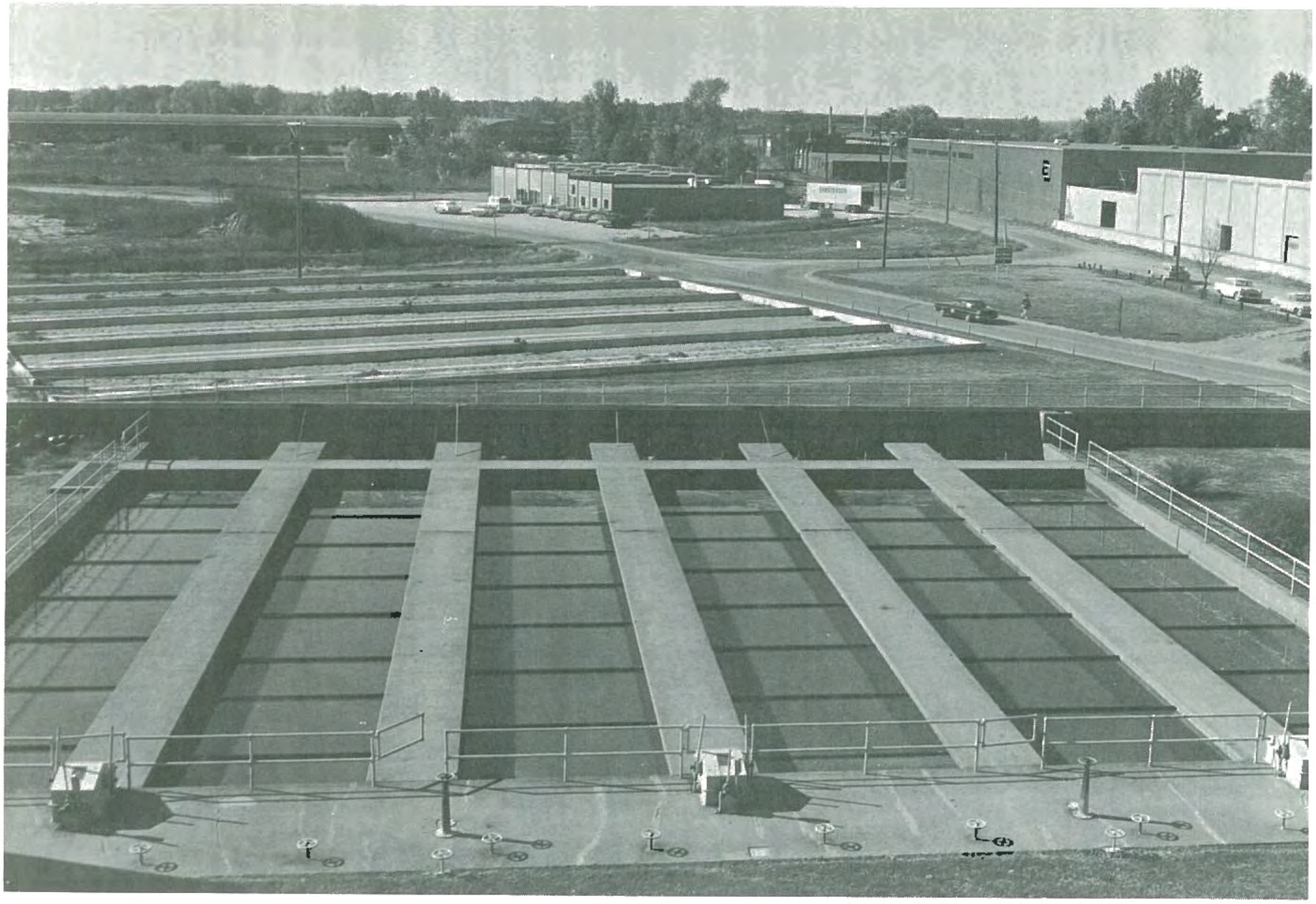
Rock Island's first treatment plant was built in 1939 to serve a 50,000 population equivalent, with discharge to the Mississippi River. It is a primary plant using mechanical settling tanks and heated digesters and is still in service. About 35 percent BOD removal efficiencies can be expected from this primary treatment. Rock Island is served mainly by combined sewers which discharge large volumes of bypass flow during rains.

All other cities and villages in the area had no treatment until plants at Milan, East Moline, and Silvis and the Moline South Slope plant were built in the late 1950s and early 1960s. These are primary treatment plants discharging into the Mississippi or Rock Rivers, except the Milan plant which discharges into Mill Creek. Rock Island has recently constructed a waste stabilization lagoon to serve a new area southwest of the City. Coal Valley constructed a secondary treatment plant, and Moline is finishing work on its new North Slope primary treatment plant.

WASTE TREATMENT

Industries in the Metropolitan Area discharge their domestic wastes into municipal sewer systems. Some of the industrial plants are discharging untreated or partially treated industrial wastes directly into the Mississippi. Some industrial wastes go into municipal sewers and through the primary treatment plants with little or no removal by treatment.

With the completion of the Moline North Slope plant the majority of the population of the Rock Island-Moline



Settling tanks and sludge drying beds at Rock Island.

Metropolitan Area will be served by primary waste treatment facilities.

In 1964 the Sanitary Water Board adopted requirements for secondary treatment plus chlorination for plants discharging into the Rock River. This means that all existing primary plants in the Metropolitan Area that discharge into the Rock River watershed will have to be improved to comply with this requirement.

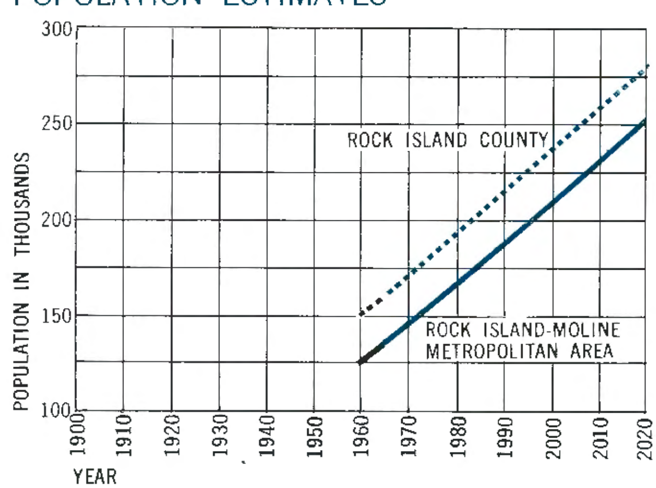
Secondary treatment plus chlorination will undoubtedly be required in the near future for all wastes discharged into the Mississippi River. Proposed stream criteria to be adopted for all interstate streams may dictate the need for secondary treatment to maintain the quality of the Mississippi within acceptable limits for various parameters. Chlorination should be provided for all treated domestic waste discharges as soon as possible because of the heavy recreational use of the Mississippi in the area. The River also serves as the raw-water supply for the Rock Island, Moline, and East Moline water treatment plants.

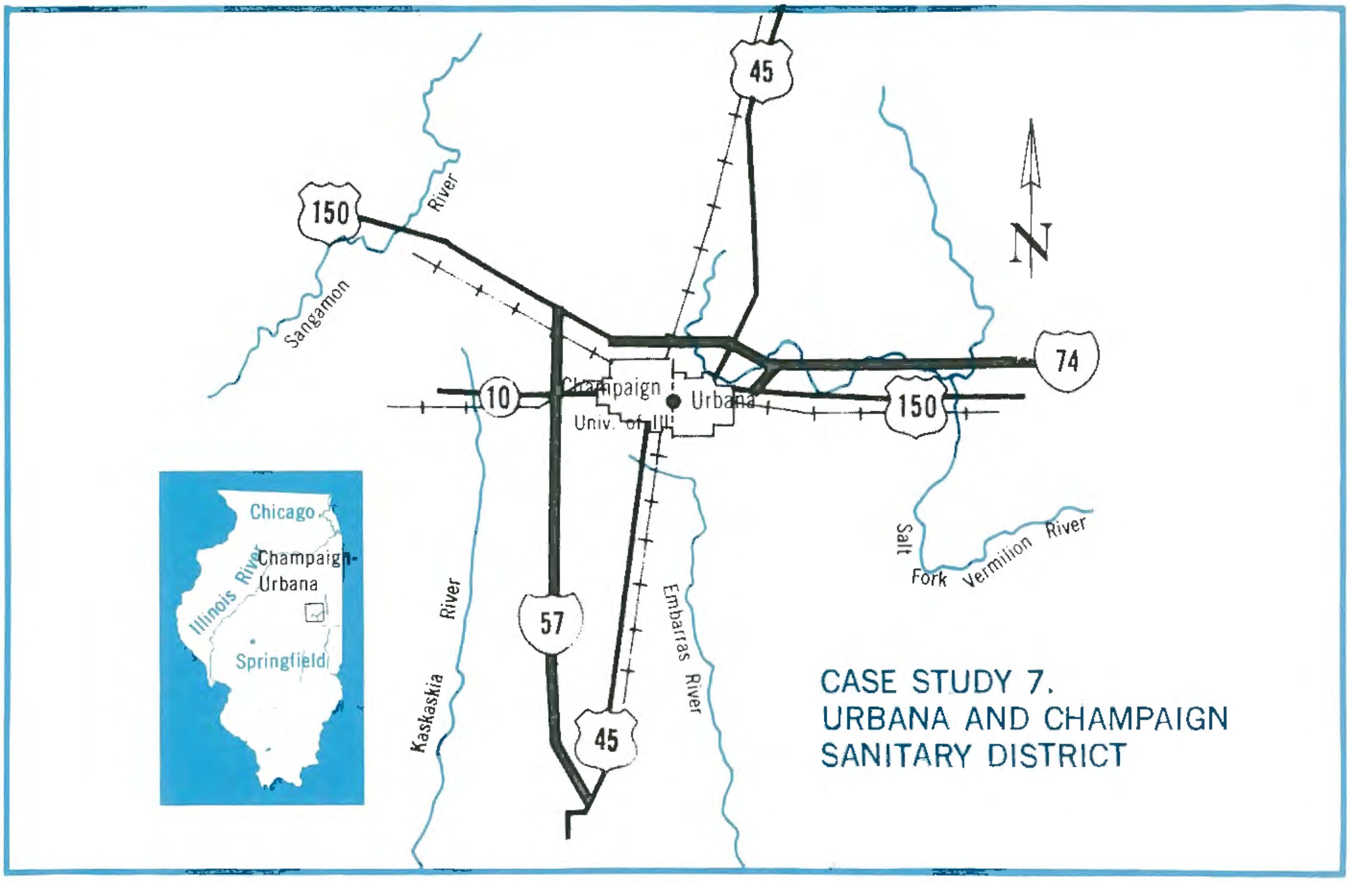
Available population figures indicate that the Rock Island-Moline Metropolitan Area will reach a population of approximately 250,000 by 2020 (Figure 28). The total capacity of the several sewage treatment plants serving the area will have to be expanded to accommodate this growth. Additional new plants will undoubtedly be added by that time to serve outlying areas, since local topography makes it difficult to convey the wastes to a central point for treatment.

Secondary treatment will be required for all plants in the area, and chlorination of all effluents should be provided to control bacterial contamination of the source of local water supplies and to reduce health hazards in the recreational use of both the Mississippi and Rock Rivers.

FIGURE 28

ROCK ISLAND COUNTY AND ROCK ISLAND-MOLINE AREA POPULATION ESTIMATES





CASE STUDY 7. URBANA AND CHAMPAIGN SANITARY DISTRICT

Urbana-Champaign, the site of the University of Illinois, is primarily a residential community. However, in recent years, there has been considerable industrial growth which can be expected to continue because Interstate 74 and 57 junction there. The increased growth rate of the University is a major influence in the present rapid development. Since these communities are located at the headwaters of three watersheds, the Kaskaskia River, the Embarras River, and the Salt Fork of the Vermilion River, and there is no means of providing reservoir capacity for streamflow augmentation, a high degree of sewage treatment is required. The Sanitary District is now designing additional treatment facilities to provide for present needs and future growth.

The area served by the Urbana and Champaign Sanitary District covers nearly 11,000 acres and includes the cities of Champaign and Urbana, the University of Illinois, and portions of Champaign, Urbana, and Hensley Townships.

The District was organized in 1922 and built its first treatment plant in 1924 for a design population of 45,000. The 1922 projection of combined student and resident population for 1960 was 66,000, but 76,877 was the combined official 1960 census population of the two municipalities. The Sanitary District estimates its present population to be 93,500. The estimated 1980 population equivalent of 174,800 includes domestic wastes from the two communities, the University, and industrial wastes. University estimates are for 32,500 students in 1974. The 174,800 population equivalent estimated for 1980 would be an increase of 87 percent over the present District population.

Waste treatment facilities at present consist of three plants. The Main Treatment plant is directly tributary to the West Branch of the Salt Fork of the Vermilion River. The Southwest Treatment plant was built in 1957 to serve a population of approximately 3200 and is tributary to the Kaskaskia River. The Lake Park Subdivision plant was built in 1960 for a population of 300 and is tributary to a branch of the Embarras River.

The Sanitary District is now designing a new Southwest Treatment plant with capacity for 40,000 population waste load and an average effluent flow of 5.0 mgd. The Sanitary District anticipates that a connected population of 15,000 will be served by the new plant in 1967. This new treatment plant will use the activated sludge process. Chlorination of the plant effluent will be provided, because it will be tributary to the Shelbyville Reservoir on the Kaskaskia River. The BOD of the plant effluent is expected to range from 10 to 20 mg/l. This quality of effluent is essential, because flows in the Copper Slough drainage ditch and the Kaskaskia River provide a minimum of dilution water. At this location, both streams have essentially no flow during the dry summer months. The Kaskaskia River at Route 10 had a mean flow of only 12.3 cfs in the 1961-62 water year.

For planning purposes, it should be assumed that the discharge in the Kaskaskia River below the confluence with the Copper Slough will range from no flow for significant periods to an average of 15 to 25 cfs, or 9.7 to 16.2 mgd. Therefore, the sewage plant effluent must be of such quality that it will not create nuisance conditions or cause intermittent fish kills and destroy aquatic life.

PLANT EXPANSION

It may be necessary to provide tertiary treatment at the Southwest plant in an effluent lagoon or other available tertiary treatment in order to meet existing and proposed water quality criteria. A tertiary lagoon would provide an additional retention time for waste stabilization and, thus, would reduce the distance required for exertion and satisfaction of biochemical oxygen demand in the Kaskaskia River.

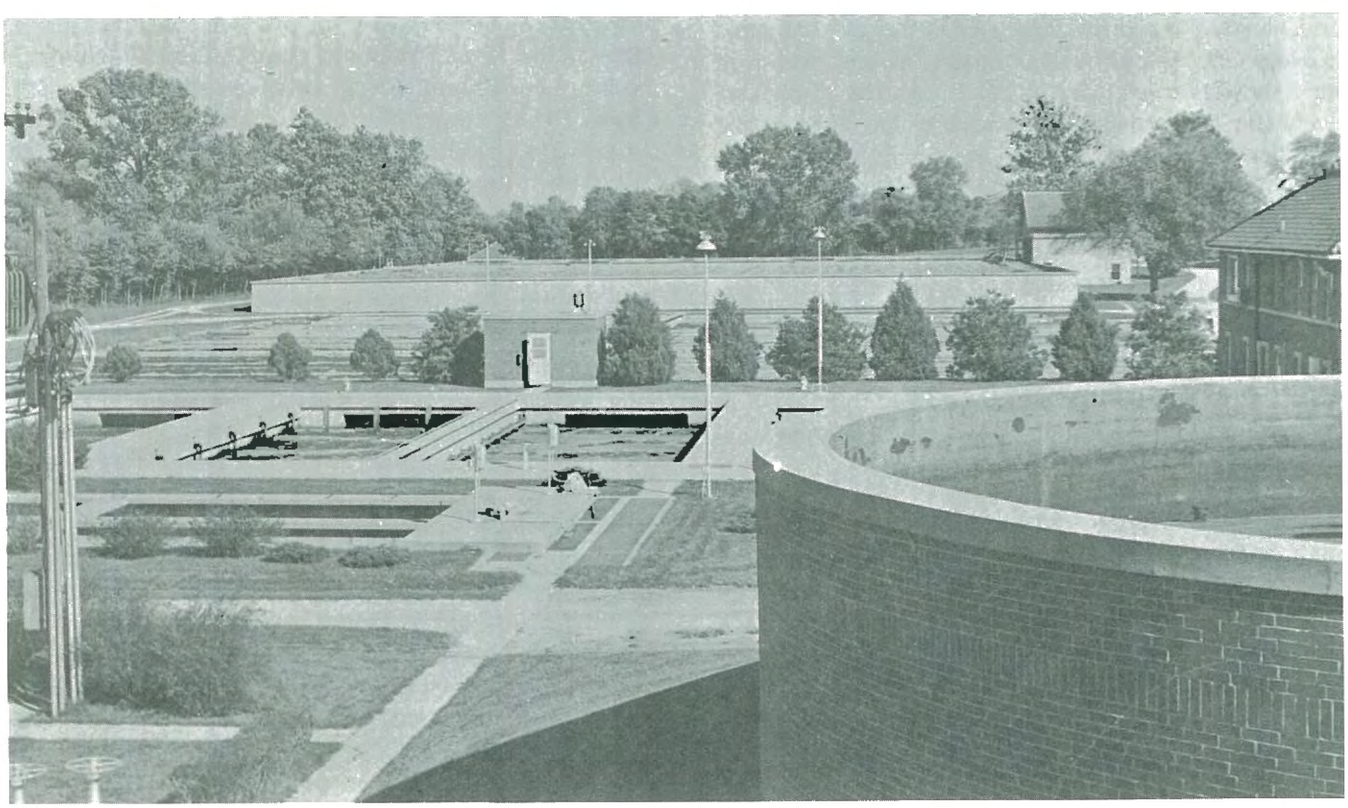
Assuming 96 percent BOD removal through the plant, including tertiary treatment, the population equivalent of the plant effluent in 1980 will be 1600. If a condition of a maximum BOD of 9 to 10 mg/l in the plant effluent is met, a streamflow of 5 to 6 cfs will be required.

Conservative loadings on the sewage treatment works will reduce the requirement for additional capacity necessary as tertiary treatment. If the population served by the Southwest plant remains essentially residential, the usual adverse effects of objectionable industrial wastes will not be a problem.

The Sanitary District pumps the major portion of wastes from the Kaskaskia drainage area over to the Main Treatment plant, except for those of the area served by the existing Southwest plant. After the new Southwest plant is built, this pumped waste load will eventually be reduced by the 40,000 population equivalent for which the new plant is designed.

The Main Sewage Treatment plant is to be expanded to treat about 95,000 population equivalent in the activated sludge portion, and the original trickling filters will accommodate about 60,000 population equivalent at 15 pounds BOD/1000 cubic feet of filter media, for a total Main plant capacity of 155,000 PE. This assumes no credit for primary settling treatment units. If 25 percent removal of the raw sewage concentration is credited to primary treatment, the plant capacity will be approximately 195,000 population equivalent. Modern activated sludge plants operate effectively without the removal of solids by primary settling, so these primary units may be of minimum size for design purposes. The expected removal across the plant is about 90 percent, including industrial waste loads and the trickling filter effluent, which is generally considered to be of a lesser quality than that from an efficient activated sludge plant.

The West Branch of the Salt Fork to which the Main plant discharges will provide inadequate dilution because the minimum flow is only 0.8 mgd, whereas the average plant effluent flow will be 15 mgd at design capacity. The expected streamflow 95 percent of the time will be 2.1 mgd, and the mean annual discharge will be about 35.7 mgd. If a maximum BOD concentration in the stream of about 9 to 10 mg/l is to be met (50 pounds effluent BOD/cfs of flow), about 53 cfs



would be necessary in the branch of the Salt Fork. At Homer some 25 stream miles below the treatment works discharge, the 95 percent duration flow is 14.8 cfs, or about 9.5 mgd, and the mean annual flow is 269 cfs, or 174 mgd.

Tertiary treatment at the Main plant will probably also be necessary as the load increases. Chlorination of the Main plant effluent is not now required, because the stream is not used for full body contact recreation and public water supply, but this may be deemed necessary by 1980. Also, it will probably be desirable to phase out the trickling filter portion of the plant so that treatment approaching 95 percent removal of BOD may be attained to keep the stream from becoming severely degraded. The trickling filter might be used as a "roughing" filter for partial treatment of high strength wastes.

POPULATION ESTIMATES

By 1980 the tributary population equivalent is expected to reach about 135,000. At 90 percent reduction, the plant effluent would be equal to a population equivalent of 13,500, if the raw sewage waste strength does not increase because of additions of highly concentrated organic industrial wastes. The Sanitary District will probably have to require pre-treatment of any such wastes prior to their discharge into the sewers and treatment works. The present concentration of the raw sewage, including industrial wastes, is 220 mg/l BOD in dry weather. This compares favorably with the 200 to 210 mg/l of a normal domestic waste. The Sanitary District charges industry for waste treatment. The service charge is based on volume and concentration of wastes and is an incentive to industry to keep waste loadings to a minimum.

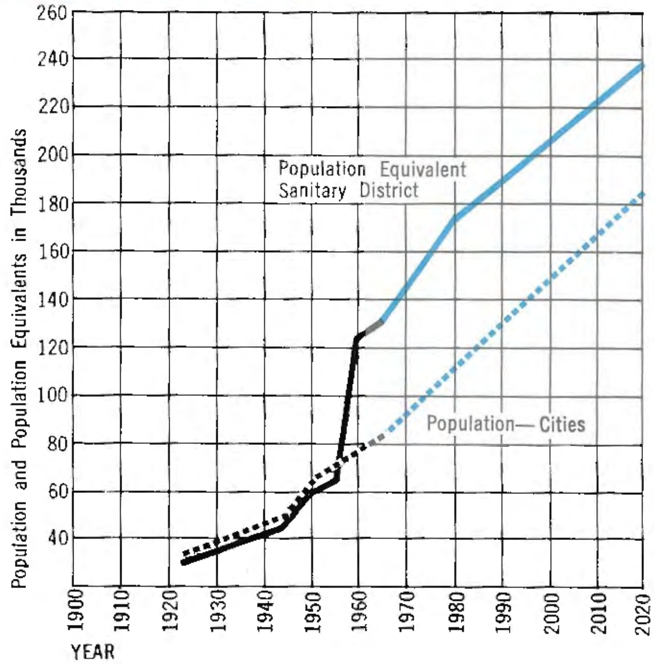
The estimated 2020 population of the Sanitary District is 152,000, assuming that the present ratio of County population to the combined City population continues (Figure 29). The County population is expected to reach 270,000 in 2020. If the ratio of industrial waste to domestic waste in the Sanitary District remains the same, the total population equivalent will be 236,000, including industry and the University of Illinois. Quite possibly, the incoming industry will be predominately of the "dry" type, which could lessen the proportion of industrial waste so that the 2020 population equivalent may be less than this prediction.

It is logical to expect that the 1980 waste load will be distributed between two, and possibly three, treatment plants in the following population equivalent proportions:

Two Treatment Plants	
Main Plant (effluent to Salt Fork)	176,000
Southwest Plant (effluent to Kaskaskia)	60,000
Three Treatment Plants	
Main Plant (effluent to Salt Fork)	146,000
Southwest Plant (effluent to Kaskaskia)	60,000
Southeast Plant (effluent to branch of Salt Fork)	30,000

FIGURE 29

URBANA AND CHAMPAIGN SANITARY DISTRICT



As the Sanitary District's sewer system expands, it is also logical to assume that the wastes now treated in the Lake Park plant will be collected and pumped to treatment elsewhere, probably in the Southwest plant.

The Lake Park subdivision treatment plant south of Champaign serves fewer than 300 people. Effluent from this plant discharges to the Embarras River Basin. Natural drainage of a part of the southeastern area of Urbana is to the Embarras Basin. Sewage from this area is now pumped to the Main plant for treatment. If the area expands greatly from 1980 to 2020, it may become necessary to consider alternatives to pumping wastes to the Main plant. One such alternative would be to provide treatment in the southeastern area with discharge of the treated effluent to the watershed of the Salt Fork of the Vermilion River.

The Embarras between Champaign-Urbana and Savoy is an intermittent stream, and for extended periods of time there would be no flow for dilution of treated effluents of any magnitude greater than the present discharge from the Lake Park plant. Charleston takes its water supply from an impoundment of the Embarras about 50 miles downstream from Champaign-Urbana. Discharge of effluents to a tributary branch of the Salt Fork of the Vermilion is the best alternative. The Vermilion River is not used for water supply in Illinois or Indiana.

The sewage collection pattern for the Urbana and Champaign Sanitary District will, in the future, need to be based in part upon the effects of effluent loads in the three watershed areas involved.

CASE STUDY 8. WASTE DISPOSAL BY INJECTION WELLS

The Velsicol Chemical Corporation effectively disposes of wastes by using a deep injection well at their plant at Marshall. One of the first disposal wells in Illinois, it was placed in service on March 22, 1966, at a total cost of about $80,000. Its function is to accommodate a waste water flow from the manufacture of an insecticide, Chlordane. The waste flow has a volume of about 30 gpm and contains about 15 percent dissolved salts. Previously, this waste was polluting Mill Creek. Alternate means of providing disposal for this waste were considered and estimated to cost about $200,000. The injection well has operated satisfactorily. It was drilled with a rotary rig, and protection of fresh water zones was provided by setting a casing through each zone, as shown in Figure 31. The well was drilled to a total depth of 2636 feet into the Devonian formation. Chemical wastes are processed before they are injected into the underground formation with equipment shown in Figure 30. Since the drilling of this waste disposal well, the State has issued permits authorizing the construction of other injection wells near Tuscola and Hennepin.

The Jones & Laughlin Steel Corporation plans to drill a well at Hennepin to be used for disposal of hydrochloric and chromic acid wastes from the cleaning and galvanizing of steel. The Mount Simon Sandstone offers the best conditions for this method of disposal, and it is anticipated that the formation will be encountered about 3200 feet below the surface. The formation is expected to be more than 1500 feet thick.

The volume of hydrochloric and chromic acid wastes to be disposed of will be 65,000 gallons per day and will increase to 105,000 gallons per day under full-scale operations. The injection system has been designed to operate at a 130 gallons-per-minute average rate, with peak capacity of 260 gpm. It will be operated intermittently, depending on demand.

Disposal of salt water by deep well injection is illustrated by the Union Oil Company system at Noble. Settling pits, skimming tanks, pumps, and piping are required to prepare the wastes for injection. Corrosion resistant tubing and packer materials are a necessity, and precautions are taken to protect fresh water zones by means of special cementing and casing methods. The Noble system is one of the more elaborate and expensive methods—representing a total investment of approximately $400,000. Injection wells to depths around 1800 feet are estimated to cost approximately $15,000.

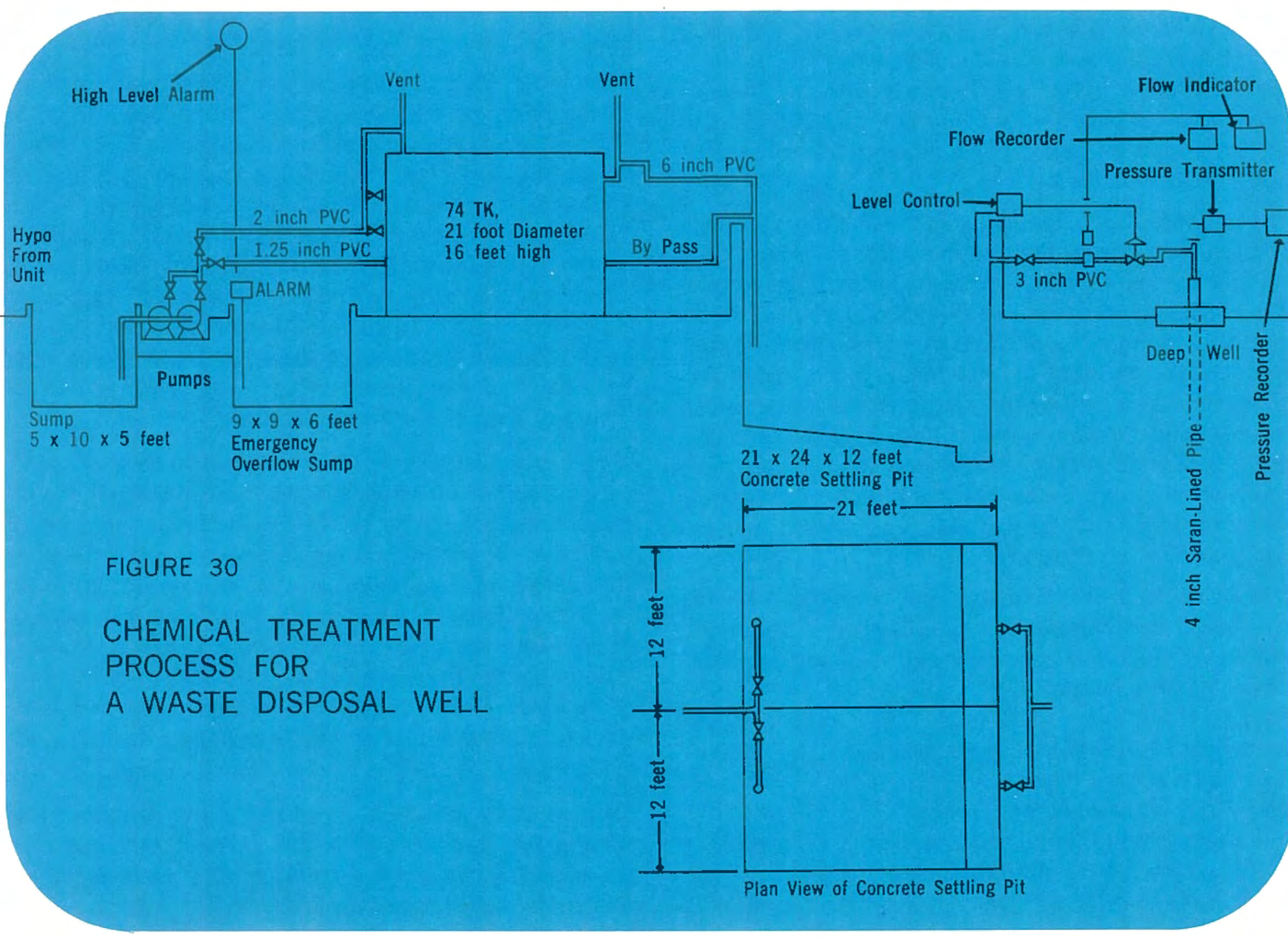
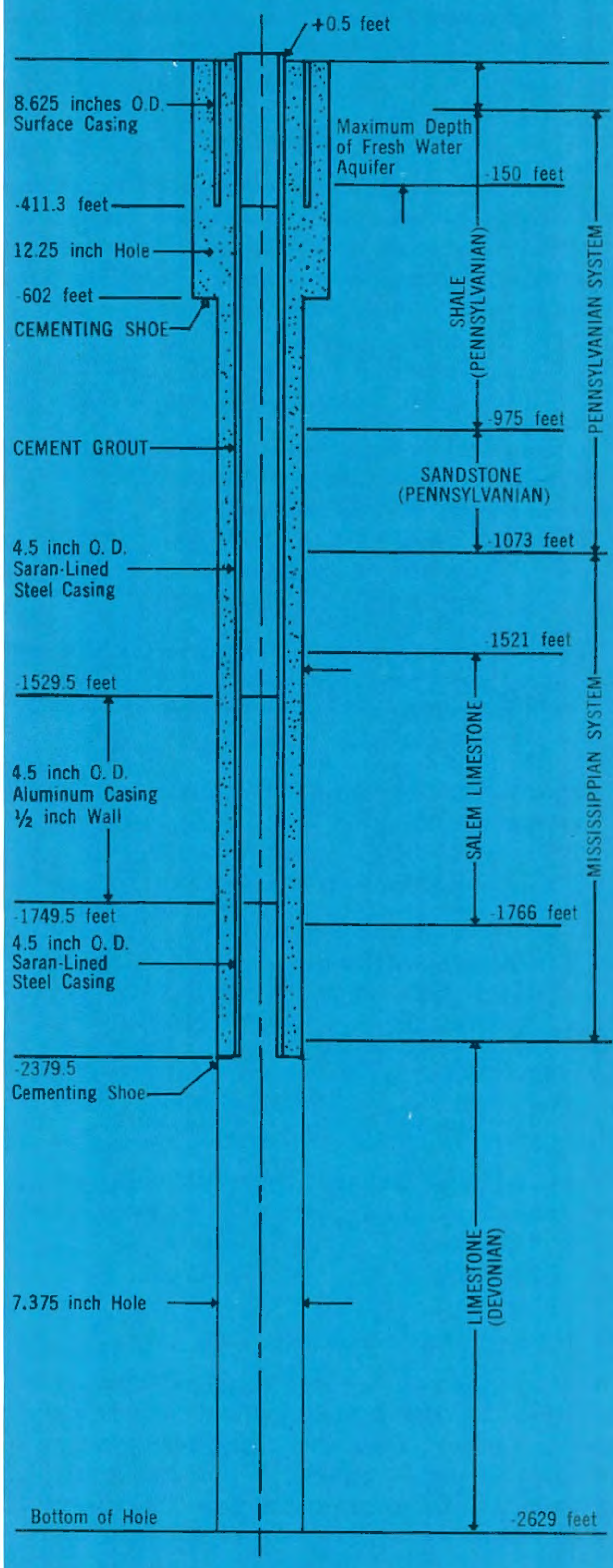


FIGURE 30

CHEMICAL TREATMENT PROCESS FOR A WASTE DISPOSAL WELL

FIGURE 31
WASTE DISPOSAL WELL



CONCLUSIONS AND RECOMMENDATIONS

I. The Federal Water Pollution Control Act of 1965 reflects a public desire to improve and enhance the quality of our streams beyond standards which were accepted or tolerated in the past. One specific effect of that Act will be the adoption of water quality criteria in Illinois by June 30, 1967. These criteria are anticipated in this chapter.

Present stream conditions are being controlled by the State Sanitary Water Board to avoid health hazards from pollution. Increasing pollutional loads will require greater degrees of treatment, with secondary treatment generally in effect. Tertiary treatment may in some instances be required to remove the nutrients that contribute to the eutrophication of streams and lakes. Facilities for effluent disinfection must be provided for most of the sewerage works in the State. In some parts of the State, notably in the Chicago Metropolitan Area, the maximum degree of treatment technically feasible will be required.

In considering the role of water pollution control as part of a State Water Plan, four basic questions emerge: 1) What is the quality of the water in our streams at present? 2) What water quality criteria or standards must be maintained for the various water uses? 3) What is the magnitude of such a program for water pollution control in Illinois in terms of manpower and dollars? 4) Exclusive of industrial investments, what will be the costs to the taxpayers for providing adequate municipal facilities for the collection and treatment of wastes to meet these criteria for various uses?

Stream water criteria are based on the application of scientific knowledge and judgments, and thus the standards or criteria included here are based on present thinking and best judgment, but must be periodically evaluated in the future as water demands, uses, and technology change.

The proposed criteria for interstate streams consistent with the Federal Water Pollution Control Act of 1965 are summarized in this chapter. Different standards are specified according to different uses. These are the tentative standards that are expected to be enforced in Illinois, both for intrastate and interstate streams.

Water quality criteria for interstate streams will be forwarded to the Federal Water Pollution Control Administration, and when approved by that agency will be in effect.

With few exceptions, the objective and trend will be toward a water of suitable quality for aquatic life and recreational purposes, but the criteria may be adjusted and may be different for the various reaches of a stream. Criteria will be subject to change, depending upon local requirements, economic factors, and the change in the environmental character of a particular area of a stream or river basin.

II. State Staffing and Budgetary Requirements

Based on the recent report, "Staffing and Budgetary Guidelines for State Water Pollution Control Agencies," prepared by the Public Administration Service under a contract with the Federal Department of Health, Education, and Welfare, some estimate can be made of the personnel and funds which should be made available to the State's water pollution control agency. Projected to 1975, the minimum available staff should be 133, the desirable 204. This would include professional personnel such as sanitary engineers, biologists, chemists, bacteriologists, and allied technicians. The total budget should be a minimum of $1,700,000; the desirable budget would be $2,475,000.

In contrast to these staffing and budgetary standards, the present staff available to the Sanitary Water Board is 54 persons. The annual budget is currently $518,400. It is thus clear that, if a reasonable performance is expected in the management of the State's water quality, an increase of from three to five times in staff and funds will be required.

III. Costs for Sewers, Separation, and Treatment

To achieve and maintain the stream water quality which is outlined in this chapter will require large expenditures. The following cost estimates are the annual expenditures which will be required by municipalities and other local governments to achieve and maintain clean streams. In making these estimates, consideration has been given to the improved quality criteria and higher degree of treatment, the growing population and waste load generated, and reasonable cost escalation. The estimates do not include costs to industry for the concurrent financial burdens which they will also face. The costs are not adjusted for grants or loans which may be made available by the State and agencies of the Federal Government. The 1966 figures are the approximate current rate of expenditure which is programmed to increase as indicated.

A. The following are estimates of annual funds needed by local governments within the Sanitary Water Board area of jurisdiction.

For additions and new treatment works:

1966:	$30,300,000
1980:	52,500,000
2020:	117,300,000

For sewers (excluding house services:)

1966:	$24,000,000
1980:	42,000,000
2020:	93,000,000

For replacement of obsolete or inadequate sewer lines and necessary storm-water separation:

1966:	$11,000,000
1980:	21,000,000
2020:	46,500,000

Annual totals for the area of the State under Sanitary Water Board jurisdiction (excluding the Metropolitan Sanitary District of Greater Chicago) for treatment facilities, sewers, and replacement of old sewer lines and necessary storm sewer separation:

1966:	$65,300,000
1980:	115,500,000
2020:	256,800,000

B. Annual totals within the area of the Metropolitan Sanitary District of Greater Chicago:
For treatment facilities and sewers:

1966:	$30,000,000
1980:	60,000,000
2020:	150,000,000

For sewer replacement and necessary repair and required storm sewer separation:

1980:	$32,000,000
2020:	75,000,000

Totals for Metropolitan Sanitary District of Greater Chicago:

1980:	$92,000,000
2020:	225,000,000

C. Annual totals for the entire State:
For treatment facilities and sewers:

1980:	$154,500,000
2020:	360,300,000

For necessary sewer separation and replacement:

1980:	$ 53,000,000
2020:	121,500,000

Grand totals for treatment, sewers, storm sewer separation, and sewer replacement for the entire State:

1980:	$207,500,000
2020:	481,800,000

IV. Research and Studies

The program of pollution control and water quality improvement outlined in this chapter will require a giant effort on the part of the State, local governments, and industry. It calls, in general, for employing existing technology in increased conventional treatment of wastes before discharge to the streams.

There is reason to expect that by or before a complete statewide treatment program of such magnitude is achieved, research findings will point the way to means for more complete treatment. In fact, the presently projected means will predictably fall short of the waste reduction that will be needed in at least some areas of the State. Of particular concern is the eutrophication of lakes which will be used increasingly for water supply and recreation. Eutrophication is related to the fertilizing elements of nitrogen and phosphorous that stimulate algae growths and other aquatic vegetation. These problems are already present and will predictably become severe.

Another major concern requiring study is the determination of the most economical means of achieving advanced or tertiary waste treatment where needed. Research and pilot studies are needed to test new methods and to compare effectiveness and costs among such methods. The various methods should be compared with increased low-flow dilution or waste collection and diversion. Therefore, Illinois must maintain a strong research program related to water quality management and must be prepared to experiment with promising new methods.

V. State Assistance in Local Funding

It is recommended that an allocation be made from the proposed Illinois Resource Development Fund for State assistance to municipalities for sewerage plant construction. This plan for grants to Illinois municipalities includes the following considerations:

A. Estimates have been prepared of the anticipated costs for Illinois municipal sewage treatment facilities to 1980 and beyond to meet water quality criteria in the future.

B. The Clean Water Restoration Act of 1966 provides an enlarged system of Federal grants to municipalities for construction of treatment plant facilities. The distribution of these Federal grants, which will be administered by the State, provides:

—30 percent of the cost of any treatment facility;

—40 percent of the cost of any project to which a state is contributing 30 percent;

—50 percent of the cost of any project to which a state contributes 25 percent, if the state in addition has agreed to impose water quality standards on all navigable streams within the state;

—10 percent bonus to any project that is part of an area-wide plan.

C. Experience has shown that grants are an incentive that favorably influences the authorization of local financing for treatment facilities.

At the present time the waste treatment construction program is being financed with 30 percent Federal and 70 percent local financing. This has proven difficult for municipalities in many recent cases, and the ability of municipalities to finance this percentage under the accelerated program which is projected is doubtful. It is, therefore, concluded that State assistance is highly desirable if not essential.

D. The authorizations contained in the Clean Water Restoration Act extend through fiscal year 1971, and it is not possible to anticipate beyond that year with certainty. In consideration of the history of increases in such grants and in consideration of the great national needs, it may be reasonable to assume at least a continuation of the 1971 rate. Projecting the State contributions through the 1980 fiscal year, target date for the action program recommended in this report, gives an aggregate sum for the period 1969 through 1980 of $347 million. This is the amount recommended for allocation from the Illinois Resource Development Fund.

The following table gives the most favorable financing among several alternatives and assumes a 55 percent Federal contribution, 25 percent State contribution, and 20 percent from local funds.

PROJECTED SCHEDULE

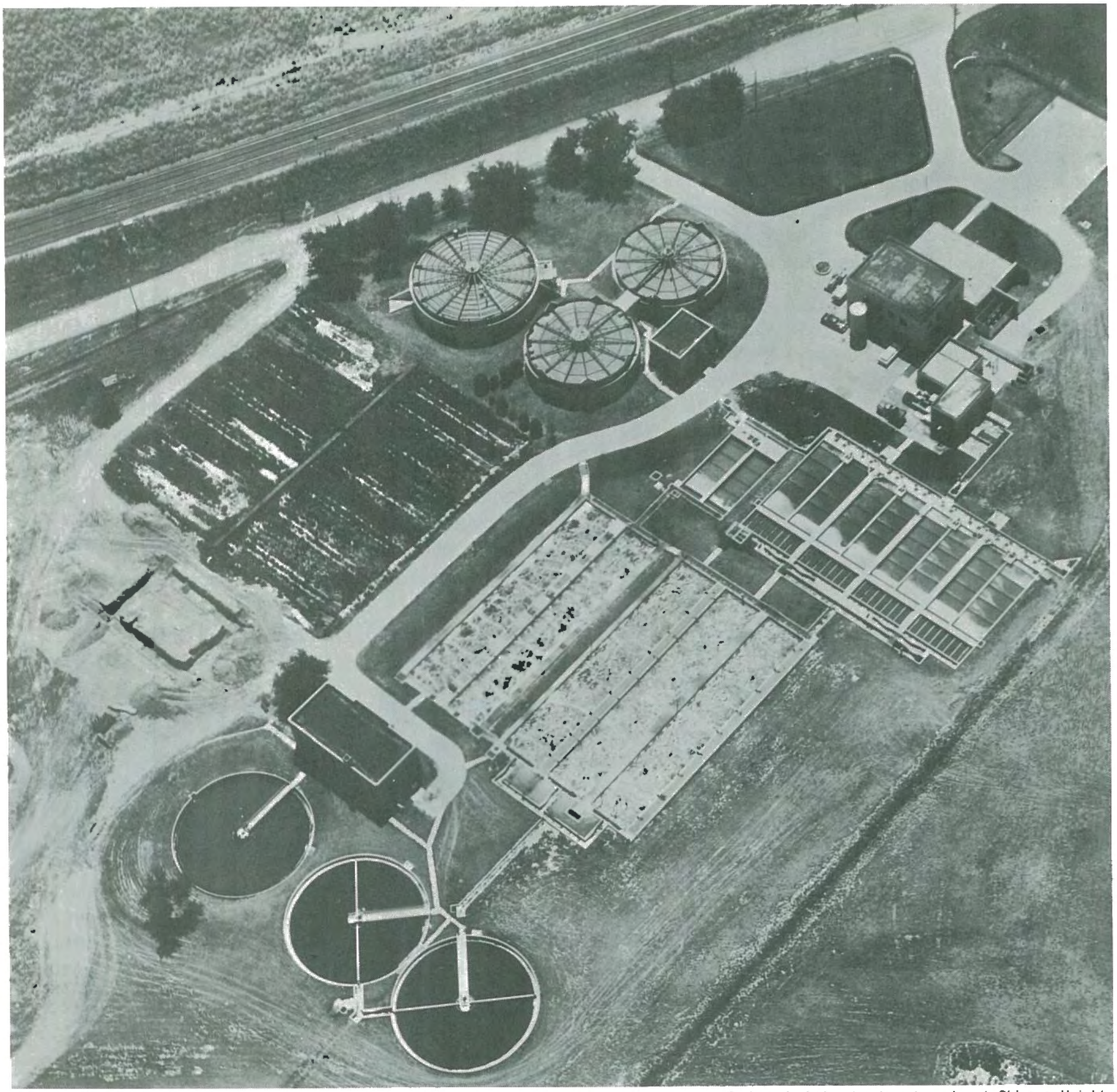
Illinois Municipal Waste Treatment Construction
(Numbers are in Millions of Dollars)

Fiscal Year	Federal Funds	State Funds	Local Funds	Project Value	Construction Needs
1967	6.2				
1968	22.9	10.4	8.3	41.6	67.5
1969	36.7	16.7	13.6	66.8	70.5
1970	53.4	24.3	19.4	97.0	73.9
1971	67.2	30.6	24.4	122.3	78.0

It will be noted in the table above that fiscal year 1970 is the first in which the scheduled project values will exceed construction needs, at which time construction will begin to gain on the accumulated backlog of needed facilities.

Assuming that funds from the proposed Illinois Resource Development Fund would not become available until fiscal year 1969, the State would need to appropriate $10.4 million from regular appropriations for fiscal year 1968 to obtain the assumed Federal contribution.

Treated effluent enters the DuPage River



Activated sludge treatment works at Chicago Heights.

ACKNOWLEDGMENTS

Part of this chapter was prepared under the direction of Mr. Clarence W. Klassen, Chief Sanitary Engineer, and Mr. D. B. Morton, Chief of the Bureau of Stream Pollution Control, of the Sanitary Engineering Division.

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chapter five
land and water management

illinois technical advisory committee on water resources

"To waste, to destroy our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them amplified and developed."

Theodore Roosevelt

SUMMARY

Land and water management is virtually synonymous with soil and water conservation. In Illinois, the conservation planning task is one-third finished. This has been accomplished in the past 29 years, since the first soil and water conservation district was organized.

Much of Illinois was originally a marshy prairie with such poor drainage it could not be farmed. The State has been converted into some of the world's most productive crop land. More than 82 percent of the State's land is now suitable for cultivation. Although the accomplishment is great, much remains to be done.

The chapter summarizes the principal features of Illinois agriculture. It discusses soil and water as resources, the associated problems, and the means for their solution. The history of soil and water conservation is summarized, the results of soil surveys and land classification is reported, and case studies illustrate how knowledge, organizations, and people combine to manage the soil and water resource.

Watershed development for flood control and upland and bottom-land drainage is a vital part of land and water management. Public Law 566 provides Federal funds and technical assistance for watershed protection and flood prevention projects. Four watershed projects have been completed in Illinois, and seven others have been approved for construction. A number of other proposed projects are in various stages of planning. A series of case studies of typical watershed projects in Illinois illustrates the drainage and flood problems which such projects help to solve.

Upland agricultural drainage is discussed as is irrigation. Irrigation is not extensive at present, but may in the future be used to further increase the State's crop yields.

INTRODUCTION

This chapter deals with the management of Illinois land and water, a subject of vital importance to the continuing quality and quantity of our water resources. This is a complex subject in many ways. It would be complex even if the only objective were to conserve our soil and to control runoff by applying land and structural practices which are not fully understood. But it is far more involved than the application of established practices, particularly in Illinois where most of the land is in private ownership and intensively managed for crop production. The short-term and long-term objectives of farmers are the basis of decision. If their objectives are unsound, there may be a long process of education involved.

Management of land and water resources is also greatly influenced by the soil resource and its capabilities and limitations, by the climate, and by changing economic circumstances.

Finally, land and water management is greatly affected by various laws and the many governmental agencies and organizations established to carry them out. It is through such agencies that individual farmers may get technical and financial assistance to achieve good farm management. It is also through such agencies that it is possible for individual farmers to work together in solving problems that affect more than one farm or are beyond the resources of the individual.

Thus, in assessing the present problems and approaching the work yet to be done, the subject-unfolds by re-studying a summary of crop and livestock production, describing the soil and water conservation movement and its development in Illinois, the land and water problems according to resource areas of the State and soil classes, and the small watershed program. Finally, special attention is given to agricultural drainage, which is historically of great importance to land and water management in Illinois and to irrigation, which is a limited practice now, but under a different set of economic or policy circumstances could become of great importance in our water economy.

Agriculture in Illinois has changed much during the past 45 years, and will continue to progress. Technological changes began in the 1920s when the tractor replaced the horse, enabling each farmer to cultivate more land. This started the trend which decreased the number of farms and increased the average size of the farms in Illinois. In 1920 there were 240,000 farms which averaged 135 acres per farm; in 1965 the number of farms had been reduced to 141,000, and the average size had increased to 214 acres per farm (Figure 1).

During the past 20 years, improved crop varieties, increased use of fertilizers, improved land culture practices, and the use of high plant populations have greatly increased the State's agricultural production. The acreage of corn harvested increased from 7.9 million acres in 1920 to 9.7 million in 1965. Corn production increased from 285 million bushels in 1920 to 891 million bushels in 1965 (Figure 2). Soybean acreage, the fourth ranked income crop, increased from 1.8 million acres in 1940 to more than 6 million acres in 1965. Soybean production increased from zero in 1920 to 174 million bushels in 1965.

Wheat acreage decreased from 4.1 million acres in 1920 to 1.6 million acres in 1965, and production decreased from 71 million bushels in 1920 to 57 million bushels in 1965.

The number of livestock on the farms in Illinois varies from year to year (Figure 3). The number of hogs and pigs increased from 4.6 million in 1920 to 7.1 million in 1966. The number of cattle and calves increased slowly from 2.35 million in 1930 to 3.7 million in 1966. The number of chickens decreased from 25 million in 1920 to 9.2 million in 1966.

FIGURE 1

TREND IN SIZE AND NUMBER OF FARMS

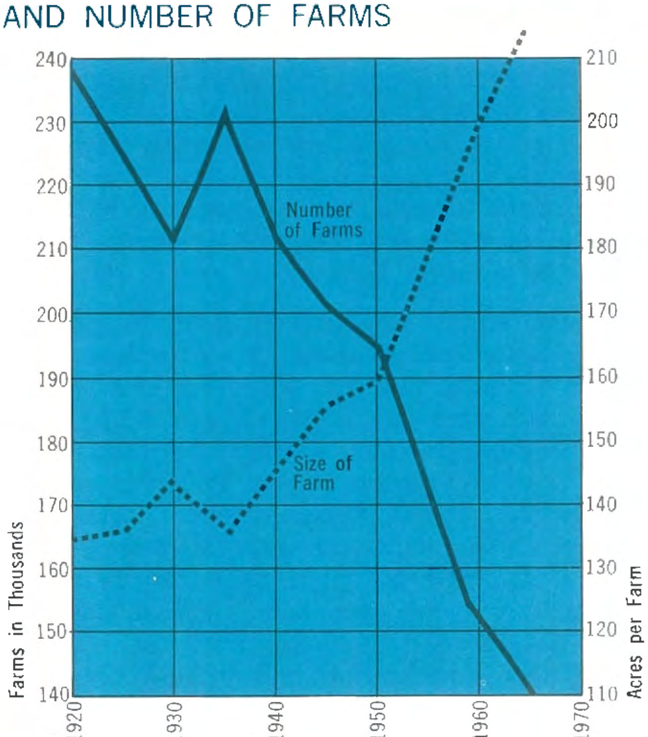


FIGURE 2

CROP PRODUCTION

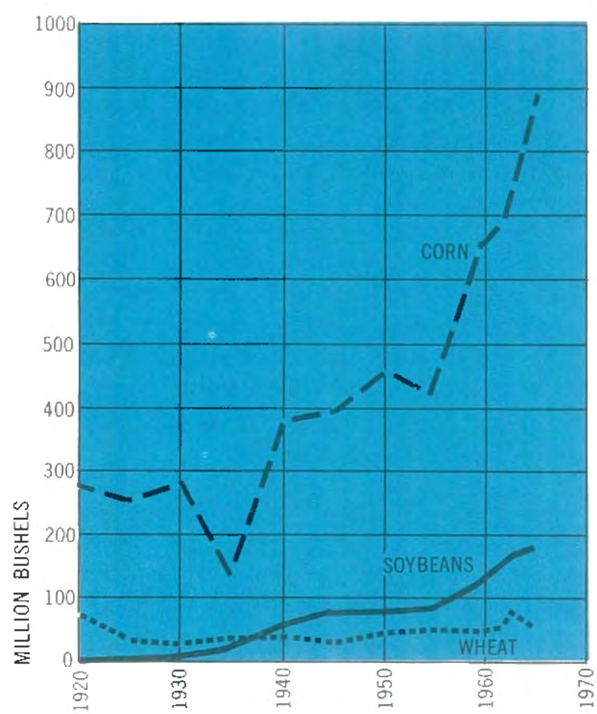
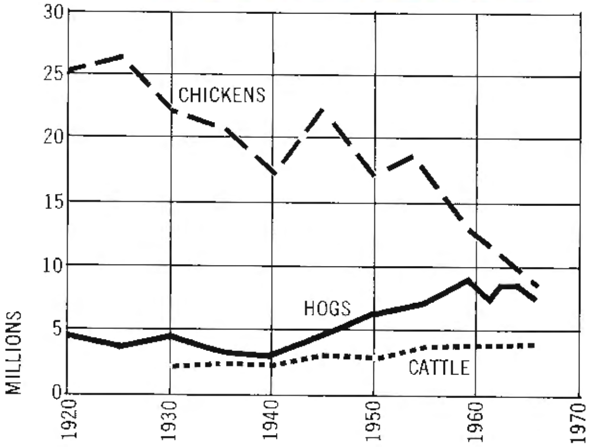


FIGURE 3 LIVESTOCK PRODUCTION



In 1964 the value of sales from all crops made up 49.5 percent ot total cash farm income in Illinois, while the value of sales from livestock and livestock products contributed the remaining 50.5 percent. Corn production was the largest single source of cash receipts, 23.6 percent of the total. In order, cash receipts from other livestock production were: cattle, 20.3 percent; hogs, 20.1 percent; and soybeans, 17.0 percent. Receipts from these four commodities were more than four-fifths of total cash farm income for the State in 1964.

SOIL AND WATER CONSERVATION

The management of land and the management of the water on it and in it are closely related. Similarly, land and water management is virtually synonymous with soil and water conservation, a movement that has swept across America during the past 30 years. Rarely, if ever, has such a worthwhile program been conceived, born, and brought to fruition in so few years.

In 1930 Congress appropriated a modest sum to establish ten experiment stations to investigate erosion control. Soil erosion control demonstration areas, usually involving an entire watershed, were established throughout the United States by the Service. One of the first was at LeRoy.

The Omnibus Flood Control Act of 1936, as amended, authorized the Department of Agriculture to investigate and construct watershed projects and led to development of comprehensive programs of upstream watershed protection and flood prevention.

In 1951, Secretary of Agriculture Charles F. Brannan established as the basic physical objective of soil conservation activities by Department agencies "the use of each acre of agricultural land within its capabilities and the treatment of each acre of agricultural land in accordance with its needs for protection and improvement."

Since 1944, the Agricultural Conservation Program has consisted entirely of sharing with farmers the costs of soil building and soil and water conservation practices. The Program has shared annually with 1.2 to 3.8 million farmers the costs of establishing locally adapted on-farm soil and water conservation practices in the public interest.

The Watershed Protection and Flood Prevention Act (Public Law 566) became law in August 1954. The Act provided for Federal assistance to local organizations in planning and constructing watershed projects.

The first thirteen small watershed projects were approved for operations in June 1956. As of July 1, 1966, the U. S. Department of Agriculture had received 2502 applications for assistance under P. L. 566 on more than 181 million acres; 1211 watersheds involving 84 million acres had been approved for planning; installation of works of improvement had been authorized on 729 watersheds involving nearly 42 million acres; 118 of the projects have been completed.

In 1937 the Illinois General Assembly passed the Soil and Water Conservation District Law enabling landowners to organize soil and water conservation districts. The purpose of such a district is to conserve the soil and water resources of the State by controlling and preventing soil erosion and floodwater and sediment damages.

The State is now fully organized with 98 Soil and Water Conservation Districts. In most cases a district is a county, but a few cover two counties. In 1965 there were 153,657 farms with 33,231,332 acres in these districts. The technical staff of the U. S. Soil Conservation Service, through the local districts, has helped 29 percent of the landowners of the State work out conservation plans for 23 percent of the acreage in the 98 districts. Many thousands of landowners and farm operators receive assistance from a soil and water conservation district in applying one or more conservation practices before a conservation plan is worked out for the entire farm.

LAND AND WATER PROBLEMS

The physical problems of land and water management are related to the capabilities and limitations of soil itself, and to the uses to which the land is put—be it in crops, pasture, or woodland. It is also useful to survey the soils and their uses from an over-all State view, as well as by regions of more or less similar areas of the State. After assessing the soil resource and its uses, this section will conclude with examples of how farmers have organized and are moving toward the goal of using each acre within its capabilities and applying treaments in accordance with its needs for protection and improvement.

LAND CAPABILITY CLASSIFICATION

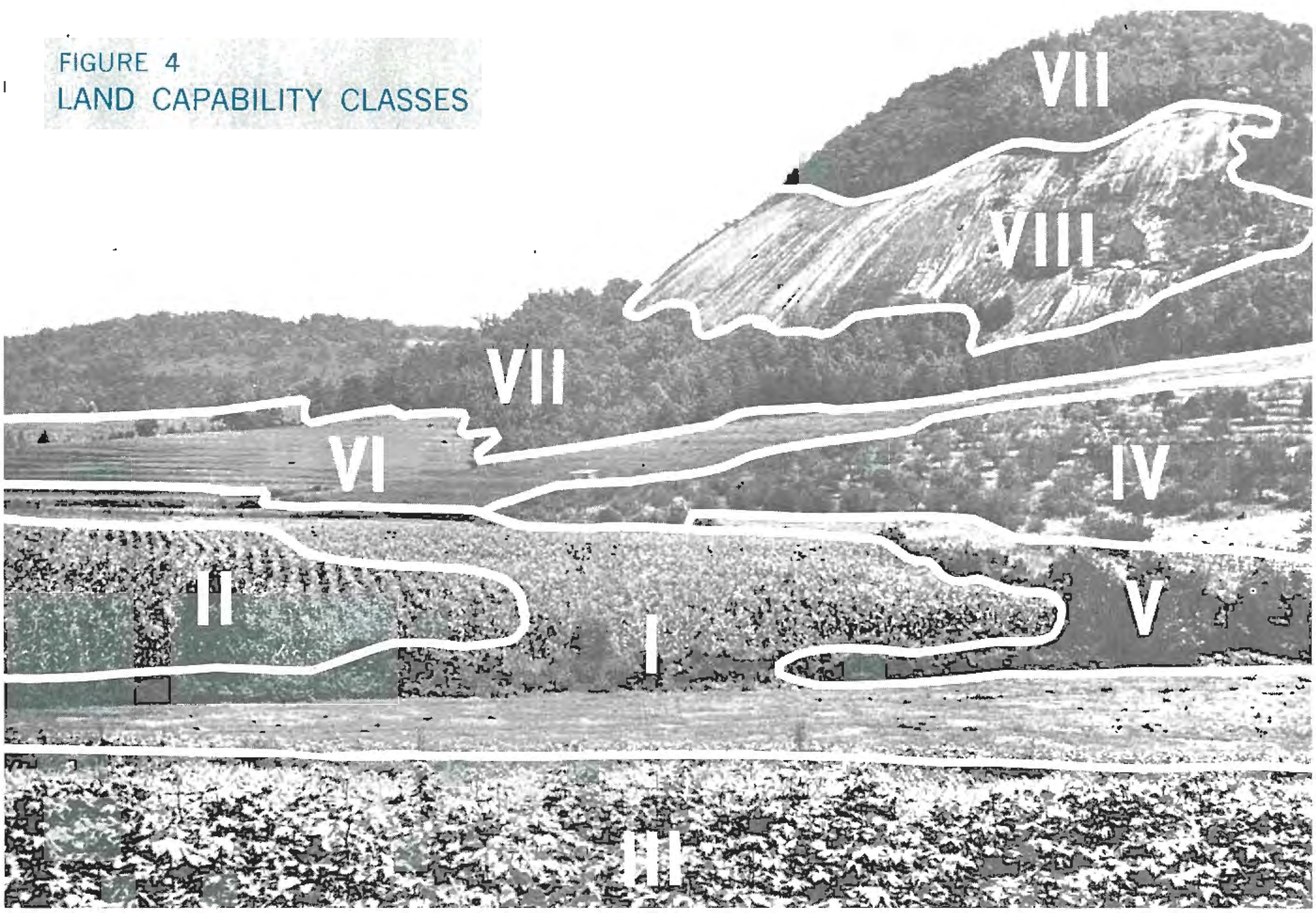
The standard soil survey map shows the different and significant kinds of soil and their location in relation to other features of the landscape. The information on the soil map must be explained in a way that has meaning to the user. The capability classification is one of a number of interpretive groupings made uniformly throughout the United States, primarily for agricultural purposes. As in all interpretive groupings, capability classification begins with the individual soil mapping units—the building stones of the system.

The capability classification is a grouping of soils and land types that shows, in a general way, how suitable they are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when the soils are used, and the way in which they respond to treatment (Figure 4).

In this system, all the kinds of soils are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest groupings are numbered I through VIII. Class I includes the soils that have few limitations, the widest range of use, and the least risk of damage from use. The soils in the other classes have progressively greater limitations.

The subclasses indicate major limitations within the classes. Within most of the classes, there can

FIGURE 4
LAND CAPABILITY CLASSES



be as many as three subclasses to indicate erosion hazards, wetness, or root zone limitations.

Soils are classified into capability classes and subclasses in accordance with the degree and kind of permanent limitations, but without consideration of major and generally expensive land-forming that would change the slope, depth, or other characteristics of the soil, and without consideration of possible but unlikely major reclamation projects. The capability grouping of the soils is designed to 1) help landowners and others use and interpret the soil maps, 2) introduce users to the detail of the soil map itself, and 3) make possible broad generalizations based on soil potentialities, limitations in use, and management problems. Soils are grouped into capability units, subclasses, and classes primarily on the basis of their ability to produce common cultivated crops and pasture plants over a long period without deterioration.

Capability Classes

Land in Classes I, II, III, and IV is suited for cultivation and other uses.

Class I — These soils have few limitations that restrict their use. They are suited to a wide range of plants and may be used safely for cultivated crops, pasture, woodland, and wildlife. They are nearly level, with a low erosion hazard from wind or water. They are deep, have adequate drainage, and are easily worked. They hold water well and are either fairly well supplied with plant nutrients or highly responsive to inputs of fertilizer. The soils in Class I are not subject to damaging overflow. They are productive and suited for intensive cropping.

Soils in Class I that are used for crops need ordinary management practices for maintaining productivity—both soil fertility and soil structure. Such practices may include the use of one or more of the following: fertilizers and lime, cover and green-manure crops, conservation of crop residues and animal manures, and sequences of adapted crops.

Class II — These soils have some limitations that reduce the choice of plants or require moderate conservation practices. They require careful soil management, including conservation practices, to prevent deterioration or to improve air and water relations when they are cultivated. The limitations are few and the practices are easy to apply. The soils may be used for cultivated crops, pasture, woodland, or wildlife food and cover.

Limitations of soils in Class II may include, singly or in combination, the effects of 1) gentle slopes; 2) moderate susceptibility to wind or water erosion or moderate adverse effects of past erosion; 3) less than ideal soil depth; 4) somewhat unfavorable soil structure and workability; 5) slight to moderate alkalinity, easily corrected but likely to recur; 6) occasional damaging overflow; and 7) wetness that can be corrected by drainage, but exists permanently as a moderate limitation.

Class III — These soils have severe limitations that reduce the choice of plants or require special conservation practices, or both. They have more restrictions than those in Class II. When they are used for cultivated crops, the conservation practices are usually more difficult to apply and to maintain. They may be used for cultivated crops, pasture, woodland, or wildlife food and cover.

Limitations of soils in Class III restrict the amount of clean cultivation; timing of planting, tillage, and harvesting; choice of crops; or a combination of these. The limitations may result from the effects of one or more of the following: 1) moderately steep slopes; 2) high susceptibility to water or wind erosion or severe adverse effects of past erosion; 3) frequent overflow, accompanied by some crop damage; 4) very slow permeability of the subsoil; 5) wetness or some continuing waterlogging after drainage; 6) shallow depths to bedrock, hardpan, siltpan, or claypan that limit the

rooting zone and the water storage; 7) low moisture-holding capacity; 8) low fertility, not easily corrected; or 9) moderate alkalinity.

When cultivated, many of the wet, slowly permeable but nearly level soils in Class III require a drainage system and a cropping system that maintains or improves their structure and ability to be tilled. To prevent puddling and to improve permeability, it is commonly necessary to supply organic material to such soils and to avoid working them when they are wet. Each distinctive kind of soil in Class III has one or more alternative combinations of use and practices required for safe use, but the number of practical alternatives for average farmers is less than for soils in Class II.

Class IV — These soils have severe limitations that restrict the choice of plants, require very careful management, or both. The restrictions in use are greater for these soils than for those in Class III, and the choice of plants is more limited. When they are cultivated, more careful management is required, and conservation practices are more difficult to apply and maintain. These soils may be used for crops, pasture, woodland, or wildlife food and cover.

Soils in Class IV may be well suited to only two or three of the common crops, or the amount of harvest produced may be low in relation to inputs over a long period. Use for cultivated crops is limited as a result of the effects of one or more permanent features, such as 1) steep slopes, 2) severe susceptibility to water or wind erosion, 3) severe effects of past erosion, 4) shallowness, 5) low moisture-holding capacity, 6) frequent overflows accompanied by severe crop damage, 7) excessive wetness with continuing hazard of water logging after drainage, or 8) severe alkalinity.

Many sloping soils in Class IV in humid regions are suited for occasional, but not regular cultivation. Some of the poorly drained, nearly level soils are not subject to erosion, but are poorly suited to inter-tilled crops because of the time they require to dry out in the spring and because of their low productivity for cultivated crops. Some soils in Class IV are well suited to one or more of the special crops, such as fruits and ornamental trees and shrubs, but this suitability in itself is not sufficient to place a soil in Class IV.

Land in Classes V, VI, VII, and VIII is limited in use and generally not suited for cultivation.

Class V — These soils have little or no erosion hazard, but have other limitations that generally make their use impractical, except for pasture, woodland, or wildlife food and cover.

The limitations of Class V soils restrict the kind of plants that can be grown on them and prevent normal tillage of cultivated crops. They are nearly level, but some are wet, subject to overflow, stony, have climatic limitations, or have some combination of these limitations. Examples are 1) bottom lands subject to frequent overflow that prevents the normal production of cultivated crops, 2) level or nearly level stony or rocky soils, and 3) ponded areas where drainage for cultivated crops is not feasible, but pastures can be improved and benefits from proper management can be expected.

Class VI — These soils have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture, woodland, or wildlife food and cover.

The physical condition of soils in Class VI is such that it is practical to apply pasture improvements, if needed, such as seeding, liming, or fertilizing, or to control water with contour furrows, drainage ditches, diversions, or water spreaders. These soils have continuing limitations that cannot be corrected, such as 1) steep slope, 2) severe erosion hazard, 3) effects of past erosion, 4) stoniness, 5) shallow rooting zone, 6) excessive wetness or overflow, or 7) low moisture capacity. Because of one or more of these limitations, they are not generally suitable for cultivated crops. But they may be used for pasture, woodland, wildlife cover, or some combination of these uses.

Some soils in Class VI can be safely used for the common crops, provided unusually intensive management is applied. Depending on soil features and local climate, they may be well or poorly suited as woodlands.

Class VII — These soils have extremely severe limitations that make them unsuitable for cultivation and that restrict their use largely to grazing, woodland, or wildlife.

The physical condition is such that it is impractical to apply such pasture improvement as seeding, liming, or fertilizing, or to control water with contour furrows, ditches, diversions, or water spreaders. Soil restrictions are more severe than those in Class VI because of one or more continuing limitation that cannot be corrected, such as very steep slopes, erosion, shallowness, stoniness, wetness, or other limitations that make them unsuited for common cultivated crops. Under proper management they can be used safely for grazing, woodland, wildlife food and cover, or some combination of these uses.

Depending on the soil characteristics and local climate, soils in this class may be well or poorly suited to woodland. They are not suited to any of the common cultivated crops. Under unusual management practices, some soils in this class may be used for special crops in unusual circumstances. Some areas may need seeding or planting to protect the soil and to prevent damage to adjoining areas.

Class VIII — These soils and land forms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or aesthetic purposes.

They cannot be expected to return significant on-site benefits from management for crops, grasses, or trees, although benefits from wildlife use, watershed protection, or recreation may be possible.

Limitations that cannot be corrected may result from one or more of the following: 1) erosion or erosion hazard, 2) severe climate, 3) wetness, 4) stoniness, and 5) low moisture capacity. Rock outcrop, sandy beaches, river wash, mine tailings, and other nearly barren lands are included in this class.

CONSERVATION NEEDS AND PROBLEMS

What, then, is the job ahead for soil conservationists? Essentially, it is to guide the application of the developing technology so as to make efficient use of the productive potentials of soil and water resources without depleting or destroying their capabilities for future use.

It is true that new technology promises continually to increase the output of food, fiber, and other benefits from an unchanging area of land and water; it is equally true that new machines, chemicals, and production techniques are of little or no value without good arable soils to which they can be applied. Productive land for agriculture will become more, not less, important in the years ahead. In addition, the non-agricultural needs of added millions of people—for living space, recreational areas, and urban and industrial sites—must be met from these same lands.

CONSERVATION NEEDS INVENTORY

In 1957 the U. S. Department of Agriculture began a National Inventory of Soil and Water Conservation Needs to survey the conservation needs on the fields, pastures, ranges, and woodlands of the nation. The Inventory was designed to reflect anticipated changes in land use by 1975 and to define the need for each conservation practice. It gave special consideration to watershed protection needs.

The U. S. Soil Conservation Service was in charge of the Inventory, but every agency concerned with use and conservation of soil and water resources participated. In Illinois, the Agricultural Experiment Station, the Department of Conservation, and the Division of Soil and Water Conservation were major contributors. Altogether, some 30,000 people in 3000 counties in the United States participated in the Inventory. Information from all sources—soil surveys, the Census of Agriculture, Time Resources Review, and others—was brought together and consolidated in each county.

The basic data of the Inventory came from soil surveys of pre-selected sample areas in each county with non-Federal agricultural land. The Inventory did not include urban and built-up areas or Federally-owned lands.

Under direction of county and state committees, the Inventory was completed in 1961. The Inventory for Illinois was published by the Cooperative Extension Service, University of Illinois, in August 1962. Many of the soil and water conservation districts published and distributed to the landowners that part of the report pertaining to their county.

The information secured through the Inventory has been used extensively to call attention to the increasing use of land for non-agricultural purposes and to emphasize the importance of careful conservation of vital soil, water, and other natural resources. Updating of the material in the report is in progress now, and should be completed by the end of the year.

LAND CAPABILITY AND LAND USE

The Inventory shows that about 82 percent of the non-Federal agricultural land in Illinois, or about 27 million acres, is in capability Classes I, II, and III and is suitable for regular cultivation. Most of this land is already being used as cropland.

Also, there are about 2 million acres of Class IV land suitable for occasional cultivation, if intensive conservation practices are applied, but better kept in permanent vegetation. About half of Class IV land is now being cultivated and creates a continuing conservation problem.

About 4 million acres of Class I through III and about 1 million acres of Class IV land now in pasture and woodland provide some reserve that could be cultivated if needed. However, there does not appear to be any immediate prospect of conversion of this land to cultivated crops.

Land in the other four capability classes is used mainly for grazing and woodland, generally in accordance with its capabilities, although about 1 million acres of Class V through VIII land is being improperly used as cropland.

One of the major tasks of conservation is to bring about the conversion of land poorly suited to cultivation to less hazardous, and often more productive, uses. Although the economics of individual operating units dictates exceptions, in general it would be desirable to convert most of the Class IV land and all of the Class V through VIII land to permanent vegetation. If necessary, the reduction in cropland could be offset by cultivation of some of the Class I to III land now in pasture or woodland. The basic soil and land-use data of the Conservation Needs Inventory provide a county-by-county guide to these needed land-use adjustments.

TRENDS IN LAND USE

With the basic soil and land capability data at hand, the Inventory Committee in each county estimated changes in land use likely to occur by the year 1975. The Committee then identified the major soil and water conservation problems of the land expected to be devoted to each agricultural use.

The answers obtained in any such attempt to look into the future depend in part on the particular set of economic conditions assumed to exist during the period studied. For purposes of the Conservation Needs Inventory, all projections were made under the uniform assumption that the national population would reach 210 million by 1975 and that a moderate rise in per capita consumption would require a farm output 30 percent larger than the 1953 production.

The national summary of the judgments by the county committees indicates that the acreage devoted to each of the major agricultural uses will change little in the years ahead.

The Inventory for Illinois indicates that the acreage of cropland will decrease about 200,000 acres or

1 percent by 1975; pasture will decrease about 400,000 or 8 percent; and forest and woodland will decrease about 200,000 acres or 5 percent.

The biggest net change in land use is expected to be in land converted to urban and other non-agricultural uses. Nearly I million acres is expected to be converted from agricultural use in Illinois from 1958 to 1975. The 1958 surveys which predicted land uses to 1975 are judged to be as good an estimate to 1980 as is presently available. This trend is likely to speed up as more and more people require more space in which to live, work, and play.

Although the proportions of agricultural land devoted to each major use are not expected to change a great deal, considerable shifting of land from one use to another can be expected. Crop production will tend to be concentrated in areas where soils are best suited to cultivation or where location provides economic advantages. Low-grade cropland in other regions will revert to pasture, woodland, or other uses. Even within localized areas and on individual farms, many changes are needed to better match the use of land with its capabilities.

The total acreage involved in these land use changes will be much greater than the net effect on the acreage devoted to each use. It appears that about 10 percent of the agricultural land in the United States will be involved in conversions to different uses by 1975.

These shifts in land use present one of the major soil conservation problems of the next few decades. It is important that they be made on the basis of sound knowledge of soil characteristics. Landowners will need soil surveys and detailed interpretive information to help them decide where land-use changes would be feasible and profitable. They will need technical assistance in establishing new vegetation on land taken out of cultivation, in choosing cropping systems for new cropland, and in applying needed conservation practices to each tract of land in its new use.

SOIL SURVEYS IN COMMUNITY PLANNING

Since its inception, the Soil Conservation Service has based its agricultural soil and water conservation program on soil surveys. Erosion and slope information, as well as knowledge of the soil types on individual farms, is essential for development of sound farm conservation plans. A soil map and its agricultural interpretation provides the basis for a land-capability map, color-keyed to delineate areas without special problems, areas of caution, and the danger zone.

Recently, urban planners have come to recognize the value of using soil surveys and land capability maps in assigning land uses for urban development. For example, in Ela Township in Lake County a capability map has proved most valuable in delineating major land uses for residential areas, agriculture, industry, transportation, and recreation.

The most serious soil and water problems in urban areas are flooding, seasonal high water tables, corrosion of utility pipes, poorly functioning septic tanks, and foundation failures. These conditions often do not show up until after the investment has been made for construction of buildings and installation of facilities.

Perhaps the key problems are related to sewage disposal. It has been found that the septic tanks' leaching fields are frequently clogged. Underground water sources that supply domestic wells may be polluted. Other areas are plagued by flooded basements, standing water that becomes stagnant, cracked foundations, crumbling driveways, eroding slopes, or yards in which neither grasses nor trees will grow.

Timber stand improvement.

This new use of the old soil survey can serve the urban planner as a blueprint of the land. It will help him in making wise choices among alternative uses, and assist him in resisting pressures from those who have short-term objectives or are poorly informed. The soil map can be interpreted to show the soils that are good sites for roads, private dwellings, schools, septic fields, commercial areas, parks, and other urban facilities. At the same time it shows soils that are not suitable. The soils unsuited for homes, schools, or other buildings may be fine as sites for parks, golf courses, wildlife sanctuaries, or agricultural crops.

MAJOR CONSERVATION NEEDS

The Conservation Needs Inventory indicates the amount of agricultural land in each area which needs conservation treatment and the major problems affecting it. About two-thirds of the non-Federal land used for cropland, pasture, or woodland needs some kind of conservation treatment. About one-third is adequately treated or, like the 1.3 million acres of Class I cropland in Illinois, needs no special conservation practices.

These figures show two things that are equally significant. They show the creditable progress that owners and users of the land, with the aid of professional conservationists and others, have already made in applying conservation practices. At the same time they show the magnitude of the job ahead.

The Inventory gives many figures detailing the conservation needs of the land in different uses. Only a few of the major ones can be mentioned here.

For example, as has been known for a long while, erosion is the major problem requiring conservation treatment on cropland. It is the dominant problem on about half the cropland in Illinois. Other important problems are excess water on about half of the cropland acreage and unfavorable soil conditions on a smaller acreage. Altogther, some two-thirds of the Illinois' cropland still needs soil and water conservation treatment of some kind.

Nearly three-fourths of the non-Federal pasture and woodland needs conservation treatment, improvement, or protection. About one-fifth of the pasture and range, including land retired from cultivation, needs new grass stands, and a third of it needs improvement of existing stands.

Likewise, about one-sixth of the privately owned forest and woodland needs new timber stands and about one-third needs improvement of existing stands.

The conservation job is the one facing the private owners and users of land in Illinois. Getting this job done with dispatch is one of the essentials in meeting the needs of a growing population. It is part of the new technology that is needed to keep expanding the output of a land area that does not expand.

Although improving technology may be relied upon to meet the food and fiber needs of the future, the soil and water resources on which to practice the modern methods and use the new machines and chemicals must be preserved. Extensive and continuing land use adjustments, both regionally and on individual farms, will be a feature of the changing agriculture in the decades ahead.

The increasing use of land for non-agricultural purposes involves more and more people with first-hand conservation responsibilities. The developer of suburban housing, the builder of an industrial plant, the proprietor of a golf course—in fact, every householder, whether in city, suburb, or country—is concerned with the soils and hydrology of his particular site. Each is a land user in his own right and shares with the farmers and ranchers of the nation the need and the responsibility to practice conservation. So, as land resources are increasingly divided among many uses, the conservation job is more widely spread through the entire population.

Whether they know it or not, people in all segments of the population are concerned with conservation on agricultural land. Soil and water conservation is not for farmers alone.

Needs for Illinois

Information on conservation needs for Illinois is summarized in Table 1 and Figure 5. Brief summaries follow for each of the eleven land resource areas of the State. In these summaries, the eight soil classifications are those described in some detail in the preceding section. Land use in crops, pasture, and woodland is self-explanatory. The "other" land use includes urban and built-up areas of 10 acres or more.

The Inventory of Conservation Needs revealed a number of striking generalities about Illinois soils and land use as shown in Table 1 and Figure 5. Most striking is the virtual dominance of Class II land, which is highly productive and relatively free of management problems. Also striking is the large proportion of the State's better lands in Classes I, II, and III that is used for crops, rather than for pasture or woods. Finally, it is of interest that the agricultural agencies expected relatively small ad-

TABLE 1 USE OF INVENTORY ACREAGE BY LAND CAPABILITY CLASSES FOR ILLINOIS RESOURCE AREAS, 1958 AND ESTIMATED FOR 1975

Capability Class	Cropland		Pasture		Forest and Woodland		Other Land		Total	
	1958	1975	1958	1975	1958	1975	1958	1975	1958	1975
Class I	922	941	104	87	150	132	158	127	1,334	1,287
Class II	16,410	16,305	1,189	942	819	636	700	594	19,118	18,477
Class III	4,465	4,543	752	657	835	723	427	347	6,479	6,270
Class IV	1,188	1,106	439	443	413	433	175	148	2,215	2,130
Class V	70	80	60	47	135	120	58	46	323	293
Class VI	526	441	366	380	403	438	131	126	1,426	1,385
Class VII	283	225	397	382	1,109	1,150	194	171	1,983	1,928
Class VIII	0	0	0	0	2	1	11	6	13	7
Totals	23,864	23,641	3,307	2,938	3,856	3,633	1,854	1,565	32,891	31,777

Numbers are in 1,000 acres.
Source: Illinois Soil and Water Conservation Needs Inventory, 1962. University of Illinois College of Agriculture, Cooperative Extension Service.

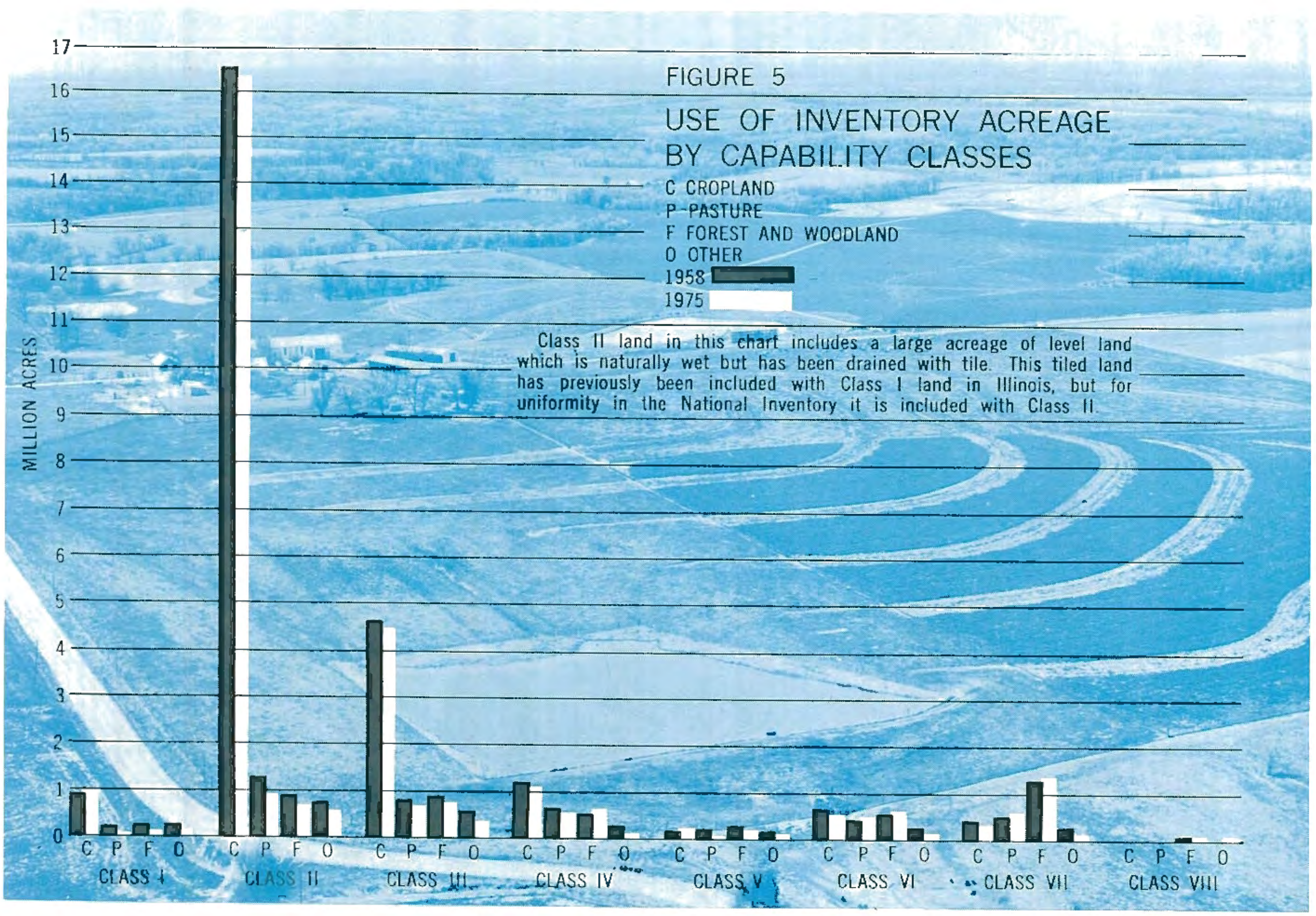


FIGURE 5
USE OF INVENTORY ACREAGE BY CAPABILITY CLASSES

Class II land in this chart includes a large acreage of level land which is naturally wet but has been drained with tile. This tiled land has previously been included with Class I land in Illinois, but for uniformity in the National Inventory it is included with Class II.

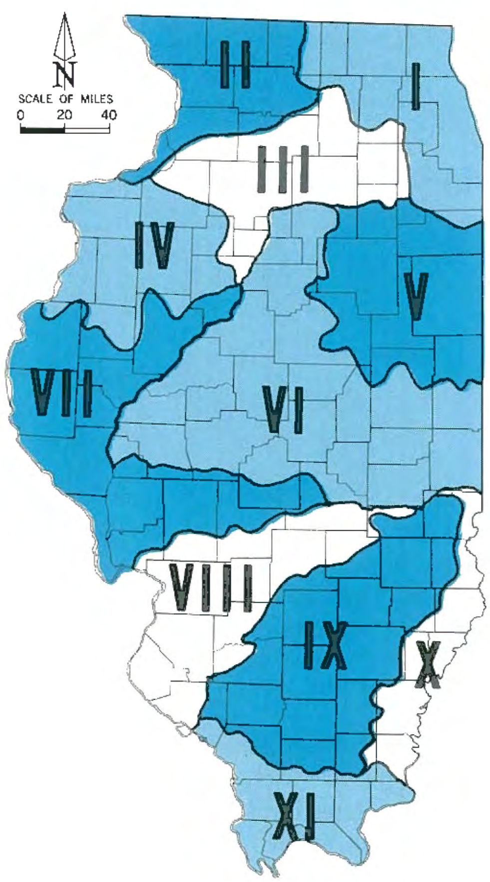
justments in land use from 1958 to 1975. Not shown on the summary charts is the rather sobering fact that, after approximately 30 years of soil and water programs in Illinois, only about one-third of our farms are planned and managed according to accepted farm plans. This is about the national average, and indicates the magnitude of the task facing Illinois and the nation to bring farm land into adjustment with long-term capabilities.

LAND AND WATER PROBLEMS

Since there is substantial variation in the soils, land use, and management problems throughout Illinois, the State has been divided into eleven land resource areas as shown on Figure 6. For the State as a whole and for each of these eleven areas, the land use and management problems of erosion, excess water, or soil limitations are summarized. Solution to the management problems is illustrated for each of the resource areas by an example drawn from one of the Soil and Water Conservation Districts in the area.

FIGURE 6

LAND RESOURCE AREAS



LAND AND WATER PROBLEMS IN ILLINOIS

Problems by Percent of Class

Land Class	Percent of State	Erosion	Excess Water	Soil
I	4	—	—	—
II	58	44	53	3
III	20	53	39	8
IV	7	80		20
V	1		100	
VI	4	90	4	6
VII	6	77		23
VIII	1	—	—	—

Resource Area I

Resource Area I has dark-colored soils on gently sloping areas and light-colored soils on rolling topography. Parent materials range from fine- to coarse-textured glacial drift of Wisconsinan age. The majority of the soils are silty and highly productive, but less productive sandy and gravelly soils occur in the northwestern portion and clayey soils occur in the southeastern portion. Many areas require tile drainage. Erosion, drainage, and low fertility are problems. Dairy farming predominates, with 77 percent of the land in crops, 9 percent in pasture, 6 percent in woodland, and 8 percent in other use.

Resource Area I/Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	3	—	—	—
II	71	50	46	4
III	15	75	19	6
IV	4	80		20
V	3		100	
VI	1	68	7	25
VII	2	52	16	32
VIII	1		100	

The McHenry County Soil and Water Conservation District is a typical district of Resource Area I. The District was organized in early 1947 and consists of approximately 342,650 acres.

On June 30, 1965, nearly 1000 landowners were cooperators of the District, and more than 600 farmers had worked out basic conservation plans. The predominant conservation practices being applied are: conservation cropping systems, strip cropping, tree planting, wildlife habitat areas, and the following water-related practices: 680 acres of contouring; 2,330,000 lineal feet of tile drains; 11 sprinkler irrigation systems; and 127 farm ponds.

Resource Area II

Resource Area II has light- and dark-colored soils from loess; some bedrock and glacial outcrops; moderately sloping to hilly area with dark-colored silty soils on the less sloping topography; and light-colored silty soils, often shallow to bedrock, on steeper topography. Limestone, shale, and sandstone are the bedrock materials. Slopes are often long and uniform. Erosion, low fertility, and shallowness are problems. Livestock farming predominates with 73 percent of the area in crops, 13 percent in pasture, 19 percent in woodland, and 5 percent in other use.

Resource Area II/Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	6	—	—	—
II	43	55	36	9
III	25	82	4	14
IV	11	77		23
V	2		100	
VI	8	78		22
VII	5	55		45
VIII	—	—	—	—

The Ogle County District is typical of soil and water conservation districts of Resource Area II. The District consists of approximately 500,000 acres and was organized in May 1942. On June 30, 1965, nearly 900 landowners were cooperators of the District, and more than 600 farmers were farming with a definite conservation plan.

Grass waterway drains on Ogle County farm.

The following conservation practices have been applied to the highly productive land: conservation cropping systems, cover crops, minimum tillage, strip cropping, wildlife habitat area, and the following water-related practices: 57,000 acres of contouring, 340 miles of terraces and diversions, and 2000 acres of grass waterways.

More recently, the District has broadened its concern to include land and water problems which extend beyond ownership boundaries and has solved these problems by planning on a sub-watershed basis. The local people have asked for assistance on a watershed under Public Law 566.

Resource Area III

Dark-colored soils from loess and glacial materials are found in Resource Area III, which is nearly level to moderately sloping with predominantly silty soils, but some sandy areas. Glacial materials are of Wisconsinan age. Many acres have poor natural drainage, but are permeable and drain readily with tile. Most of the soils are highly productive. Drainage, erosion, and fertility are problems. Sandy areas are droughty. Livestock and grain farming predominate, with 87 percent in crops, 5 percent in pasture, 4 percent in woodland, and 4 percent in other use.

Resource Area III/Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	5	—	—	—
II	83	53	45	2
III	5	82	9	9
IV	3	80		20
V	—	—	—	—
VI	1	68	24	8
VII	2	87		3
VIII	—	—	—	—

The Bureau County Soil and Water Conservation District is a typical district in Resource Area III. The District was established by referendum on March 30, 1942, by unanimous vote. The District now includes the entire county of approximately 542,280 acres.

On June 30, 1965, more than 600 landowners were cooperators of the District, and 440 had worked out conservation plans for their land. The predominant conservation practices applied to the land are: conservation cropping systems, pasture improvement, and the following water-related practices: 43,000 acres of contouring, 90 miles of terraces and diversions. 400 acres of grass waterways. 14 farm ponds, and 100 miles of drainage tile.

The District co-sponsored the Tiskilwa watershed project under P. L. 566. The primary benefit was the reduction of flood-water damage in Tiskilwa.

Resource Area IV

Resource Area IV, with dark-colored soils from loess, is nearly level to moderately sloping with silty soils. Some steeper slopes and light-colored soils occur along streams. The loess covers glacial material of Illinoian age. Some areas have poor natural drainage, but the soils are permeable and drain readily with tile. The dark-colored soils are highly productive; and light-colored soils are only moderately productive. Erosion, drainage, and low fertility are problems. Livestock and grain farming predominate, with 73 percent of the region in crops, 13 percent in pasture, 10 percent in woodland, and 4 percent in other use.

Resource Area IV/Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	5	—	—	—
II	61	51	46	3
III	13	85	5	10
IV	9	89		11
V	2		100	
VI	3	98	2	
VII	7	91		9
VIII	—	—	—	—

The Warren County Soil and Water Conservation District is typical of Resource Area IV. The District consists of approximately 322,790 acres and was organized in April 1942.

The District had nearly 800 cooperators, and nearly 700 basic conservation plans on June 30, 1965. The predominant conservation practices that are being applied are: good conservation cropping systems, cover crops, pasture improvement, woodland weeding, tree planting, and the following water-related practices: 6500 acres of contouring, 300 acres of grass waterways, 222 grade control structures, 284 miles of tile drainage, and 221 miles of terraces and diversions.

Old Tom Creek Watershed in Warren and Henderson Counties was one of two pilot watershed projects developed in Illinois. Flood control and conservation of soil and water on the watershed were the primary objectives of the project.

Resource Area V

Soils in Resource Area V are dark-colored, moderately fine to fine textured from glacial materials on level to gently sloping topography. Surface soils are silty, but subsoils are often clayey. Sandy areas are common along the Kankakee and Iroquois Rivers. Areas with clay subsoils, if wet, do not tile well and, if sloping, erode easily. Soil productivity is variable. Erosion, low fertility, drainage, and droughty soils are problems. Cash-grain farming predominates, with 87 percent in crops, 6 percent in pasture, 3 percent in woodland, and 4 percent in other use.

Resource Area V Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	2	—	—	—
II	84	29	66	5
III	8	47	21	32
IV	2	54		46
V	1		100	
VI	1	97	3	
VII	2	53	1	46
VIII	0	0	0	0

The Livingston County Soil and Water Conservation District in northeastern Illinois is typical of the other districts in Resource Area V. It was organized in March 1945 and consists of approximately 643,500 acres, one of the largest districts in the State.

As of June 30, 1965, nearly 700 landowners had become cooperators of the District, with nearly 500 basic conservation plans for their land. The predominant conservation practices being applied to the land are: conservation cropping systems, pasture improvement, wildlife habitat areas, and the following water-related practices: 24,300 acres of contouring, 113 miles of terraces and diversions, 1800 acres of grass waterways, 100 farm ponds, and 190 miles of tile drainage.

Recreation Lake, Old Tom Creek Watershed.

Resource Area VI

Resource Area VI, with dark-colored soils from loess, is a nearly level to gently sloping area with predominantly silty soils. In limited areas near streams light-colored soils occur on strongly sloping topography. Sandy soils on dune topography occur in Mason County near the Illinois River. Many soils have poor natural drainage, but drain readily with tile. The dark-colored silty soils are highly productive; the light-colored soils are less productive; and the sandy soils are low in productivity. Erosion, drainage, and low fertility are problems; the sandy soils are droughty. Cash-grain farming predominates with 83 percent in crops, 7 percent in pasture, 6 percent in woodland, and 4 percent in other use.

Resource Area VI/Land and Water Problems

		Problems by Percent of Class		
Land Class	Percent of Area	Erosion	Excess Water	Soil
I	4	—	—	—
II	77	40	59	1
III	8	80	10	10
IV	4	66		34
V	1		100	
VI	2	84	15	1
VII	4	51		49
VIII	0	—	—	—

Logan County is typical of Resource Area VI. The Soil and Water Conservation District was organized in June 1952 and consists of approximately 400,000 acres.

The District had more than 532 cooperators and more than 300 basic conservation plans developed by June 30, 1965. The predominant conservation practices that have been applied to the land are: conservation cropping systems, pasture improvement, wildlife habitat areas, and the following water-related practices: 17,000 acres of contouring, 175 miles of terraces and diversions, 946 acres of grass waterways, 104 miles of tile drainage, and 103 miles of open drainage ditches.

Resource Area VII

Light-colored soils from loess and till and darker soils with weak claypans from loess are found in Resource Area VII. Nearly level ridges with moderately dark, weak claypan soils are widely separated by strongly sloping or hilly areas with light-colored soils. Glacial till, and occasionally bedrock, outcrop on the steepest slopes. The glacial till is principally of Illinoian age, but some Kansan occurs. Many level areas often need drainage. Tile drains somewhat slowly but satisfactorily. Gray spots on the level ridges are less permeable and less productive than surrounding soils. Erosion and low fertility are problems on the sloping soils. General farming predominates, with 60 percent in crops, 13 percent in pasture, 20 percent in woodland, and 7 percent in other use.

Grass waterway, Fayette County

Resource Area VII/Land and Water Problems

		Problems by Percent of Class		
Land Class	Percent of Area	Erosion	Excess Water	Soil
I	4	—	—	—
II	52	46	53	1
III	13	70	16	14
IV	9	98		2
V	—	—	—	—
VI	7	97	3	
VII	15	97	1	7
VIII	0	—	—	—

Pike County is typical of Resource Area VII in the western part of the State. The soil and water conservation district was organized in June 1946 and consists of approximately 486,000 acres of rolling-to-steep land.

More than 700 landowners are cooperating with the Pike County District, and more than 500 of them have basic conservation plans. The farmers are applying the following conservation practices: conservation cropping systems, cover crops, tree planting, wildlife areas, and the following water-related practices: 22,700 acres of contouring, 400 acres of grass waterways, 234 grade stabilization structures, 300 miles of terraces and diversions, and 543 farm ponds.

The Hadley Creek Watershed, partially in Pike County, was one of the two completed pilot projects in Illinois. The Big Blue Watershed, completed under P. L. 566, was the first watershed in Illinois to include municipal water supply. In 1963 this watershed was selected as the watershed of the year by the National Watershed Congress.

Resource Area VIII

Resource Area VIII has moderately dark claypan soils from loess and light-colored soils on slopes. Nearly level ridges with moderate claypan soils and high sodium slick spots are separated by strongly sloping to hilly areas with light-colored soils, predominantly from loess. Silt pans occur in some of the sloping soils. Glacial material of Illinoian age outcrops on the steepest slopes. The claypan soils are slowly permeable and are commonly drained with surface ditches. They are also moderately productive, except for the slick spots. The soils on steep slopes are less productive. Low fertility and erosion are problems on the sloping areas. General farming and dairy farming predominate, with 70 percent in crops, 10 percent in pasture, 15 percent in woodland, and 5 percent in other use.

Resource Area VIII/Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	4	—	—	—
II	46	34	66	
III	29	42	49	9
IV	8	70		30
V	—	—	—	—
VI	6	92	2	2
VII	7	95		5
VIII	0	—	—	—

The Fayette Soil and Water Conservation District typifies the districts in Resource Area VIII. It was organized in July 1944 and consists of approximately 499,500 acres.

As of June 30, 1965, nearly 600 landowners had become cooperators of the District, and more than 400 had developed basic conservation plans. On the same date, farmers had applied the following conservation practices: conservation cropping systems, cover crops, pasture renovation, wildlife habitat areas, tree planting, and the following water-related practices: 7400 acres of contouring, 50 miles of terraces and diversions, 335 farm ponds, and 549 acres of grassed waterways.

Resource Area IX

Moderately dark, claypan soils with extremely slow permeability on the flats and light-colored soils on the slopes are found in Resource Area IX. Nearly level ridges with claypan soils derived from loess and high sodium slick spots are separated by strongly sloping to hilly areas with light-colored soils, predominantly from loess. Some sloping soils have silt pans. Glacial material of Illinoian age outcrops on steep slopes. Since tile does not function in the claypan soils, drainage must be by surface ditches. Fertility is low; level areas have drainage problems; and sloping areas have erosion problems. General farming predominates, and many farms are small, with 62 percent in crops, 12 percent in pasture, 18 percent in woodland, and 8 percent in other use.

Resource Area IX/Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	2	—	—	—
II	31	63	37	
III	48	66		3
IV	11	79		21
V	1		100	
VI	5	94		6
VII	2	76		24
VIII	0	—	—	—

Drainage Ditch Marion County

Marion County, with approximately 368,000 acres of land, has the same problems as all of the counties in Resource Area IX. The Marion County Soil and Water Conservation District was organized in August 1944.

From that time to June 30, 1965, nearly 800 farmers became cooperators of the District, and more than 550 developed conservation plans. The predominant conservation practices applied to the land are: conservation cropping systems, cover crops, minimum tillage, pasture improvement, wildlife habitat improvement, woodland protection from grazing, and the following water-related practices: 6900 acres of contouring, 51 miles of terraces and diversions, and 1065 farm ponds. Last September the governing board of the District updated their program to more nearly reflect the present needs and opportunities.

Resource Area X

The light-colored, silty soils from loess on uplands in Resource Area X often contain silt pans and nearly level areas; dark-colored soils of variable texture and drainage are found on terraces and bottom lands. Loess covers Illinoian age till in the uplands, and sediments of Wisconsinan age form the terraces. Some areas on terraces are wet, but are usually moderately permeable and will drain with tile. Low fertility and erosion are problems on the rolling land. Grain and livestock farming predominates, with 70 percent in crops, 9 percent in pasture, 13 percent in woodland, and 8 percent in other use.

Resource Area X Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	8	—	—	—
II	46	40	52	8
III	36	48	42	10
IV	5	92		8
V	1		100	
VI	3	70	22	8
VII	1	43		57
VIII	0	—	—	—

The Wabash County Soil and Water Conservation District typifies the districts in Resource Area X. The District, now county-wide, was originally part of the RCLW District organized in February 1941. In June 1945 it became the Wabash County Soil and Water Conservation District, with approximately 139,500 acres. In 1963 the program was broadened to include cooperation with community groups to solve mutual soil and water problems on a group or watershed basis.

By June 30, 1965, nearly 800 landowners were cooperators with the District, and nearly 600 were farming according to basic conservation plans. The farmers are applying the following conservation practices to reduce erosion and increase production: conservation cropping systems, pasture improvement, wildlife areas, woodland protected from grazing, as well as the following practices related to water: 10,000 acres of contouring, 130 miles of terraces and diversions, 308 miles of grass waterways, 379 farm ponds, and 194 grade stabilization structures.

Resource Area XI

Resource Area XI has light-colored soils from loess, and bedrock outcrops are common. It is a hilly-to-steep area with light-colored, silty soils and rough, stony land. The area is unglaciated, with loess overlying limestone and sandstone bedrock in the northern part of the area and Coastal Plains materials in the southern part. Silt pans occur in many of the loess soils. Rather wide stream valleys occur in the area and contain nearly level, light to moderately dark soils of sandy to clayey texture. Most of the row crops are grown in these valleys. Erosion, shallow soils, and low fertility are problems in the upland. Drainage, low fertility, droughty soils, and overflow are problems on terrace and bottom-land soils. General farming, fruit production, and woodland predominate, with 41 percent in crops, 17 percent pasture, 35 percent woodland, and 7 percent in other use.

Resource Area XI Land and Water Problems

Problems by Percent of Class

Land Class	Percent of Area	Erosion	Excess Water	Soil
I	3	—	—	—
II	26	48	43	9
III	25	48	52	
IV	8	88	3	9
V	2		100	
VI	14	95	1	4
VII	22	59		41
VIII	0	—	—	—

The Johnson County District is typical of the soil and water conservation districts in Resource Area XI in the southern tip of the State. The District was organized in June 1941 with an area of approximately 212,000 acres.

During the past 25 years, more than 700 landowners have become District cooperators, and nearly 500 have developed basic conservation plans. The predominant conservation practices applied to the hilly topography are: 6000 acres of cropland converted to grassland, 33,000 acres of pasture improvement, 2300 acres of cover crops, 15,000 acres of woodland protected from grazing, and the following practices that are related to water: 527 acres of contouring, 8 miles of drainage channels, and 700 ponds built for watering livestock.

The District is also co-sponsor for three P. L. 566 watersheds. The Little Cache project is approved for construction; Bay Creek is approved for planning; and the Upper Cache River project has been approved for a preliminary investigation. The District is also one of the leaders in the Shawnee Resource Conservation and Development Project.

THE SMALL WATERSHED PROGRAM — P. L. 566

The United States is on the threshold of a period of the most extensive river basin planning the country has ever experienced. The critical nature of the problems of water and related land resources is clearly revealed in the comprehensive studies made by the Select Committee on National Water Resources of the U. S. Senate, under the chairmanship of the late Senator Robert S. Kerr.

The Committee recommended that framework plans be developed by 1970 for all the river basins in the nation. The Administration has moved to implement these recommendations. New policies, standards, and procedures for river basin and project planning have been adopted. These new policies, in Senate Document 97, were made effective by President John F. Kennedy on May 15, 1962.

The Water Resources Act of 1965 includes plans for grants to the states to enable them to participate more effectively and actively in planning water resource developments. Thus, the stage is being set for a large-scale program to delineate and then to build projects on the nation's rivers and their watersheds. Such a program is needed to assure an adequate, regulated supply of good quality water for all segments of society, not only for such traditional uses as navigation, flood control, hydropower and irrigation, but also for previously more neglected purposes such as community water supply, fish and wildlife development, outdoor recreation, and to enhance unique areas of natural beauty.

During the past ten years, upstream watershed projects have proved to be a necessary and vital part of river basin development. Although continuous improvements will be needed, the basic groundwork for such watershed development has been laid in law and policy at national, state, and local levels.

Up to this time, upstream watershed developments have been almost entirely subsidiary to main river developments. Watershed improvements have usually been added increments to river basin plans, justified by the remaining benefits after decisions were made on the number, size, and location of major reservoirs and related downstream improvements.

ILLINOIS WATERSHEDS

The potential is great for developing small watersheds in Illinois under Public Law 566, according to a recent study made by the U. S. Soil Conservation Service to update the Soil and Water Conservation Needs Inventory of Illinois. The study was based on the present criteria used by the Soil Conservation Service to determine the benefit-cost ratio for single-purpose (flood retarding) structures in the watersheds. P. L. 566 watershed projects and their current status are shown in Figure 7.

Nearly 200 watersheds within the Upper Mississippi River Basin in Illinois were designated as feasible P. L. 566 projects. The four completed projects in the State are within that river basin. Thirty-three of the nearly 200 watersheds have applied for assistance under the P. L. 566. Planning assistance is progressing on several of these watersheds.

Approximately 50 watersheds in the Wabash River Basin were determined feasible, using the S. C. S. criteria. Local sponsors of 19 of the 50 watersheds have applied for assistance under P. L. 566. The Scattering Fork and Seven Mile (White County) Watersheds are authorized for construction, and three others are in the planning stage.

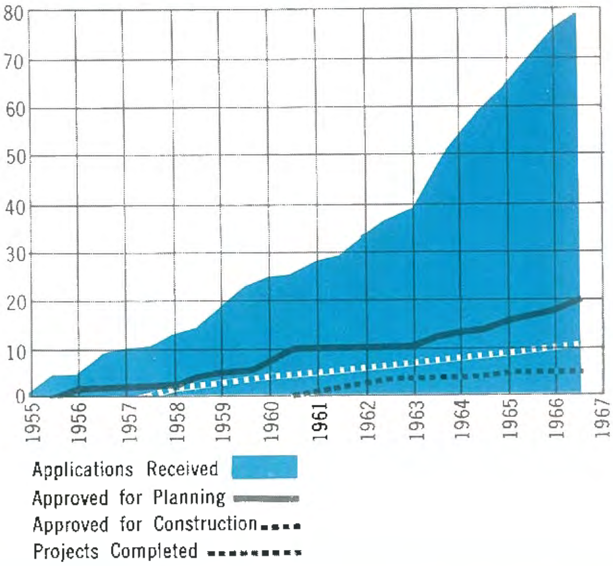
Eleven watersheds in southeastern Illinois in the Ohio River Basin were also found to be feasible for P. L. 566 projects. Local sponsors in five of these watersheds have applied and are receiving assistance in planning the watersheds.

It is anticipated that it will take an indefinite number of years to bring all of these watersheds under


ILLINOIS
P. L. 566
WATERSHED
PROJECTS
FIGURE 7
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
McHENRY
LAKE
CARROLL
OGLE
DE KALB
KANE
COOK
DU PAGE
WHITESIDE
LEE
ROCK ISLAND
HENRY
BUREAU
LA SALLE
KENDALL
WILL
MERCER
PUTNAM
GRUNDY
KANKAKEE
KNOX
STARK
MARSHALL
WARREN
LIVINGSTON
IROQUOIS
WOODFORD
PEORIA
HANCOCK
McDONOUGH
FULTON
McLEAN
FORD
TAZEWELL
ADAMS
SCHUYLER
MASON
CHAMPAIGN
VERMILION
BROWN
DE WITT
MENARD
CASS
LOGAN
MACON
PIATT
SANGAMON
DOUGLAS
PIKE
MORGAN
SCOTT
MOULTRIE
EDGAR
COLES
CHRISTIAN
GREENE
SHELBY
CUMBERLAND
CLARK
MACOUPIN
MONTGOMERY
CALHOUN
JERSEY
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
MADISON
BOND
MARION
CLAY
RICHLAND
LAWRENCE
CLINTON
ST CLAIR
WAYNE
EDWARDS
WABASH
MONROE
WASHINGTON
JEFFERSON
WHITE
RANDOLPH
PERRY
FRANKLIN
HAMILTON
JACKSON
WILLIAMSON
SALINE
GALLATIN
UNION
JOHNSON
POPE
HARDIN
ALEXANDER
PULASKI
MASSAC
INVESTIGATION BY STATE AGENCIES
APPLICATION APPROVED BY GOVERNOR
WATERSHEDS AUTHORIZED FOR PLANNING
WATERSHEDS TERMINATED
WATERSHEDS APPROVED FOR CONSTRUCTION
WATERSHEDS COMPLETED
1. Honey Creek
2. Little Cedar Creek
3. Tiskilwa
4. Madden Run
5. Robinson Creek
6. Crawfish
7. Big Creek
8. Saline River (Middle Fork)
9. Rubicon Creek
10. George's Clifty
(Part of Upper Cache River)
11. Ellison Creek
12. Richland Creek
13. Hambaugh-Martin
14. Shoal Creek
15. Big Blue
16. Hickory Creek
17. Hog River-Pig Creek
18. Curts Creek
19. Valley City
20. Brownsville Creek
21. Seven Mile (Jefferson)
22. Stillman Creek
23. Scattering Fork
24. Medina
25. Hallock
26. Little Cache
27. Auxier-Big Creek
28. Bay Creek
29. Silver Creek (East Fork)
30. Coal and Crane
31. Clear Creek
32. Upper Embarras
33. Seven Mile (White)
34. Hurricane Creek
35. Briar Creek
36. Four Mile Creek
37. Hager Slough
38. Sugar Creek
39. Lost Creek
40. Mill Creek
41. Flat Branch
42. Little Creek
43. Big Mound
44. Pond Creek
45. Upper Cache River
46. McKee Creek
(Middle & South Fork)
47. McKee Creek (North Fork)
48. Schaad Ditch
49. Solomon Creek
50. Lick Creek
51. Brouilletts Creek
52. Wabash & Emma Drainage
53. Cedar Creek
54. Raccoon Creek
55. Salt Fork
56. Elliott Creek-
Little Wabash No. 24
57. Ramsey Creek
58. Rector-North Fork
59. McHenry-Hawthorne
60. Whetstone
61. Meadow Slough & Bear Creek
62. Jordan Creek
63. Seven Mile Branch
64. Otter Creek
65. Middle Fork (Big Muddy)
66. Morrison Hollow
67. Salt Creek
68. S. E. Branch
Kishwaukee River
69. Eagle Creek
70. Kickapoo Creek
71. Rocher-Modoc
72. Muddy Creek
73. Upper Crab Orchard Creek
74. Forked Creek
75. Bear-Indian Creek
76. Nutwood
77. Mary's River
78. Big Muddy Creek
79. Horse Creek

FIGURE 8

P. L. 566 WATERSHED PROJECTS



control, because local residents must initiate the application for assistance and help to determine the proposed multiple-purposes of a project.

From January 1955 to August 31, 1966, 79 applications for assistance under the P. L. 566 Watershed Act were submitted (Figure 8). Planning assistance was terminated on 21 of the applications in the preliminary investigation stage, because the costs exceeded benefits. Twenty-nine other proposed projects will be studied by the U. S. Soil Conservation Service in the preliminary investigation stage to determine their economic feasibility.

Twenty of the projects proposed in Illinois have been found to be economically feasible, and final plans have been submitted to the local sponsors for approval. Eleven of the projects have been approved by the local sponsors and the U. S. Department of Agriculture and are approved for construction; four of these have been completed.

CASE STUDIES

The following case histories of six of the watersheds illustrate the different problems and the solutions involved in watershed projects.

CASE STUDY 1.

BIG BLUE CREEK WATERSHED

The Big Blue Creek Watershed covers an area of 26,690 acres in the eastern part of Pike County in west-central Illinois. The upper extremity of the main stem is 6.5 miles north of Pittsfield. The lower end of the watershed is at the confluence of Big Blue Creek and the Illinois River, 5.5 miles northeast of Detroit (Figure 9).

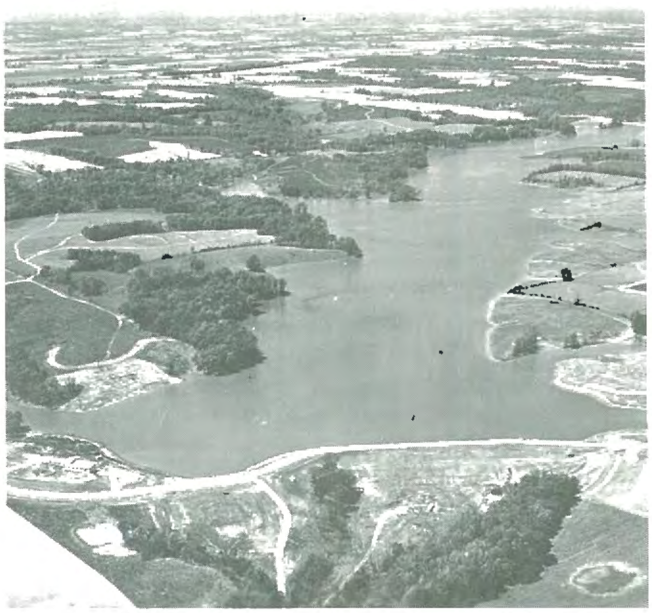
The headwater area in the western third of the watershed is characterized by gently rolling hills and a few level ridge tops, which are the remnants of the maturely dissected Illinoian glacial till plain.

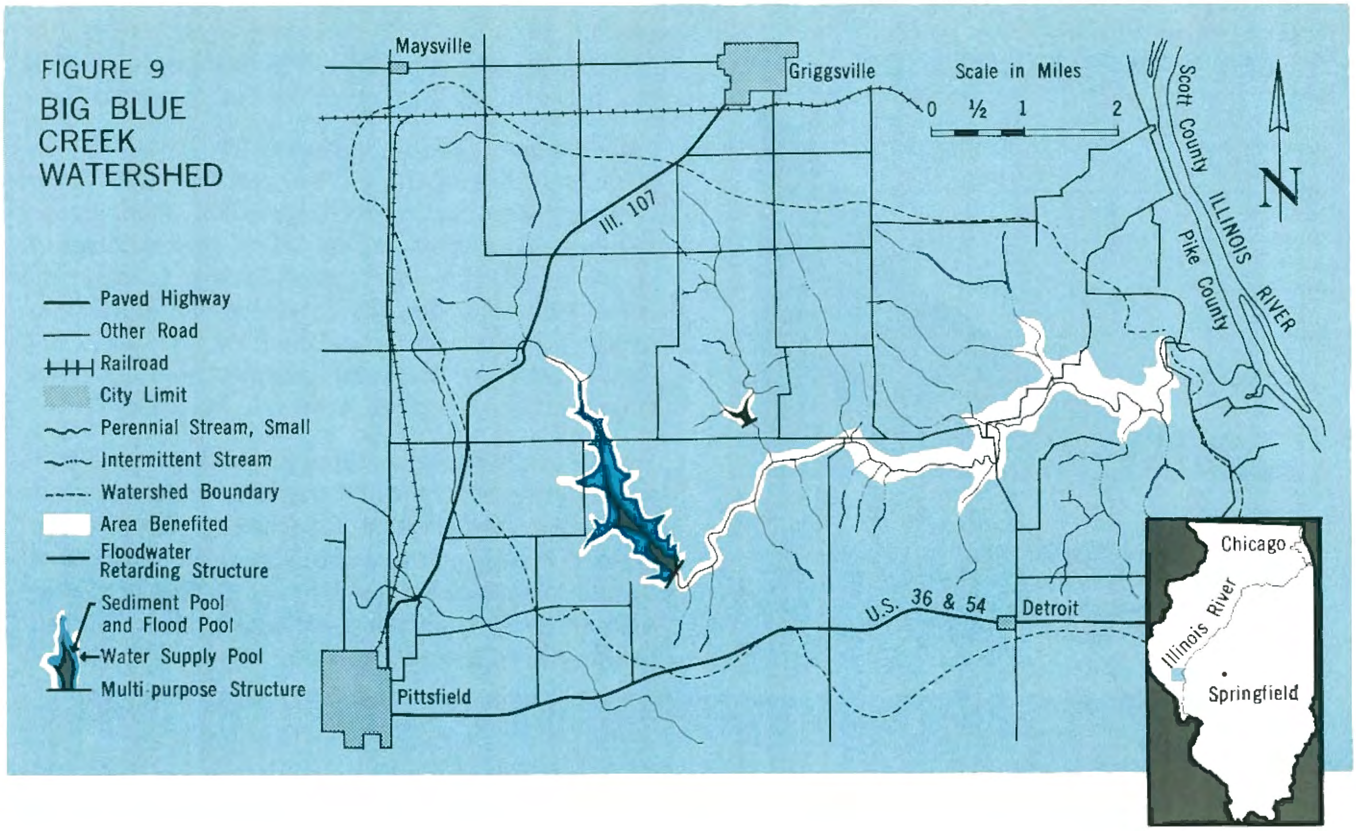
The main valley in the eastern part of the watershed contains a broad, flat deposit of alluvium and is bordered by steep and frequently rocky valley walls. The short tributary valleys are generally rocky, v-shaped, and have high gradients. The total relief in the watershed is approximately 353 feet.

WATERSHED PROBLEMS

Flood-water damage to the cropland in the flood plain was one of the major problems in this watershed. The condition of the Big Blue Creek channel was such that a one-year frequency storm caused overbank flow and damage to the highly-valued crops in the lower two-thirds of the flood plain. The topography in the upland area is such that sheet and gully erosion was a problem for the farmers.

The second major problem in this watershed was the inadequate water supply for Pittsfield, which now has a population of about 4000. The first source of water was from private wells and cisterns.





As the community grew, the demand increased for water for various uses such as fire protection and sanitation. A deep well was used until 1924, when a small reservoir was constructed.

From 1952 to 1955, water-supply conditions became critical. The reservoir was filling with silt because the small watershed was not protected through soil conservation practices. The City drilled two new deep wells and contracted to haul water from a city on the Mississippi River about 25 miles away. The situation remained critical as the demand for water increased and one of the new wells failed. The State Department of Health notified Pittsfield that the water supply was inadequate and unsatisfactory and the filtering plant obsolete. The farmers living within a 10-mile radius hauled water from Pittsfield for their livestock.

In July 1958 local residents submitted an application to the Governor of Illinois for assistance under P. L. 566. The U. S. Soil Conservation Service helped the local sponsors develop a plan to reduce the flood-water damages in the flood plain and to give Pittsfield an adequate water supply. The plan was approved in June 1959; construction of the project began in November 1960 and was completed in July 1961.

Works of Improvement

More than 50 percent of the planned land treatment measures have been applied in the upland area of the watershed. Approximately 165 farms are located within the boundary of the watershed; 66 of the landowners are cooperators in the Pike County Soil and Water Conservation District, and 44 have developed complete conservation plans for their farms.

The following soil conservation practices have been applied to control soil erosion in the upland area of the watershed: 1200 acres of contouring, 43 acres of grass waterways, 6.5 miles of terraces and diversions, 11 stabilizing structures, 40 acres of trees planted, 25 farm ponds for livestock water, and 145 acres of wildlife habitat. The estimated cost of the land treatment measures is $213,627, of which $193,515 is local cost and $20,112 from P. L. 566 funds.

The two major structures have been completed (Figure 9). Structure 1 is multiple-purpose, designed to retard flooding and supply water to Pittsfield. Structure 2 is a single-purpose dam for flood control. The total construction cost of the two structures was $393,730, of which $278,612 was paid from local funds and $115,118 from the P. L. 566 fund.

It was estimated that the average annual benefits from this project will be $18,141, and the average annual cost of the structural measures $14,573. The benefit-cost ratio shows that for every dollar spent, the local people will receive $1.24 in benefits. This completed project will reduce the average annual flood-water damage by about 63 percent. The project was co-sponsored by the Pike County Soil and Water Conservation District and the city of Pittsfield.

Effect of the Project

The farmers living in the flood plain of the Big Blue Watershed are convinced of the effectiveness of the two flood retarding structures. The single purpose flood retarding structure serves as a recreational area for local Boy Scout troops. The boys have planted multi-flora rose fences and pine trees around the 33-acre lake.

The citizens of Pittsfield are pleased with the results of the project for a number of reasons. Since the completion of the project, new construction in the community has included three large warehouses, a new store front, a new bank building, and a large nursing home. The Greater Pike Industrial Association has purchased 132 acres just north of town for an industrial park. Two plants are now considering Pittsfield as a place to locate. Ten new homes are under construction in two new housing developments.

The psychological effect of an adequate water supply on the whole community has been tremendous. Public recreational facilities are being developed on the 240-acre lake site. The Chamber of Commerce and various businessmen financed a picnic area and other facilities. Individuals donated labor to build camp sites, tables, and fireplaces. In 1963 the Big Blue Watershed was selected as the Watershed of the Year by the National Watershed Congress.

CASE STUDY 2. HAMBAUGH-MARTIN WATERSHED

The Hambaugh-Martin Watershed covers an area of about 8600 acres in the southeastern corner of Brown County (Figure 10). The watershed extends in a fan shape for a distance of approximately 4.7 miles from its extremity at Versailles to the confluence of the outlet of the main drainage ditch of the watershed and the Illinois River at Meredosia. The upland area is 44 percent of the total acres, while 56 percent of the watershed is in the Illinois River bottom. The entire bottom-land area of the watershed is a part of the McGee Creek Levee and Drainage District. The levee along the Illinois River, the tie-back levee along Camp Creek on the north, and the tie-back levee along McGee Creek on the south give protection from the Illinois River. All of the flood water from the McGee Creek Levee and Drainage District is pumped into the Illinois River.

The watershed is separated into two sharply distinct topographic divisions, the Illinois River bottom area, and the upland bluff area. The upland bluff

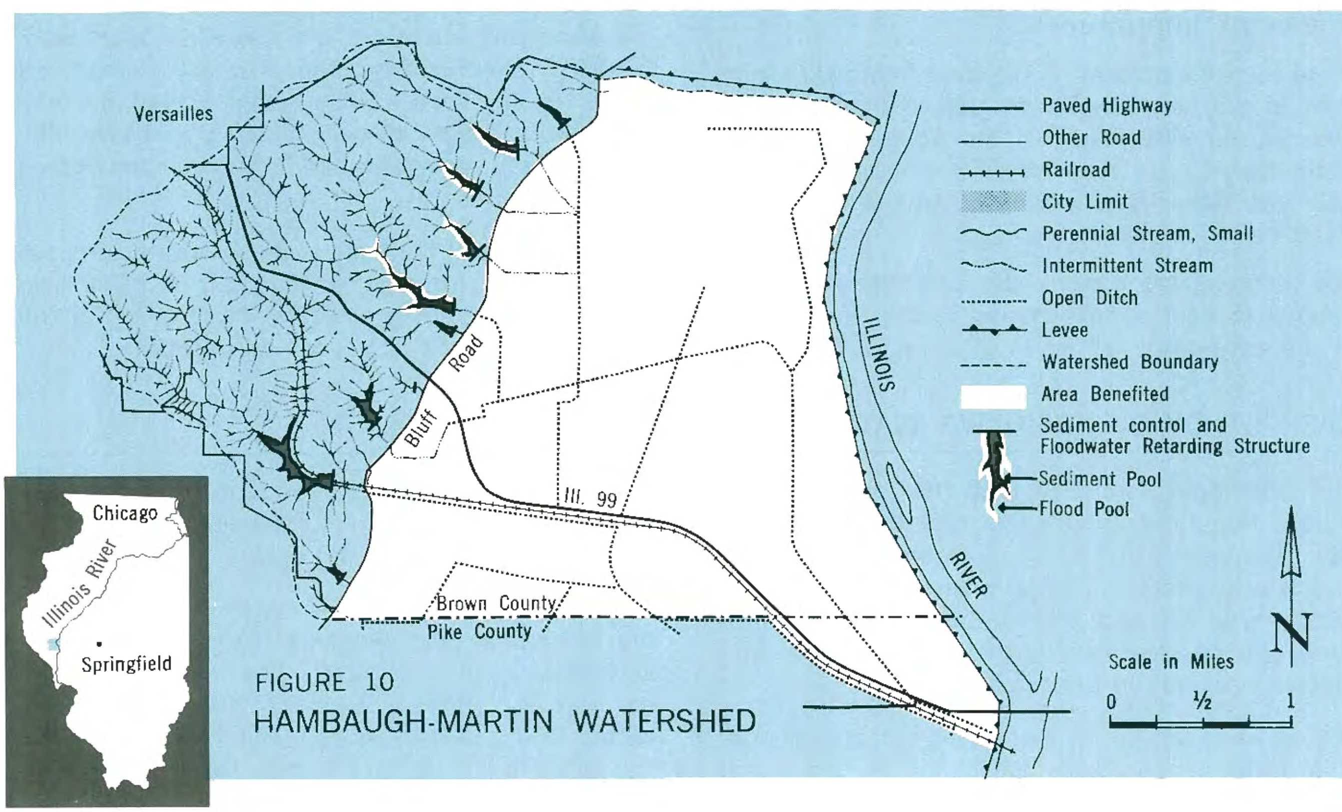


FIGURE 10
HAMBAUGH-MARTIN WATERSHED

area rises abruptly from the bottom-land area and creates a maximum relief of 140 feet in less than 0.5 mile. The entire upland consists of sharp v-shaped valleys separated by narrow, flat-topped ridges.

The soils of the upland bluff area were developed in deep loess under timber vegetation; therefore, they have the light-colored topsoil characteristic of soils with a low organic matter content.

Watershed Problems

The deposition of sediment in all of the bottom-land drainage ditches was the most serious problem in this small watershed. The major portion of the sediment came from the upland loess bluff area by sheet, gully, and channel erosion and was transported to the drainage ditches by numerous intermittent streams with steep gradients. Large gullies advanced into the cropland near the upper part of the watershed to create another major problem.

Local residents submitted an application to the Governor of Illinois for assistance under the Watershed Protection and Flood Prevention Act in December 1957. The U. S. Soil Conservation Service helped the local sponsors develop a plan to reduce the deposition of the sediment into the channels of the McGee Levee and Drainage District in the Illinois River bottom land. The plan was approved in July 1958; construction of the project began in December 1958 and was completed in March 1962.

Works of Improvement

More than 80 percent of the land treatment measures in the plan have been applied in the upland area of the watershed. Of the 58 farmers in the watershed, 52 are cooperators in the Brown County Soil and Water Conservation District and 34 have basic plans for their farms.

The following soil conservation practices have been applied to control soil erosion in the upland area of the watershed: 17 miles of terraces, 526 acres of contour farming, 310 acres of new pasture, 10 farm ponds, 4 stabilizing structures, and a number of acres of tree planting. The Brown County ACP Committee has given high priority to assisting the farmers in the watershed in applying conservation practices.

All of the nine flood-water retarding and sediment control structures in the plan have been completed. The drainage areas back of these structures vary from 37 acres to 1340 acres, and the height of dams from 11 feet to 41 feet.

The estimated cost to the local farmers for the soil conservation measures was $58,000. The total cost of the project was estimated to be $246,279; the local sponsors share was $75,210, and $171,069 came from P. L. 566 funds.

It has been estimated that the average annual benefits from this project will be $9,132 and the average annual cost of the structural measures $6,548. The benefit-cost ratio shows that for every dollar spent, the local people will receive $1.39 in benefits. The improvements will reduce the average annual damage in the Hambaugh-Martin Watershed by 85 percent. This project was co-sponsored by the Brown County Soil and Water Conservation District and the McGee Levee and Drainage District.

Effect of the Project

A noticeable difference in runoff can be seen in the channels below the project structures. All of the completed structures are above the bluff road. Formerly, the flooding after a heavy rainfall left debris on the road. Since completion of the project, the road has not been flooded, and very little sediment has been deposited in the drainage ditches in the bottom land.

The lakes behind the three large structures are used for recreation, for boating, fishing, and picnicking. During the past several years, more than 25 different local groups have used these facilities.

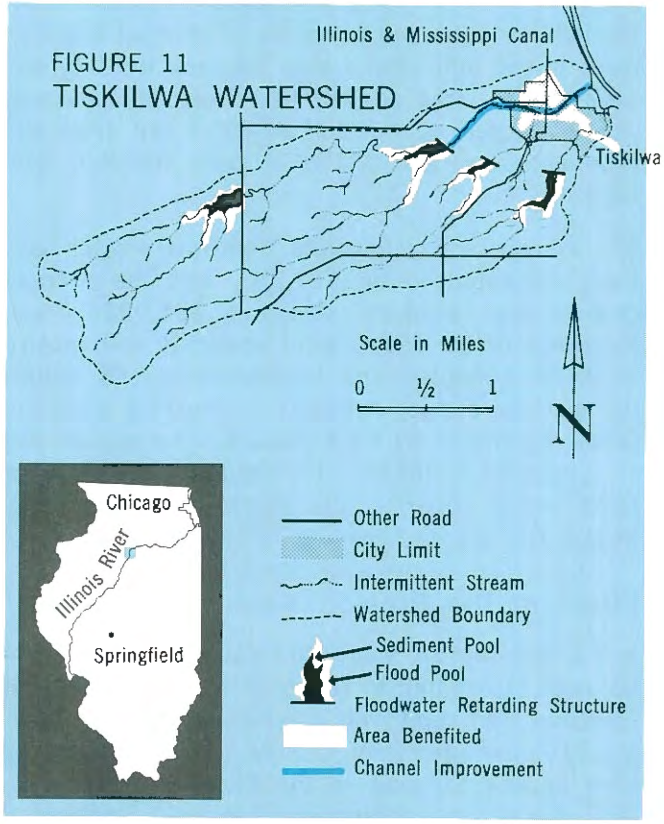
CASE STUDY 3. TISKILWA WATERSHED

This 3300-acre watershed is in the central part of Bureau County, 7 miles south of Princeton (Figure 11). The village of Tiskilwa, with about 400 homes and 43 businesses and a present population of 1050, is at the east end of the watershed. Residents are businessmen, retired farmers, and commuters who work in Princeton.

The stream valleys of the watershed are narrow, with little or no flood plain. Slopes along the streams are so steep that the land is used almost entirely for pasture. The maximum relief in the watershed is 420 feet in 4 miles.

The main problems in this small watershed were the flood-water and sediment damages to the 83-acre flood plain in Tiskilwa. The largest flood was on July 21, 1949, when 3.83 inches of rain fell in two and one-half hours. Ten businesses were flooded with 22·inches of water, eight homes had at least 12 inches of water over the first floor, and the grade school had 24 inches. Several of the bridges in Tiskilwa were washed out, and the residential area was covered with several inches of silt.

Local residents submitted an application to the Governor of Illinois for assistance under P. L. 566 in May 1955. The local sponsors, with assistance from the S. C. S., developed a plan to reduce the flood-water and sediment damages to Tiskilwa. The plan was approved in July 1956; construction started in May 1959 and was completed in October 1960.



Of the twenty farms in the watershed, seventeen are in the Bureau County Soil and Water Conservation District program; fourteen of the farms have basic soil and water conservation plans.

To control soil erosion in the upland area of the watershed, 13 acres of grass waterways, and 10.4 miles of terraces and diversions have been completed.

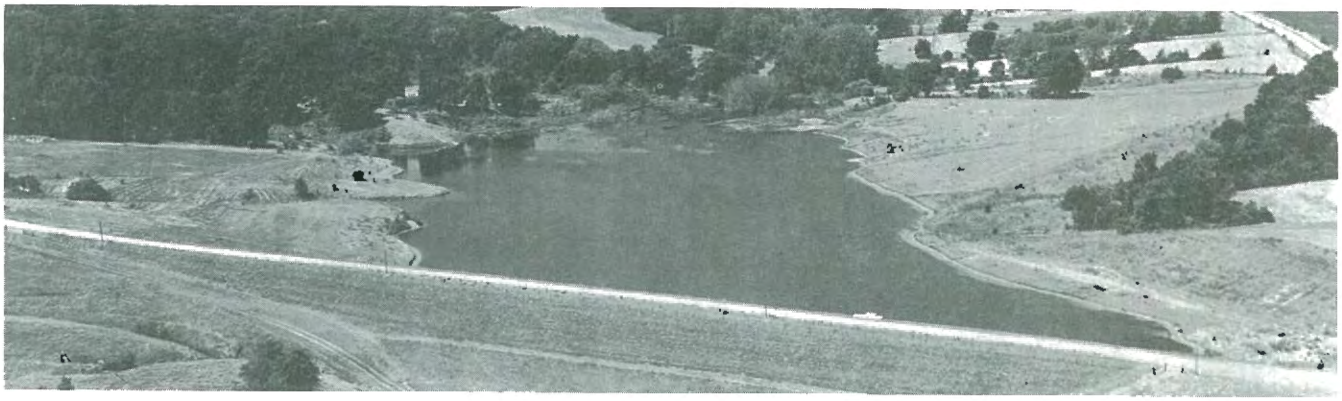
Four flood-water retarding structures were constructed in the valleys of the watershed just above Tiskilwa to control a storm which produces 6 inches of runoff. Limited improvements were made on the 1.25 miles of channels through Tiskilwa. The cost of the structural measures was estimated at $307,624; $106,600 from local sponsors and $201,024 from P. L. 566 funds. The Bureau County Conservation District and the village of Tiskilwa co-sponsored the project.

Effect of the Project

The flooding of Tiskilwa has not been a problem since the construction of the four flood control structures. The largest storm since the project was completed in 1960 occurred when 8.8 inches of rain fell from September 11 to 26, 1961. During that storm, 3.35 inches of rain fell in eight hours. The storm did not flood Tiskilwa, and the water was only 18 inches deep in the channel through the village.

The Illinois Mennonite Church Camp Association purchased 232 acres above the upper structure for a summer camp. About 1000 church members used the facilities during 1963, and other groups also use the camp. Public fishing is allowed by permit without charge.

The project is responsible for at least one new industry in the village. A farm chemical company built a plant there in 1958 and expanded it in 1962. According to its president, the company could not have built a plant in Tiskilwa if the village were not protected from flooding. Three houses were built in 1964, the first new homes in Tiskilwa for a number of years. The project has brought a new sense of community spirit in this small village.



CASE STUDY 4. HOG RIVER-PIG CREEK WATERSHED

The 3250-acre watershed is in the central part of St. Clair County. Mascoutah, just east of Belleville, is the approximate center of the watershed (Figure 12).

The local people have long recognized the flood-water problems of the watershed and have sought methods of protection. In 1905 a diversion channel above Mascoutah was designed, but never constructed.

Exceptionally severe storms occurred in 1915, 1917, 1946, and 1957. On June 14 and 15, 1957, more than 11 inches of rain fell on the area in a twelve-hour period. The storm heavily damaged the business district and inundated about 83 acres in the residential section of Mascoutah. The urban damage from this one flood was estimated at $90,000. Basements in the town were completely flooded, and the first floors of the stores were covered with 3 feet of water. Other problems in this watershed included flooding of agricultural land below Mascoutah and inadequate drainage of the highly productive land above the town.

After the 1957 flood, the second major flood in eleven years, the Mascoutah Surface Water Protection District was authorized by a referendum vote of 317 to 14 and was given taxing powers and an annual assessment.

Local sponsors applied for P. L. 566 assistance in September 1958. The U. S. Soil Conservation Service and the local sponsors developed a plan to reduce the flood-water damages and improve the drainage outlets in the watershed. The plan was approved in July 1961; construction started in March 1962; and all of the improvements were completed in December 1964.

Works of Improvement

The farmers in the upper part of the watershed are applying the needed soil and water conservation practices, such as crop rotations, grass waterways, land smoothing, and surface field ditches. The landowners are building these measures at an estimated cost of $36,108.

To provide the desired level of protection, the project consists of a 2-mile multiple-purpose (flood-water and drainage) diversion channel above Mascoutah, 1.9 miles of channel improvement through the City, and 1.6 miles of channel improvement in the agricultural area between the City and Silver Creek. The cost of the structural measures was estimated at $526,919—$213,248 from the local sponsors, and $313,671 from the P. L. 566 fund.

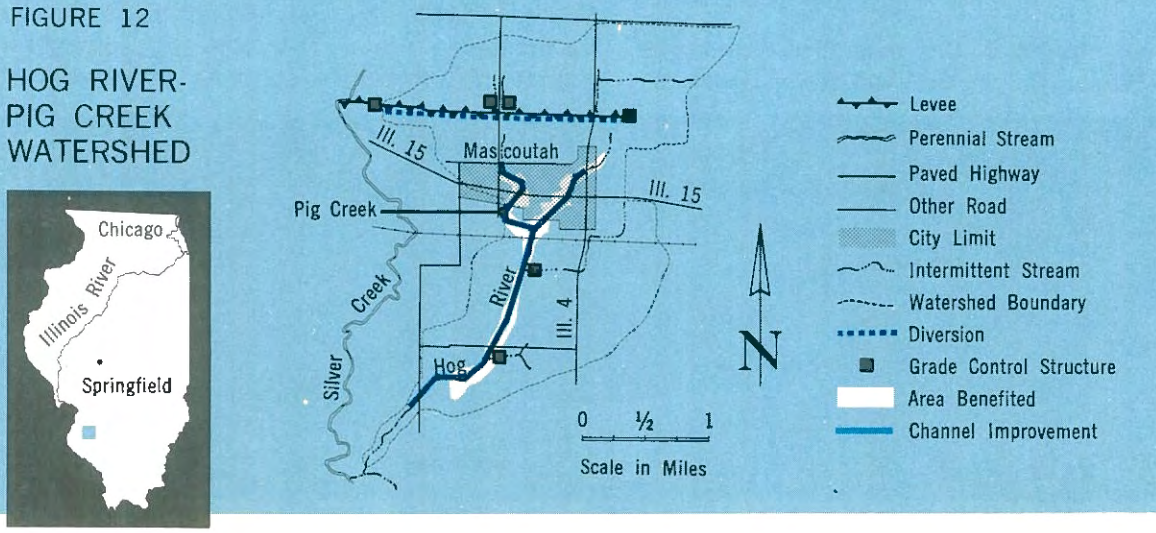
The average annual benefits from this project have been estimated to be $27,333, and the average cost of the structural measures $21,953. Thus, for every dollar spent, local residents will receive $1.25 in benefits. The improvements will reduce the average annual damages in the Hog River-Pig Creek Watershed by 89.3 percent. The project was co-sponsored by the St. Clair County Soil and Water Conservation District, the Mascoutah Water Protection District, and the City of Mascoutah.

Effect of the Project

A 2.5-inch rain in May 1963 caused the diversion north of Mascoutah to run only half full. The local sponsors also report no flood-water damages after a very heavy rainstorm in May 1964, which would have caused flooding in the City before the project. A new junior high school has been constructed

FIGURE 12

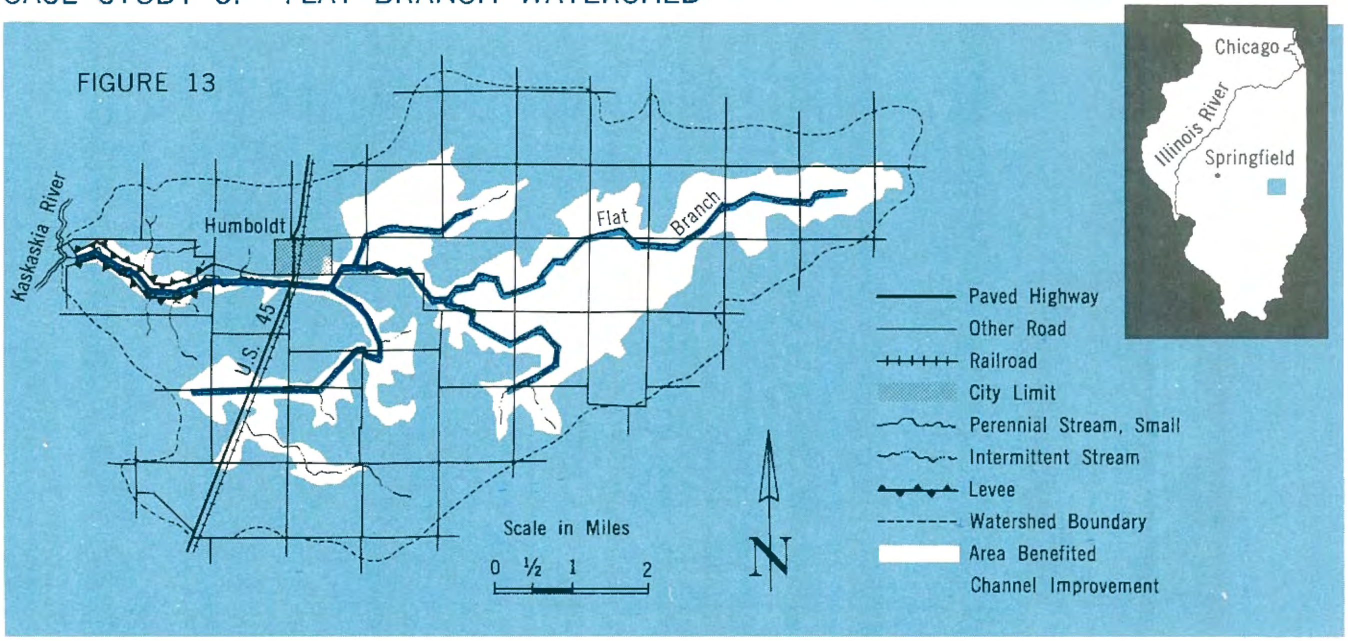
HOG RIVER-PIG CREEK WATERSHED



in an area which would have been unsuitable because of flooding before completion of the project. About 100 new homes, housing local merchants, businessmen, and Scott Air Force Base personnel, have been constructed on this once unsuitable site. Other new buildings are planned.

CASE STUDY 5. FLAT BRANCH WATERSHED

FIGURE 13



The Flat Branch Watershed of 27,580 acres is in the north-central part of Coles County. The lower end of the watershed is at the confluence of Flat Branch Creek and the Kaskaskia River, 3 miles west of Humboldt (Figure 13).

The land is flat to gently undulating, with slopes of less than 3 percent. The watershed is in the eastern cash-grain farming area of Illinois; the major crops are corn, soybeans, and wheat, with minor acreages of oats, hay, and pasture.

Watershed Problems

Flood-water damages to the cropland in the lower part of the watershed and inadequate drainage in the upper end of the watershed are the two major problems to be solved.

Capacities of the channels downstream from Humboldt are inadequate to carry excess runoff from storms over the watershed. As a result, severe flooding occurs on about 18 percent of the watershed. Approximately 80 percent of the land affected needs major improvements in its tile drainage for maximum drainage by channel enlargement and deepening of outlets into Flat Branch Creek.

Works of Improvement

Land treatment, in conjunction with structural measures, is considered necessary to provide a reasonable level of flood protection and to improve agricultural drainage.

The Coles County Soil and Water Conservation District has assisted 34 of the 90 farmers in the watershed in working out basic farm plans. The following soil conservation practices will be applied to the land in the future: conservation cropping systems, contouring, grass waterways, diversions, pasture planting, terraces, and grade stabilization structures. Installation of surface field ditches and tile drains will be required on the level land needing drainage.

The estimated cost of the necessary land treatment in the Flat Branch Watershed is $184,791, with the farmers share $122,911 and $61,880 from P. L. 566 funds.

The structural measures consist of 21.4 miles of channel improvement and associated structures. The improved channels will allow for the flow from a three-year frequency growing-season storm.

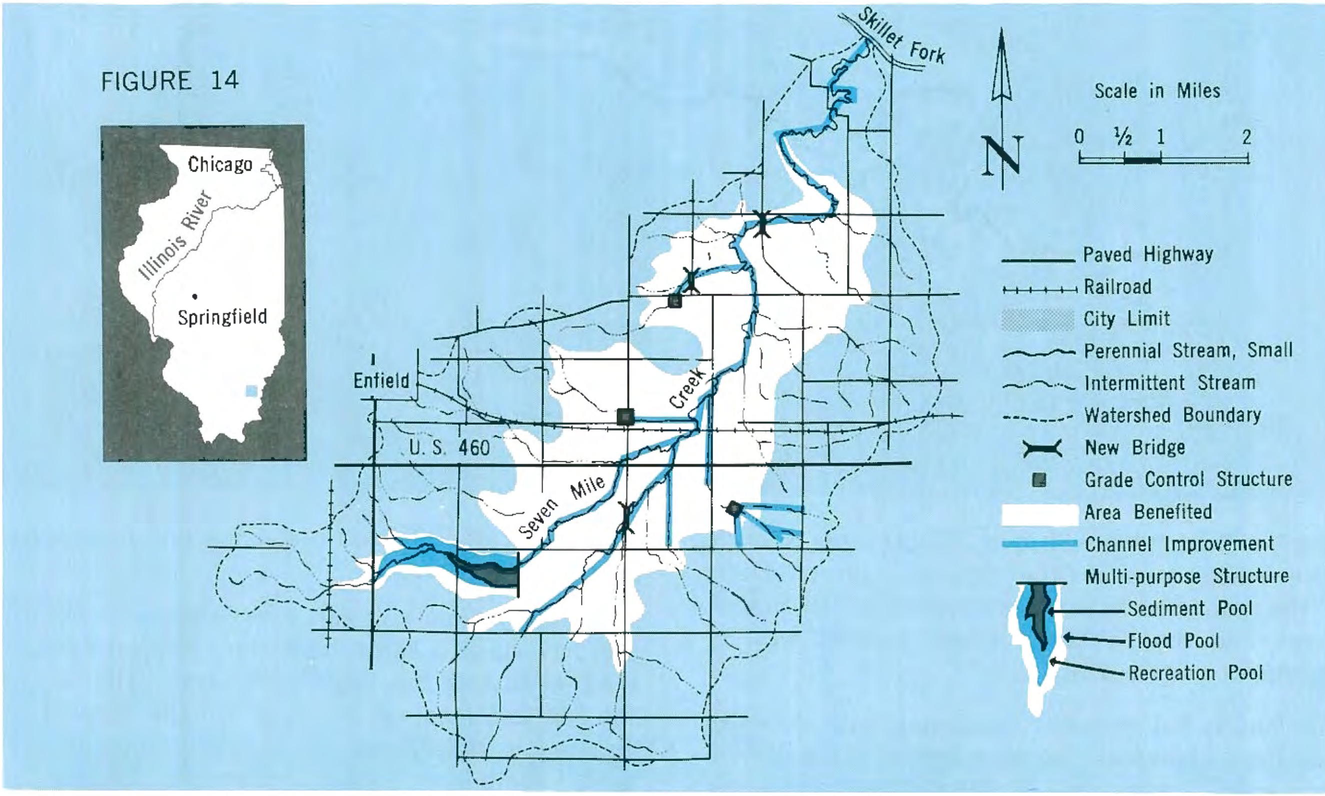
It is estimated that the total cost of the structural improvements will be $344,481, with $257,363 from P. L. 566 funds and $87,118 from the local sponsors.

The average annual benefit from this project has been estimated as $38,880, and the average annual cost of the structural measures at $17,748. The benefit-cost ratio shows that for every dollar spent the local sponsors will receive $2.20 in benefits.

The local people applied for P. L. 566 assistance in February 1963. The U. S. Soil Conservation Service and other Federal and State agencies assisted the local sponsors in developing a plan to reduce floodwater damages in the flood plain and to correct the poor drainage in the upland area of the watershed. The plan was approved for construction in October 1965. Organizations sponsoring the project are the Coles County Soil and Water Conservation District, Mutual Drainage District 2 of Humboldt, Drainage Districts 4 and 5 of Humboldt, and Union Drainage District 2 of Seven Hickory and Humboldt.

CASE STUDY 6. SEVEN MILE CREEK (WHITE COUNTY) WATERSHED

FIGURE 14



The village of Enfield, population 800, is on the northwest boundary of the Seven Mile Creek Watershed of 23,000 acres in the west-central part of White County. Seven Mile Creek flows in a meandering course 9 miles from the southwest extremity of the watershed to its confluence with Skillet Fork, about 6 miles northwest of Carmi. The total relief in the watershed is approximately 150 feet (Figure 14). The watershed project is sponsored by the White County Soil and Water Conservation District and the Seven Mile Creek Conservancy District.

Watershed Problems

Inadequate channel capacity in Seven Mile Creek and its tributary channels is the major cause of flooding and impaired drainage on approximately 7000 acres of the flood plain.

The moderate sheet erosion on many of the rolling acres was caused by excessive cultivation of row crops and the lack of land treatment measures. This area of the State has few lakes with adequate water-based recreational facilities.

Works of Improvement

Fifty-four percent of the 116 farmers in the watershed are cooperators in the White County Soil and Water Conservation District, with 36 percent of the farms under a conservation plan. The landowners in the watershed have spent approximately $110,000 on land treatment measures since the founding of the local soil and water conservation district.

The following conservation land treatment will be applied to the farms of this watershed in the future: conservation cropping systems, contouring, diversions and terraces, grassed waterways, grade stabilization structures, minimum tillage, pasture planting, and woodland improvement.

The estimated cost of the required land treatment measures is $414,985. The local people will spend approximately $350,255, and $64,730 will come from the P. L. 566 fund for technical assistance.

Structural Measures

The planned structural measures consist of one multiple-purpose structure for flood prevention and recreation, basic recreational facilities, and 16.2 miles of channel improvement with associated structures and several stabilization structures. The plan will provide a three-year level of flood protection and will reduce the flood-water damages by 86 percent.

The estimated cost of the structural measures is $1,606,465, of which the P. L. 566 share is $1,175,626 and the cost to the local sponsors is $430,839.

A total of 650 acres will be acquired for the recreational development at the multiple-purpose structure site. This includes a permanent pool area of 236 acres, an additional 70 acres for the structure site and access zone around the flood pool, and a 344-acre recreational facilities area upstream from the structure site.

Picnicking and boat launching areas, camping areas for a maximum of 200 campers per day, and a beach area for a maximum of 500 swimmers per day will be included.

The local sponsors submitted an application for P. L. 566 aid in July 1961. The project was approved for construction in September 1963.

UPLAND AGRICULTURAL DRAINAGE

Illinois is a highly urbanized and industrialized state, but the dominant land use is for agriculture. Eighty-five percent of the total land area is in farms, and agricultural production is among the nation's highest. This stature was not easily developed, and drainage of the prairie land posed an especially difficult problem. An inventive, laborious, and costly effort converted the poorly drained glacial deposits of the State's land into highly productive soils.

Agricultural drainage geologically, topographically, and historically falls into two broad categories, upland drainage and bottom-land drainage. Bottom-land drainage is reclamation of the natural bogs, swamps, lakes, and sloughs comprising the backwaters of the Mississippi, Illinois, and Wabash Rivers and the lower sections of their principal tributaries. The upland is the remainder of the land. It has gentle but inadequate relief, and usually the soils are poorly drained.

The predominate drainage problem on bottom lands is protection from flood flow. Therefore, bottom-land drainage is discussed in Chapter VI on floods, and this section is limited to upland agricultural drainage.

The major agricultural lands of Illinois fall into three subdivisions, each of which is delineated by glacial characteristics. (See the physiographic map in Figure 1, Chapter I.) These are the Till Plains Section which covers about four-fifths of the State; the Great Lakes Section, lying inside the Valparaiso Moraine in northeastern Illinois; and the Wisconsin Driftless Section in the northwestern corner of the State. The northeastern portion of Illinois is almost totally in the Till Plains Section.

The Till Plains Section, which coincides closely with the Wisconsinan and Illinoian drift sheets, is characterized by youthful plains on which the original features of glacial deposition are widely preserved. Because the Wisconsinan drift sheet is in an early stage of stream dissection, large areas are without important valleys. This causes an agricultural drainage problem of considerable magnitude.

The Great Lakes Section in northeastern Illinois contains the most youthful drift in the State. It is distinguished by an un-eroded moraine topography with numerous undrained depressions containing lakes and swamps.

Both the Till Plains and Great Lakes Sections present drainage problems in northeastern Illinois. The land may be described as having low, broad morainic ridges with intervening stretches of relatively flat or gently-undulating ground moraines. The area is also characterized by vast prairies that are very wet and soft during rainy weather.

History of Drainage

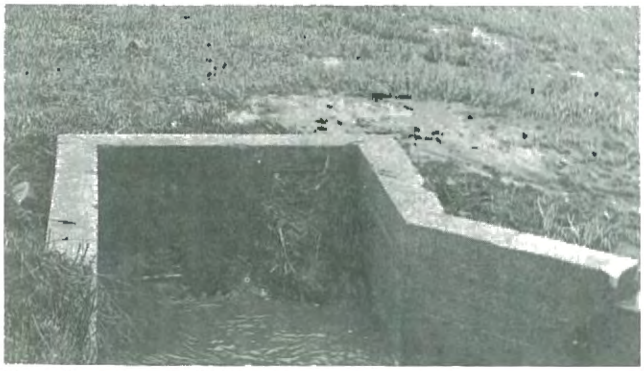
The original settlers of Illinois located in the well-drained densely wooded regions along rivers and streams. Soon the agricultural lands were expanded to include the more marginal areas between the natural streams and rivers, areas characterized by large swamps and ponds. The prairies were wet for a large part of the growing season; in order to grow food crops, homesteaders had to drain the land artificially.

They first drained the fields through shallow ditches, plowed to the nearest natural watercourse, often for long distances. These outlet ditches drained only the surface water and quickly filled with debris and silt; crops failed time and again because the soil itself remained wet.

Farmers dug the ditches deeper; when they saw water oozing from the sides of deep excavations, they conceived the idea of subsurface drainage. The first subsurface drains were long wooden boxes which improved the drainage but rotted easily. As equipment and technology progressed so did the systems of artificial drainage, but this was not the primary reason for better drainage systems.

The new drainage laws were the primary cause of the improvement of artificial drainage. Originally, the basic drainage law in Illinois said that the owner of lower lands must accept the normal streamflow from the upper lands. Serious problems arose for property owners in poorly drained areas where no natural watercourse existed.

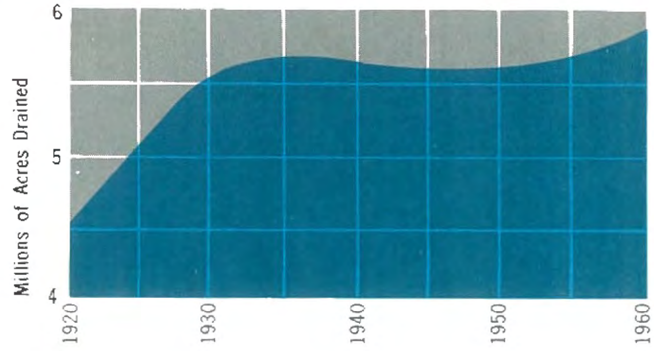
Drainage laws passed in 1826 and 1871 were both short-lived. In 1879 the Illinois General Assembly passed the Drainage Levee Act and the Farm Drainage Act. The two acts and their many amendments are the basis of Illinois' present well codified drainage law, and are now combined in the Illinois Drainage Code. These drainage laws give landowners a legal entity which can properly plan and construct adequate drainage and flood protection for the lands lying within the boundaries of a legal drainage district.



Water flows into tile inlet structure.

FIGURE 15

DRAINAGE DISTRICT DEVELOPMENT



Prior to the formation of drainage districts, the development of drainage systems was slow because the individual farmer could not finance a large project. He could drain his own land, but could not make the necessary improvements on the channels of the outlet streams into which his land drained. After the passage of drainage laws, drainage districts were formed, funds for outlet improvements were available, and vast areas were drained.

The number of acres of land in Illinois in drainage districts for the period 1920-1960 is shown in Figure 15. Table 2 is a statistical summary of drainage projects in Illinois in 1960. Only 11 of the 102 counties in the State have no drainage projects; Champaign, Douglas, and Piatt Counties have 65 percent of their total area under agricultural drainage.

TABLE 2

EXISTING ILLINOIS DRAINAGE PROJECTS, 1960

Total Drainage Projects	1,765
Acres Drained and Used for Agriculture	5,565,426
One-Owner Drains: Number	44
One-Owner Drains: Acres	78,673
Mutual Owners: Number	160
Mutual Owners: Acres	228,762
Legally Organized: Number	1,560
Legally Organized: Acres	5,548,796

A complete listing of this information by counties is available from the Division of Soil and Water Conservation, Illinois Department of Agriculture.

Source: Census of Agriculture, 1959. Volume IV. U. S. Department of the Interior.

At present, there are many inactive drainage districts in Illinois for various reasons, some because the initial objective was accomplished, and some because local interest or leadership is lacking. It is desirable that all present districts be active and a number of new ones organized, because there are thousands of acres in the State which are potentially valuable agricultural land if drained.

DRAINAGE SYSTEMS AND THE PROBLEMS INVOLVED

To drain his land, the owner may choose between two basic drainage systems—the open ditch and the underdrain systems. Each has its peculiar advantages and disadvantages, and some drainage projects are a combination of the two.

The open ditch system serves as an outlet for a series of drain furrows which are plowed into the field surface. The major advantages of the system are the low initial cost and the ability to drain impermeable soils such as clays and clayey-loams, as well as more permeable soils that are closely underlain with an impermeable strata.

One of the disadvantages of the open ditch system is that the ditches occupy land that could be cultivated. If the ditches are large and their length great, considerable acreage is lost. If the ditches are not wide with flat banks, they are difficult to cross with farm machinery. These open ditches are easily choked with weeds and silt and must be cleaned regularly.

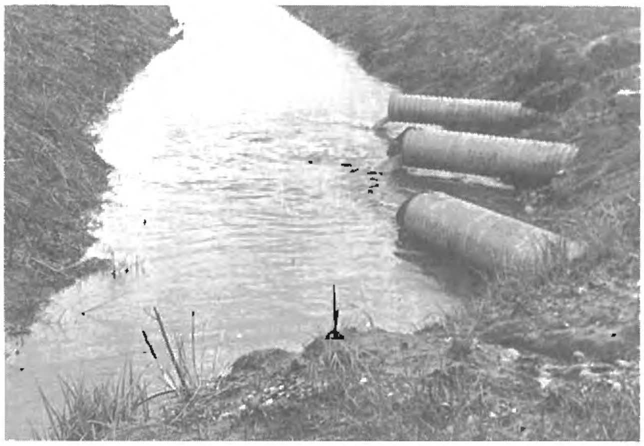
The second method for local drainage is the underdrain system, in which subsurface conduits, usually tile, drain soil waters to an outlet drain or ditch. This is the appropriate system for high-value land with permeable soil. The underdrain system may be installed to provide some surface drainage, but its major purpose is to provide subsurface drainage of excess soil moisture.

This system has all the advantages of subsurface drainage—control of moisture, warmer soil, and earlier access to the fields. With the change in recent years to larger farms and larger equipment, it is desirable that each field be cultivated within a short period of time, and this can be expedited with complete and adequate drainage. In addition to these benefits, the tile system wastes no surface land, nor is it difficult to cross with farm machinery. A tile system needs little maintenance, once it is installed.

The inital cost of the tile system is extremely high, compared to cost of the open ditch system, but on high-value lands is completely justified. An average cost for a complete tile system is about $150 to $200 per acre.

Before selecting an extensive system of drainage, the landowner should consult a drainage specialist and give proper attention to the soil type, ground slope, cropping practice, land values, and crop productivity.

An official from the local drainage district or a representative of the Soil Conservation Service of the U. S. Department of Agriculture can give excellent advice about land capabilities, types and costs of drainage, and possible sources of funds to help pay for the improvement. Proper artificial drainage is expensive, and all possible technical and financial advice should be used in selecting a drainage system.



FUNCTION OF A DRAINAGE DISTRICT

While individual farmers can usually handle the drainage of their own land, serious problems arise when the individual farmer has no natural watercourse on his property to carry the discharge from his fields.

When an owner wishes to run ditches through another owner's property to a natural watercourse, a mutual agreement may be made between the landowners concerned. This agreement should specify the location of the drains, how they will be maintained, and how costs will be apportioned. Other business arrangements in connection with the drainage should be agreed upon.

In areas where the maintenance of channels in major streams and rivers is necessary for good drainage or where several landowners may benefit from work to be done on a main outlet, the best course of action may be to organize a drainage district under the State Drainage Code.

The principal functions of the drainage districts are to improve the channels of existing streams or ditches when necessary, and to lay tile laterals to connect field drainage systems to major outlets. Most of the larger drainage districts were organized to improve existing streams and construct new open ditches. River conservancy districts may be organized under Illinois law to serve major drainage and flood control functions.

An important means to drainage and flood control construction is through Public Law 566, which provides funds and technical assistance for small watershed projects. Watershed projects in Illinois constructed with aid from this program are described earlier in this chapter and in other chapters. Drainage districts, river conservancy districts, and Public Law 566 are discussed further in Chapter IX.

CASE STUDY 7. AN UPLAND DRAINAGE COUNTY

Champaign County in east-central Illinois is a good example of the development of an upland prairie region and the associated drainage problems. The area, originally a vast grass prairie with large swamps, is 988 square miles or 632,320 acres (Figure 16).

Settlement of Champaign County began about 1820. At that time an estimated 8 percent of the County, or 53,760 acres, was timber and woodland; about 504,320 acres was grass and prairie land; and about 12 percent of the County, or 74,240 acres, was swamp and wet lands. Most of the swamp and wet lands was along the Kaskaskia River, the Embarras River, the West Branch of the Vermilion River, and their main tributaries. Early settlers located on high ground along the main streams. Two such locations were near Sadorus and on the land that is now Urbana.

The available high and productive land areas became inadequate to serve the increasing population, and the less desirable properties began to be settled. The prairies were undesirable because adequate natural drainage was nonexistent. Crop losses were common, and even wagon routes could not be established over the wet and soggy grasslands.

Residents of the prairie lands quickly realized that artificial drainage systems must be constructed in order to grow crops. Early attempts at drainage were plowed, surface ditches from low spots to an existing swamp, stream, or river. Difficulties arose when drainage ditches crossed property boundaries to reach a natural outlet.

Gradual improvement in equipment and technology provided new drainage systems. By 1865 the major obstacle to adequate land drainage was lack of funds and a fair method of apportioning costs.

Probably the most substantial single aid to drainage in Champaign County was the passage of the Levee Act and the Farm Drainage Act in 1879. Many drainage districts were then organized in Champaign County, and great areas of land were artificially drained. Between 1879 and 1890, forty separate drainage districts were formed to provide artificial drainage for about 200,000 acres, or approximately 30 percent of the total land area of the County. In 1880 the total agricultural output of Champaign County was valued at $4,440,000. By 1910 a total of 413,000 acres of land was in drainage districts, and agricultural production was valued at $10,341,000.

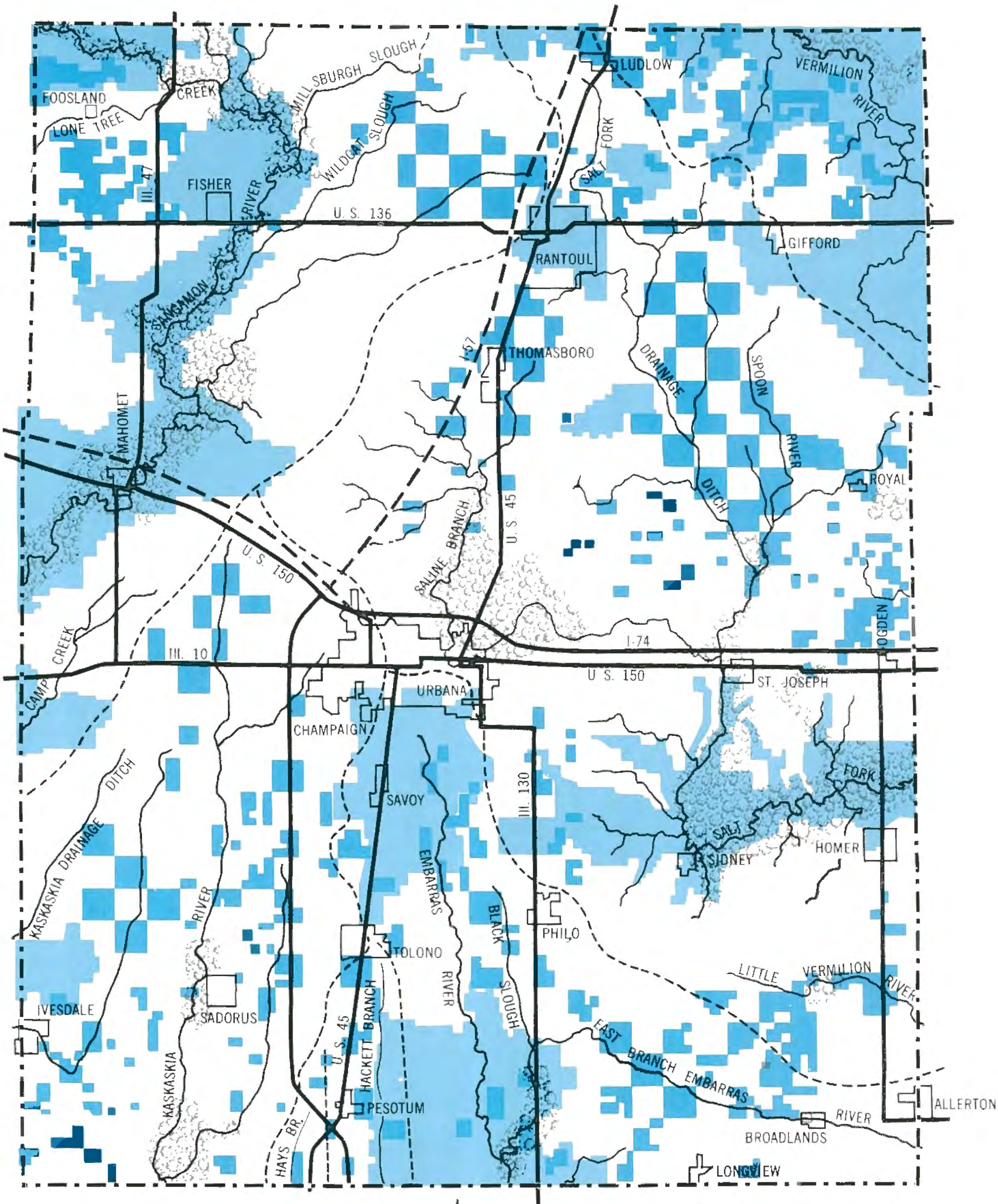
By 1950 there were 96 separate districts in Champaign County and a total of 240 sub-districts. This sophisticated system provided artificial drainage for 532,000 of the 632,320 acres, approximately 83 percent of the land area of the County. Only about 4500 of the 74,240 acres which was swamp and wet lands in 1820 remain in that condition.

Because of the drainage program, the old county classification of 80 percent grassland and 20 percent woodland has changed to 97 percent tillable farmland and 3 percent woodland. The gross agricultural product in Champaign County in 1963 was $45,224,100.

As of 1960, with 79 of Champaign County's 97 drainage districts reporting, accumulated assessments over the period 1900 to 1960 totalled $5,798,000. This yields an average assessment over the period of about $9.65 per acre drained or $0.16 per acre per year.

Over the years, the residents of Champaign County have benefited tremendously from the artificial drainage systems. Capital investment toward land drainage improvement has totalled about $2.8 million. The investment has been returned manyfold, and the work was done almost entirely with private capital on an assessment basis. In 1950 the outstanding indebtedness of all the districts of the County totalled $20,669, all in three districts. Only 108 acres was reported as delinquent in drainage taxes.

Today the drainage districts of Champaign County, as do other districts of the State, face a different problem. Despite the great success of the drainage



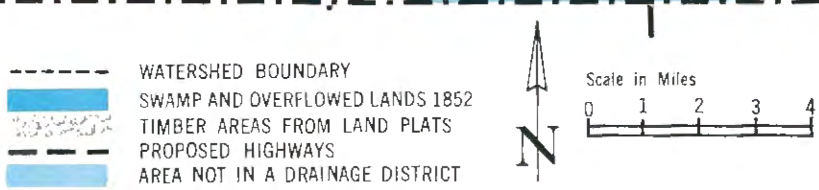


FIGURE 16
UPLAND DRAINAGE—
CHAMPAIGN COUNTY

district as a working entity, problems arise when several districts need to work together for a common goal. A district can raise funds only from within its boundaries, and district members are reluctant to invest dollars today for benefits tomorrow. Illinois law puts fiscal and legal limitations on organized districts, which prevents participation in large scale drainage and flood control improvements. These limitations, valuable in themselves, inhibit the development of inter-district projects.

An excellent example in Champaign County is the Upper Embarras Watershed project, proposed as a P. L. 566 project. About 227,000 acres of agricultural land would have been benefited. The land involved is in about 50 organized drainage districts, represented by more than 150 drainage district commissioners. This created a fantastic communications problem and the almost impossible task of determining cost and benefit allocations, for the Soil Conservation Service.

IRRIGATION

HISTORICAL AND PRESENT TRENDS

Supplemental irrigation has been practiced in Illinois for 40 years; several gladioli growers in Kankakee County began to irrigate their fields in 1926.

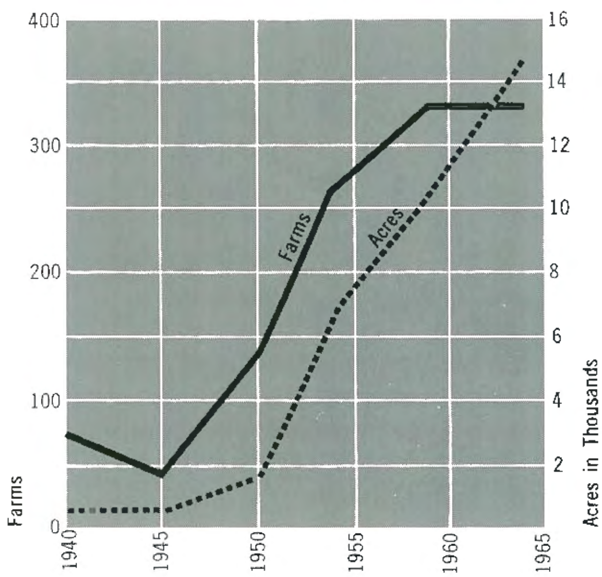
The records of the Illinois Cooperative Crop Reporting Service show that acreage of irrigated land has increased from 307 acres in 1940 to 14,650 acres in 1964. Table 3 and Figure 17 show the trend in use of irrigation from 1940 to 1964.

TABLE 3 IRRIGATION IN ILLINOIS

Year	No. of Farms	Acres
1940	72	307
1945	47	368
1950	139	1,510
1954	266	6,789
1959	332	10,127
1964	336	14,650

From the Illinois Crop Reporting Service

FIGURE 17 TRENDS IN IRRIGATION



In 1950 a study of irrigation systems in Illinois was made by field investigation, and by using information from a number of irrigation equipment manufacturers and 85 farm advisors. At that time 48 percent of the irrigation was for truck crops, 36 percent for flowers, 10 percent on pastures, 3 percent for seed corn, and 3 percent for nursery stock; 44 percent of the irrigation systems were located near Kankakee. Nearly 50 percent of the water used in Illinois was pumped from underground sources; the remaining systems used water from rivers, drainage ditches, lakes, and farm ponds.

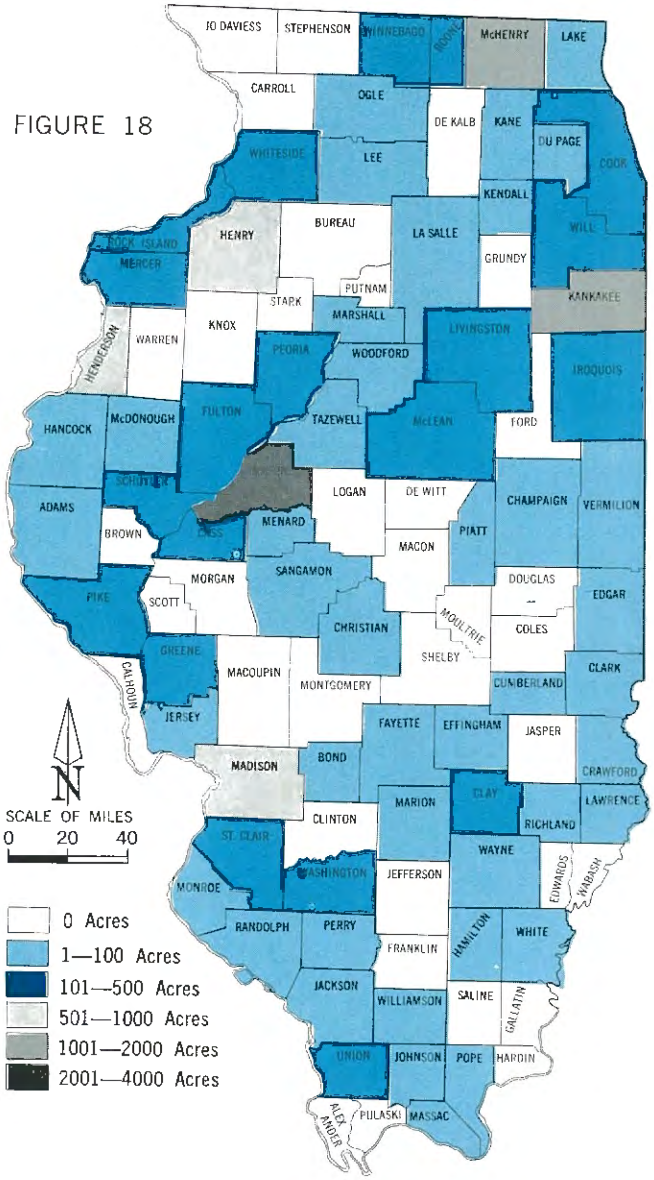
A study of the 1964 status of irrigation was made by the Department of Agricultural Engineering of the University of Illinois in cooperation with the Extension Service (Table 4). The 1964 study showed that the sources of the irrigation water were: 48 percent from underground, 28 percent from farm ponds, 10 percent from rivers, 5 percent from drainage ditches, 3 percent from city water supplies, 2 percent from strip mines, 2 percent from creeks, and 2 percent from gravel pits. The distribution of irrigated acreage in 1964 is shown in Figure 18. Counties with the most irrigated acreage were Mason, Kankakee, Henry, and Henderson. Irrigation is being practiced to some extent throughout most of Illinois.

TABLE 4 PERCENT OF TOTAL IRRIGATED ACREAGE BY CROP TYPE, 1964

Crop	Percent
Row Crops (Corn and Soybeans)	60
Truck Crops	17
Fruit Crops	9
Hay Crops	4
Sod Farms	4
Nursery	3
Small Grain	1
Pasture	1
Flowers	1

IRRIGATION ACREAGE BY COUNTIES, 1964

FIGURE 18



FUTURE OF IRRIGATION

Widespread future use of water to irrigate crops in Illinois would be of considerable importance in water resources planning, but such a development is dependent on three difficult and partially unanswerable questions.

These basic questions are associated with the economics of irrigation, the water laws, and the water supplies available for irrigation. The possibility does exist that national requirements for food, for economic benefits, or both, at some future time might make optimum yields of corn and soybeans a desirable goal throughout much of Illinois. To achieve optimum crop yields throughout the State would require a maximum use of all technological practices and would also require added water in many crop seasons.

The problem of estimating the rate and total growth of irrigation and the areas of the State where such growth may occur must be considered in this water resources plan. Irrigation has never been used extensively in Illinois, but did increase from about 1500 acres in 1950 to more than 14,500 acres in 1964. The amount of land irrigated in Illinois in any one year has depended on the weather, with sharp increases in dry growing seasons such as 1953, 1954, and 1959. Illinois has a humid climate, and about two-thirds of the State has deep, permeable soils, extremely good conditions for cash-grain farming. Most experts consider it unlikely that irrigation will be used on a widespread scale.

Farmers have not turned to irrigation since World War II, because there were other less expensive ways to increase crop yields. In 1950, only 3 percent of the Illinois' irrigated acreage was in row crops; 60 percent was in row crops in 1964. Certainly, a shift to irrigation of row crops is apparent; this is significant because more than 80 percent of the State's farmland is in row crops, and the shift occurred during a period without a major drought. Irrigation of row crops in Illinois has increased yields, even in years when weather conditions were not considered adverse or limiting. Thus, irrigation appears to be a practice that 1) is expanding in Illinois, 2) is potentially economically feasible, and 3) must be considered in any broad-scale evaluation of the future water resources of Illinois.

At this time, there does not appear to be a reasonable method for projecting the rate of growth of irrigation, or predicting when any rapid expansion might occur. The Select Committee on Water Resources predicted an increase in irrigated acreage in Illinois of approximately 3 million acres, or 12 percent of the crop land, by the year 2000. This is 205 times greater than the 1964 acreage and represents an annual average increase of about 82,000 acres. Since such growth likely would not be continuous, it is quite probable that much of this predicted growth will occur within a span of a few years, when economic benefits, possibly related to a major corn belt drought or national needs for food dependent on optimum yields, suddenly develop. However, there is no scientific or economic basis for estimating when such an increase might occur.

To a large extent, the economics of irrigation limits its acceptance. Irrigation is so expensive that other means of increasing yields will be used to the maximum in an economic sequence before irrigation is widely adopted. The time when irrigation will be practiced widely and the place it will be used first will depend on the rate of acceptance of other technological advances, such as fertilizers, high planting rates, and the new seed varieties. From a purely scientific viewpoint, the southern third of the State, which has shallower soils and a greater tendency to summer droughts than northern Illinois, might be expected to develop irrigation first. However, demand for these changes will probably occur in the more productive areas of the State.

The State's water laws, which are based on riparian doctrines, could limit widespread adoption of irrigation. New laws would be needed to mediate the controversies which would develop over water rights for irrigation. This could be most serious in southern Illinois, where the sources of irrigation water would largely be from streams and reservoirs.

The third condition that will certainly affect where and when irrigation might develop widely is the availability of water supplies. This question can be partially answered now, because the water requirements to sustain maximum crop yields can now be scientifically calculated, and because there is a detailed assessment of available sources of water, present and potential. It appears that water for irrigation will be limited in many areas and in certain years.

WATER FOR MAXIMUM CROP YIELDS

Using long-term records of county weather and crop yields, a method was devised to estimate the amount of water required in any crop season to maximize crop yields in any part of Illinois. The estimates of water requirements are not a prediction of use of irrigation, but do provide a measure of the supplemental water that would be needed to sustain maximum yields during an average twenty-year period.

Irrigation water needs were determined for each of the common types of crop-season weather that occur in different parts of the State. Climatological analyses indicated the frequency of occurrence of these various weather types; consequently, the frequency of water needs associated with the types of crop-season weather was identified.

Studies of the yield-weather relations for the 102 Illinois counties indicate that marked regional differences exist within the State. Regional analysis of the yield-weather relations for corn indicated twelve definable regions of difference (Figure 19), and similar analysis for soybeans led to the identification of four distinct yield-weather regions for that crop (Figure 20).

FIGURE 19

CORN YIELD—WEATHER REGIONS

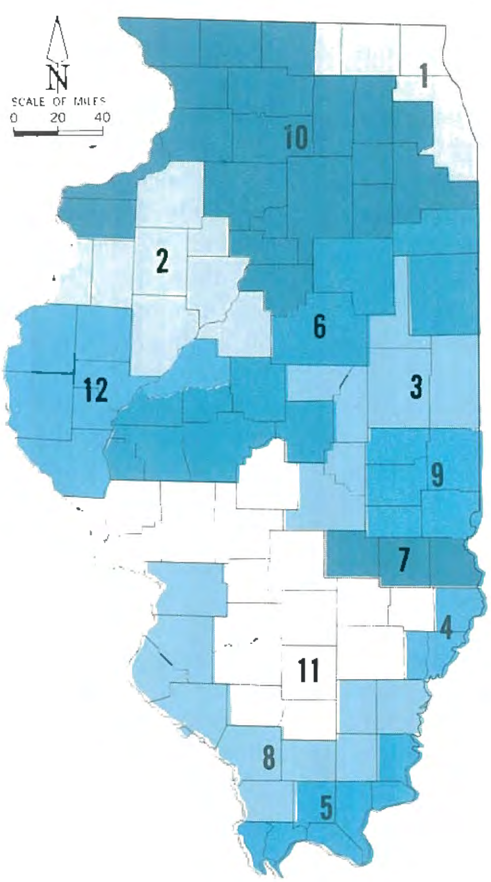


FIGURE 20

SOYBEAN YIELD—WEATHER REGIONS

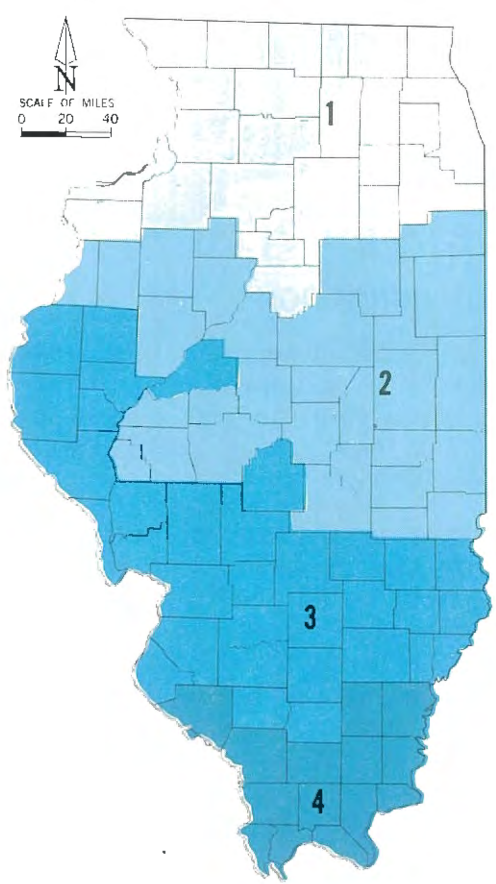


TABLE 5 FREQUENCY OF SUPPLEMENTAL WATER FOR MAXIMUM CORN YIELDS (During an Average 20-Year Period)

Region 1

Frequency (years)	Percent Increase	Water Required (inches)
4	15-18	3.3
2	11-12	2.9
2	6-7	2.2
6	1	0.9
6	0	0

Region 2

Frequency (years)	Percent Increase	Water Required (inches)
2	14	4.6
6	7-10	3.8
3	4-5	2.8
3	2-3	2.3
6	0	0

Region 3

Frequency (years)	Percent Increase	Water Required (inches)
5	14-20	5.0
2	11-12	4.3
3	6-7	3.2
3	4-5	2.8
2	2	1.6
5	0	0

Region 4

Frequency (years)	Percent Increase	Water Required (inches)
3	22-25	6.1
5	16-20	5.6
2	13-14	5.0
2	10-11	4.5
3	7-8	4.0
1	2-5	2.5
4	0	0

Region 5

Frequency (years)	Percent Increase	Water Required (inches)
7	16-20	4.3
1	8	3.0
5	4-6	2.4
1	1	1.0
6	0	0

Region 6

Frequency (years)	Percent Increase	Water Required (inches)
5	20-27	6.0
2	16-18	5.5
6	7-10	4.1
3	3-4	2.6
2	1-2	1.6
2	0	0

Region 7

Frequency (years)	Percent Increase	Water Required (inches)
7	20-28	4.7
3	14-17	4.2
2	9-11	3.4
3	6-8	3.0
1	4	2.0
4	0	0

Region 8

Frequency (years)	Percent Increase	Water Required (inches)
4	27-28	5.9
3	24	5.5
1	14	4.4
6	8-11	4.0
3	2-4	2.1
3	0	0

Region 9

Frequency (years)	Percent Increase	Water Required (inches)
2	11	4.8
3	8-9	4.4
2	6-7	3.9
6	2-3	2.5
3	1	1.0
4	0	0

Region 10

Frequency (years)	Percent Increase	Water Required (inches)
5	7-8	4.2
1	6	3.8
2	4	3.1
6	1-2	1.8
6	0	0

Region 11

Frequency (years)	Percent Increase	Water Required (inches)
4	37-49	4.8
4	25-31	4.2
4	13-20	3.5
3	8-10	2.8
1	1-5	1.0
4	0	0

Region 12

Frequency (years)	Percent Increase	Water Required (inches)
3	25	6.9
4	15-16	6.0
6	7-8	4.4
4	3-4	2.9
2	1-2	1.4
1	0	0

TABLE 6 FREQUENCY OF SUPPLEMENTAL WATER FOR MAXIMUM SOYBEAN YIELDS (During an Average 20-Year Period)

Region 1

Frequency, years	Yield (bu/acre) no added water	Percent increase, with added water	Water added, inches
1	28 −	10	5.6
6	29 −	6-8	5.5
2	28 +	3-4	3.8
5	30	2-3	3.4
6	30	0	0

Region 2

Frequency, years	Yield (bu/acre) no added water	Percent increase, with added water	Water added, inches
5	30	4-6	5.5
2	30 +	3-4	5.2
4	29	2.5-3	4.4
5	32 +	1-2.5	4.2
4	33 +	0	0

Region 3

Frequency, years	Yield (bu/acre) no added water	Percent increase, with added water	Water added, inches
2	17	38	27.4
4	20	24-27	24.8
4	21	20-23	22.4
4	24	16-19	21.9
6	26	10-15	18.3

Region 4

Frequency, years	Yield (bu/acre) no added water	Percent increase, with added water	Water added, inches
2	19	23	13.4
6	22	13-16	10.1
6	23	10-12	8.3
2	24	7-9	6.8
2	25	5-6	4.8
2	26	2	2.4

Yield and percent increases based on 1963 technology level.

For each crop and each type of crop-weather season, the maximum possible increase in yields resulting from supplemental water in July and August was determined. Hence, this analysis provided, for any part of Illinois, information which indicated that in X years out of twenty a yield increase of Y percent could be achieved with Z inches of water. All calculations were based on the level of agricultural technology in 1963.

Table 5 is a summary of the results for corn, Table 6 for soybeans, in the regions defined in Figures 19 and 20. Use of the data in these tables is illustrated by the following examples:

At any location in Region 2 (Figure 19), which is located in south-central Illinois, a 37 to 49 percent increase in corn yields could be achieved in four out of twenty years by 4.8 inches of added water in July and August. In three years out of twenty, yield increase of 8 to 10 percent would occur by adding 2.8 inches of water, and in four other years in an average twenty-year period, no increases could be obtained with additional water.

Table 6 for soybeans shows that for Region 1 (Figure 20) in northern Illinois, an increase of 6 to 8 percent in soybean yields could be achieved with 5.5 inches of supplemental water in six years of an average twenty-year period.

CONCLUSIONS AND RECOMMENDATIONS

1. Historically, soil conservation has been defined and practiced in Illinois and the United States as a means of erosion control on agricultural lands. Soil conservation districts were organized 25 to 30 years ago as a means for the Federal Government, through the Soil Conservation Service, to provide technical assistance to farmers. Much has been accomplished, but much remains to be done.

The increasing demands on our soil and water resources require a broadened concept of soil and water conservation. The present program is largely one of applying soil and water conservation practices to problem areas. These areas are without question the ones of greatest and most immediate need, but the rehabilitation of a damaged area is an after-the-fact approach to conservation. Conservation should be a positive program for management of the soil and water resource, not only to prevent damage, but also to develop the resource fully and wisely.

Illinois is carrying out part of a national soil and water conservation program, which should be accelerated to cover the entire State at the earliest practical date. Only about one-third of the farms in Illinois are planned according to approved farm plans, and not all of those are managed according to the plans.

A. It is recommended that the State urge its representatives in the national government to propose legislation that would accelerate and broaden the national land and water conservation program.

II. The traditional concept that limits soil and water conservation largely to erosion control of farmlands is outdated today in a rapidly urbanizing nation. Certainly, erosion control and drainage of farmland for agricultural production are valid and important means of conserving the land and the water of Illinois and the nation. However, the concept should be broadened to involve the whole community. The people who live in urban areas also have a vital stake in soil and water conservation and should participate in developing a broad land and water management program to conserve and develop these vital resources.

The schism between rural and urban no longer exists. The cities sprawl into the countryside and increasingly encroach on agricultural lands. Certainly, water respects no arbitrary boundaries. Sedimentation from soil erosion can fill a city water supply reservoir, or urban encroachment on agricultural land can change the drainage pattern or usurp the natural flood plain and destroy a well-planned farm management program. The problem of conservation and optimum use of the land and water resource is no longer the comparatively simple one of managing the farmland and draining it properly.

The State, in acquiring storage space for water in Federal reservoirs and in other programs of developing reservoirs for multiple purposes, now has a direct interest in preventing sedimentation.

Land uses are changing rapidly. The largest net change in land use is expected to be in land converted to urban and other non-agricultural uses. These shifts in land use will present one of the major soil conservation problems of the next few decades. Changes in land use should be planned on the basis of sound knowledge of soil characteristics. Landowners will need soil surveys and detailed interpretive information to help them decide where land-use changes would be feasible and profitable.

A. It is recommended that studies be made to determine the kind of soils information most important to urban planning and development, and that steps be taken to secure such information for areas that are not now being mapped.

III. Shifts in land use from agriculture to housing or industrial development must be planned and choices made according to the needs of the entire community.

To carry the logic one step further, land and water management should not be limited by arbitrary political boundaries. At present, soil and water conservation districts in Illinois are organized generally by counties. The proposed river basin planning commissions should provide an excellent mechanism through which districts can cooperate with other local agencies to broaden the planning concept. Through the river basin commissions, districts can participate in planning the development of land and water resources for a logical geographic area. Such planning would include not only soil and water conservation, but also recreation, water supply, flood control, and other purposes.

A. It is recommended that the present soil and water conservation districts, now organized for the entire State, cooperate with other agencies through river basin planning commissions in determining policy and planning. Carrying out specific projects, i.e., the implementation of a farm plan, will remain the responsibility of the individual farmer, with technical assistance from the staff of the conservation district.

B. It is recommended that soil and water conservation districts include representatives of both rural and urban areas on their governing boards and broaden the conservation program to include urban as well as rural areas.

C. It is further recommended that soil and water conservation districts consider the advantages of combining districts into larger administrative units.

IV. The Small Watershed Protection and Flood Prevention Act (P. L. 566) is an excellent means for multi-purpose conservation and development for a watershed on the community-wide basis recommended here. Illinois topography is well suited to projects of this type.

It is imperative that the Public Law 566 Small Watershed Program be more aggressively planned and developed at the local, State, and Federal levels.

A. It is recommended that the State consider ways to accelerate the program by allocating additional funds to supplement Federal and local sources.

V. Analysis of the material presented in this chapter shows the tremendous importance of agricultural drainage to Illinois. While farm drainage is expensive, the benefits of increased yield and higher land values more than equalize the expenditures for such drainage systems in appropriate locations. An individual farmer can usually manage to drain his own immediate property, but he must cooperate with others to form drainage districts in order to finance the construction of extended tile and open ditch waterways and major outlets. Thousands of acres in the State are potentially valuable agricultural land if drained.

Today the trend is toward super-drainage projects of great scale. Many of these projects are too expensive for individual drainage districts. The State Drainage Code places fiscal and legal limitations on the organized drainage districts, preventing many of them from participating in these large-scale drainage projects.

A. It is recommended that the appropriate State agency be authorized and empowered by the General Assembly to represent two or more drainage districts, at the request of those districts, for the purpose of contracting with the State and/or Federal agencies in the development of approved agricultural water management programs and projects.

B. It is recommended that legislation be enacted to dissolve drainage districts which have been inactive for twenty years or more. The circuit court of jurisdiction would initiate proceedings to dissolve the districts and distribute to the district membership the properties of the district, with the exception that its records should pass to the State of Illinois.

ACKNOWLEDGMENTS

Much of this chapter was written by the Division of Soil and Water Conservation, specifically Mr. Leslie W. Heiser and Mr. Ray Lynge. The section on irrigation was prepared by Mr. Stanley A. Changnon of the State Water Survey, with review by the Division of Soil and Water Conservation and an outside panel of experts. The U. S. Soil Conservation Service furnished substantial information, which is gratefully acknowledged.

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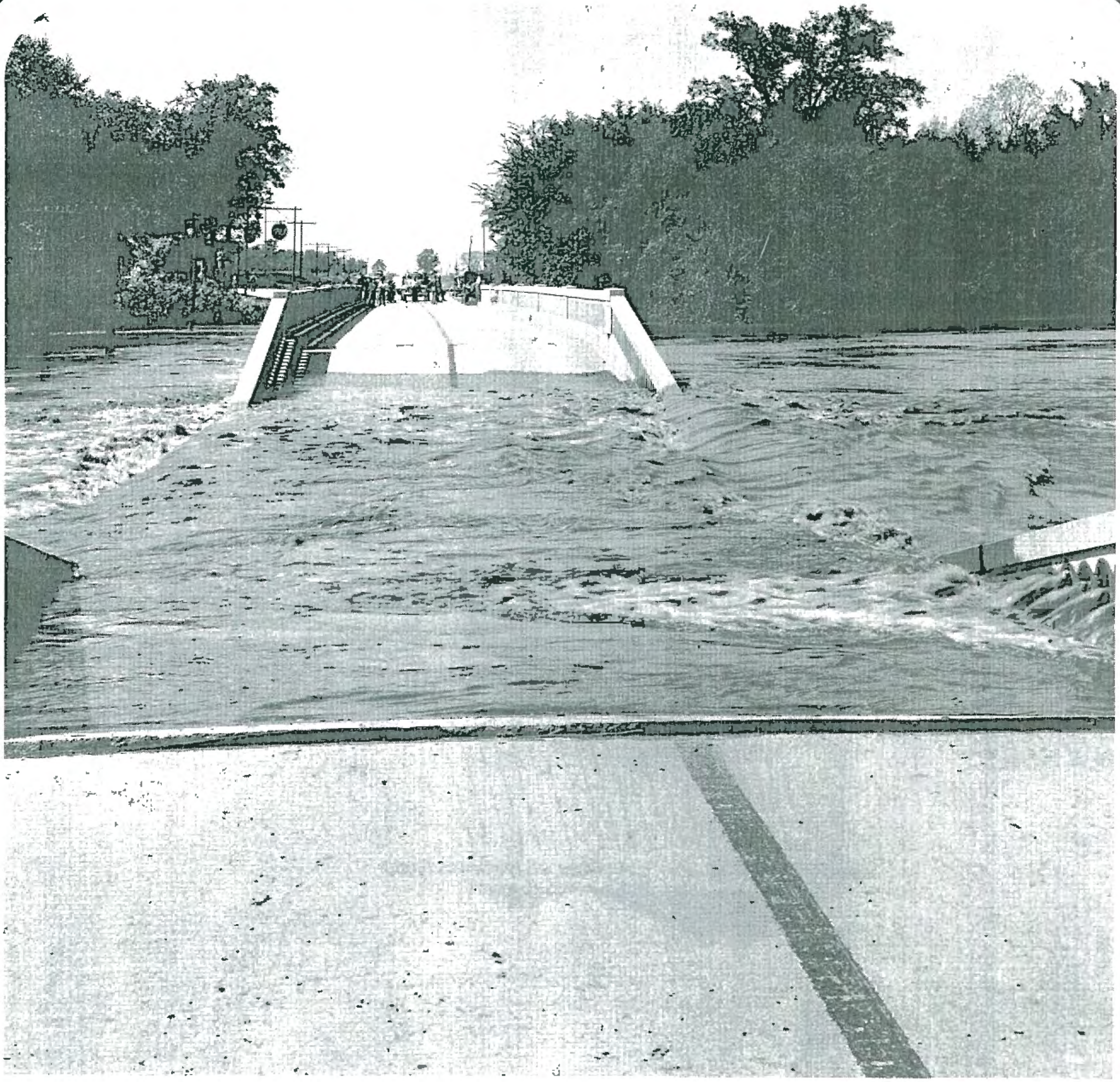
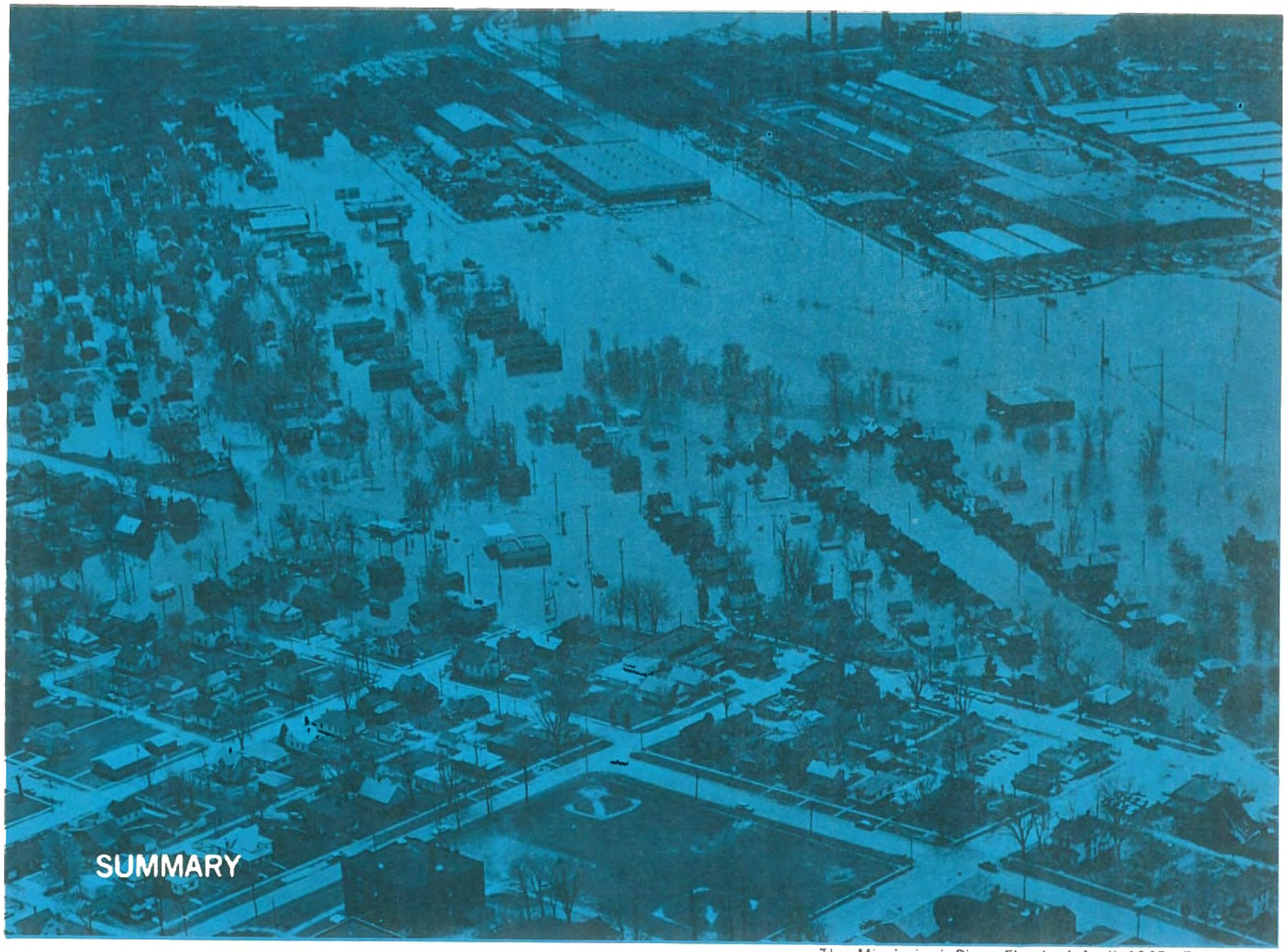


chapter six
floods and flood control

illinois technical advisory committee on water resources

"Detailed studies have documented the fact that flood damages continue to rise year after year even as expenditures for flood control climb."

Committee on Water
National Academy of Sciences



The Mississippi River Flood of April 1965, East Moline.

SUMMARY

Despite the expenditure of more than $125 million in Federal, State, and local funds during the past 30 years, Illinois still suffers approximately $30 million in average annual flood damages. Although Illinois has had a number of widespread and devastating floods on its major streams, the greater part of the annual flood damage is the sum of numerous floods on small streams. Efforts to prevent flood damages have not been completely successful, primarily because of the continued and increasing occupation and use of flood-plain lands as urbanization spreads.

Various methods of flood control are described in this chapter. These include structural measures such as reservoirs, channel improvements, levees, and by-pass channels, used singly or in combination. Regulatory measures—zoning, building codes, or encroachment limits—are also effective means to flood control. Case studies illustrate the solution of flood problems in typical circumstances.

Major floods of record and the works which have been authorized or constructed to reduce future flood losses are discussed by five major regions of the State. The greatest floods of record were those of 1943 on the Illinois River and its tributaries and the Mississippi River flood of 1965.

The solution to the flood problem lies in the development and implementation of a two-pronged attack involving the private citizen and all levels of government: 1) an accelerated program for construction of recommended, authorized, and proposed flood control projects, and 2) the enactment and enforcement of regulatory measures to prevent indiscriminate encroachment of the flood plains in the future. Such a program can only be achieved through the cooperative and coordinated efforts of the local citizen and the legislative and executive branches of government. Flood control projects have been approved for most of the major rivers and streams in the State; the need is for funds to carry them out.

The development of a flood control program for Illinois requires comprehensive river basin planning; effective county, village, town, and city flood-plain zoning based on adequate flood-plain maps; realistic expenditures at local, State, and Federal levels for physical flood control measures; and maximum use and integration of the various local, State, and Federal flood control and water resources programs.

FLOOD DAMAGES

Floods and flooding cause extensive and costly destruction and damages throughout Illinois. Few areas in the State are totally safe from the inundation caused by the overflow or accumulated ponding of excess precipitation runoff.

Not all floods have the dramatic impact and publicity of a major disaster such as the 1965 Mississippi River flood, which created havoc from Minnesota to St. Louis and caused approximately $25 million in urban and agricultural losses in Illinois alone.

Most flooding in Illinois occurs on the smaller rivers and streams with relatively lower damage costs. These smaller floods are not widely reported in news media, and thus are unknown to most of the people of Illinois. The December 1965 flood on Calumet-Union Drainage Ditch, a minor stream in southern Cook County, resulted in damages of $263,723 to 326 homes. The March 1960 flood on the DesPlaines River in Lake County caused damages of $229,000 to some 90 homes. It is the cumulative losses from these much more frequent but less publicized floods that cause the average annual flood damages of $30 million in Illinois. Each year the flood damage losses are financially equivalent to the losses from the 1965 Mississippi River flood.

ENCROACHMENT ON THE FLOOD PLAIN

Considerable effort and millions of dollars have been spent throughout Illinois for the prevention or control of floods. The flood control program has not been entirely successful. Analysis of the damage figures shows that failure to achieve the desired reduction of flood damage cannot be attributed to the inadequacy of the engineering improvements to perform their design function. Rather, the program has failed to achieve its goal primarily because of the increasing encroachment on natural flood-plain lands for human occupancy.

The effect of such encroachment on the flood plain was particularly illustrated in the results of a flood control evaluation program conducted in the Greater Hartford, Connecticut, area. The study pointed out that the ratio of the average annual cost of improvement to the average annual damage was approximately 1 to 4 in the Hartford area prior to enactment in the late 1930s of Federal legislation for national flood control. By 1960 the two figures were approximately equal. Projection of trends and costs indicates that by 1970 the average annual cost of flood protection would be slightly higher than the average annual damage caused by floods. In other words, the development of the flood plains is increasing at a faster rate than the degree of protection from flood control works. Although a comparable study has not been made for an area in Illinois, the continuing high average annual flood damages in the State, despite the expenditure of millions of dollars by private interests and local, State, and Federal governments, shows that a similar problem exists in Illinois.

The shift from an agriculturally oriented society to a highly urbanized and industrialized society has been the principal cause of encroachment on the flood plains. This change in the social and economic structure of the State did not occur overnight. The pattern, evident for more than half a century, parallels the trend for the United States. In general, the population has increasingly concentrated in and around centers of industry and business and has pushed further and further out from the urban core onto agricultural lands.

Flood gate protects Galena during the 1965 Mississippi River flood.

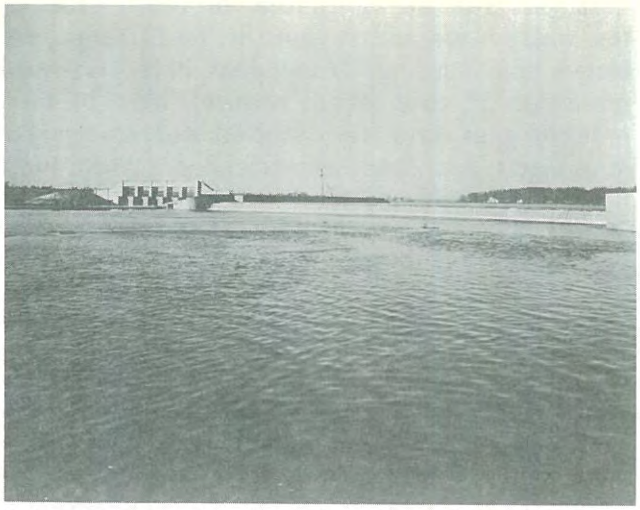
FLOOD CONTROL LAWS

The development and use of flood-plain lands in Illinois began with the first settlers in the State. The problems arising from such use have long been a matter of concern to individual property owners, to the communities affected, and to all levels of government. Prior to 1936, efforts to achieve flood control in Illinois were primarily made by local legal bodies authorized by specific State legislation. During this period, participation in flood control activities on the Federal or State level was, for the most part, limited to disbursement of funds to local interests to help them correct conditions which caused major flood damage or to construct improvements, primarily for navigation.

Following enactment of the Federal Flood Control Act of 1936 and the Illinois Flood Control Act of 1945, Federal and State agencies were authorized to participate actively in the study and planning of flood control improvements and, when properly authorized and funded, to construct such physical improvements. This legislation had several direct benefits, including: 1) the Federal and State flood control agencies, through their broad jurisdictional powers and statutory authority, were able to make comprehensive studies and improvements of entire watersheds or river basins, instead of the limited, localized studies and improvements that were performed under the preceding legislation; 2) through the very nature of the broad studies, it was possible to establish uniform standards, criteria, and safeguards to insure that State funds were devoted to development of adequate protective measures; and 3) the flood control aspect of water resource development could now be properly evaluated and judged in its relationship to other phases of the water resource program, i. e., domestic and industrial water supply requirements, recreational use of water, irrigation, navigation, and low-flow augmentation. Under this concept, flood control is considered as an integral part of overall multi-purpose water resource planning. Thus, it is recognized that flood waters represent a surplus of a valuable commodity which can replenish waters used or lost in other ways.

GOVERNMENT PLANNING

There are three principal governmental agencies actively engaged in flood control planning and construction in Illinois. Each of the agencies follows the multi-purpose concept in water resource planning as it relates to flood control. These agencies are the U. S. Army, Corps of Engineers; the U. S. Department of Agriculture, Soil Conservation Service; and the Illinois Department of Public Works and Buildings, Division of Waterways. The areal division of responsibility for planning and construction by these three agencies is defined in pertinent Federal and State statutes and by tacit agreement in a policy of cooperation through which duplication of effort is avoided and information and data are freely exchanged.



McHenry Dam, owned by the State, regulates the level of the Fox Chain-O-Lakes.

Basically, the Corps of Engineers' efforts have been directed toward control of floods on the larger rivers in the State. The Soil Conservation Service is most concerned with control of floods on smaller streams—those within drainage areas of less than 250,000 acres—with particular emphasis on headwater control works. The Division of Waterways, while exercising jurisdiction over all waters of the State, concentrates most of its efforts on flood control on the intermediate and smaller streams of the State. The principal flood control programs of the Corps of Engineers and the Soil Conservation Service have, until very recently, been directed toward protection of agricultural and small urban areas, while the Illinois Division of Waterways has been more concerned with urban and suburban flood problems in and near the populous centers of the State.

The general pattern of flood control improvements in Illinois has followed the course of population migration and the growth of major centers of economic investment, where floods would cause the greatest loss. Prior to about 1945, flood control activities were concentrated on the protection of agricultural lands and of certain flood-prone urban areas along the major rivers and streams of the State. The protective measures consisted primarily of channel improvements or the construction of levees and flood walls. These protective measures have been improved and augmented over the years and have fulfilled the function for which they were designed. Not all agricultural or urban areas on the major rivers and streams of the State are protected from flooding. Many areas have inadequate protection or none at all; however, most of these problem sites have been studied and construction of projects has been recommended. When funds become available and local cooperation is assured, protective measures will be provided to meet the justifiable needs of the area.

URBAN ENCROACHMENT

As indicated above, it is on the smaller rivers, streams, and tributaries in the State that most flood damages now occur. Particular reference is made to those streams lying within areas of urbanization throughout Illinois. A growing population, an affluent society, and better roads and other transportation facilities have resulted in the great expansion of residential and light industrial development into the countryside and onto the flood plains of the smaller streams of the State. When used for agriculture, these lands were subject to occasional and often frequent periods of inundation ranging in duration from one to several days.

The farmer, with his intimate knowledge of the soil, terrain, and crops, expected and planned for these flood periods. As a result, his farm normally suffered only minor damages. As urban encroachment occurred, with its many kinds of development, the flood that formerly inflicted only minimal damages now created a catastrophe resulting in thousands of dollars in tangible losses and probably millions in intangible losses.

Urban encroachment on the flood plains has not only greatly increased flood damage losses at the site of the encroachment, but also has aggravated flooding conditions on the downstream waterways, so much so that properties and communities which never had been extensively flooded now suffer increasingly severe flood damages. Urbanization restricts both the channel and the flood plain and thus obstructs the natural flow and spread of flood waters and causes increased flood stages upstream. The construction of residential, commercial, and industrial buildings, roads, sidewalks, parking lots, and storm sewer systems takes over areas of pervious soils or natural depressions. The result is a decrease in natural local storage and an increase in runoff from precipitation. Hence, even for a fixed amount of rainfall, the percent and rate of runoff are so increased as to require larger channel capacities downstream than would have been required had the area remained in its natural state.

Problems of this nature are prevalent in Illinois. The only practical approach to their solution lies in the comprehensive watershed study, wherein the applicability of a particular flood control measure, or a combination of several measures, can be used to eliminate the negative influence of an upstream improvement on a downstream problem area. It is only through comprehensive watershed studies that due consideration is given to the use of flood control measures to meet the other needs and uses of water and thereby gain the multi-purpose concept of water resource development. A flood control plan cannot remain static. Because of changes in population and land use, the watershed plan must continually be reviewed and revised to meet changing needs. Changes in technology also dictate continued review of any accepted plan.

FLOOD CONTROL MEASURES

Flood control measures may be considered to be either structural measures or regulatory measures (Figure 1). In Illinois, prevention of flood damages has been accomplished almost exclusively by structural measures. Regulatory measures, long advocated in some quarters, have only recently been recognized as a valuable adjunct to, and in special instances, an alternative solution to structural measures.

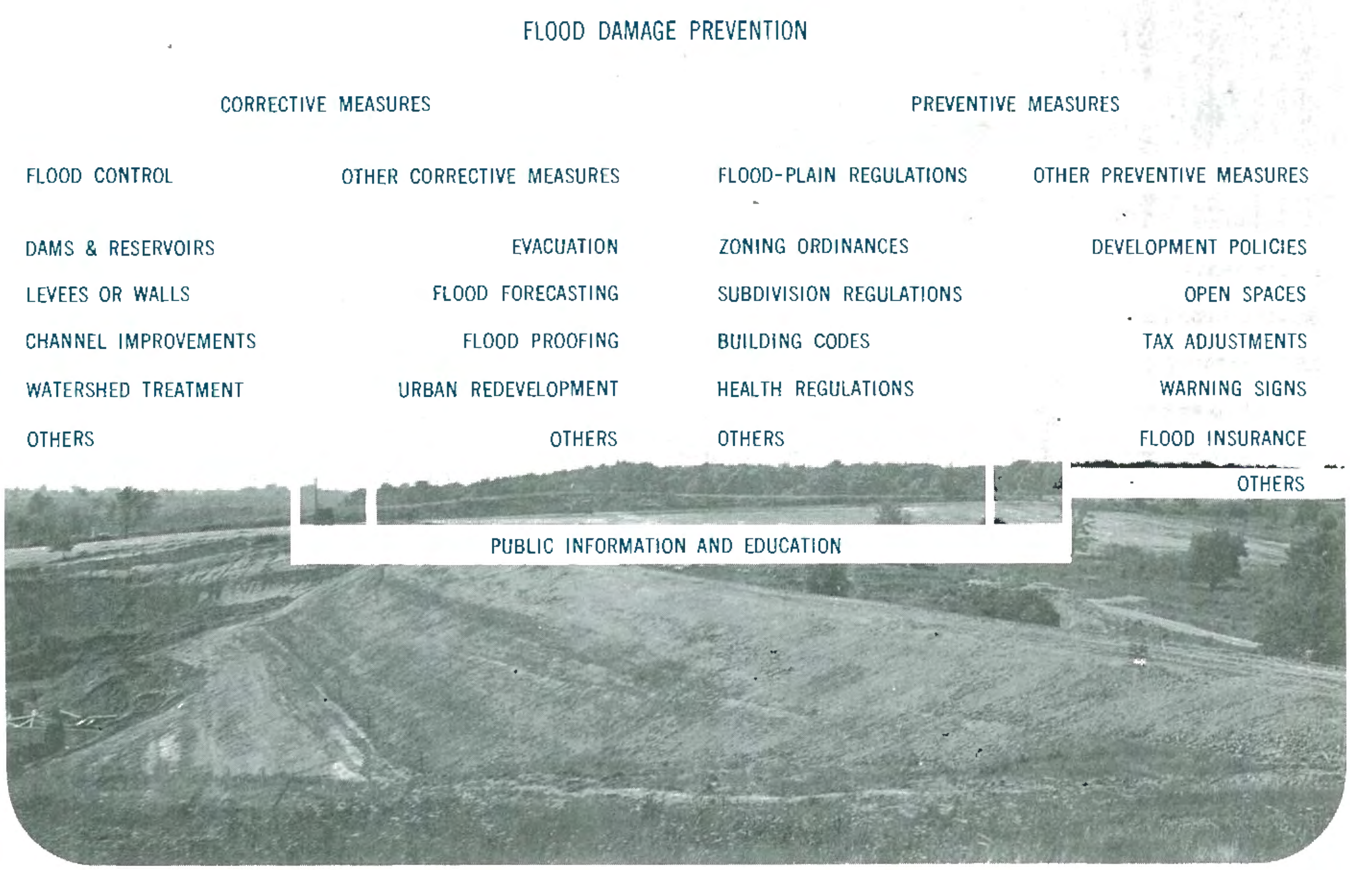
STRUCTURAL MEASURES

Structural measures which reduce flood damage include detention reservoirs, channel improvements, levees or flood walls, diversion or by-pass channels, or combinations of these.

Detention reservoirs are the most prominent and familiar features of a flood control project. The purpose of a detention reservoir is to reduce the quantity of discharge during flood periods by storing the water in an upstream area for controlled release on subsidence of downstream flows. A detention reservoir may be either single- or multi-purpose in design. The single-purpose reservoir is often used for headwater control in agricultural protection. The multi-purpose reservoir is used on larger streams or near centers of population. Operation of either type of reservoir requires that space allocated to flood storage be emptied of water as soon as possible after a flood, in anticipation of the next period of excess flow. Use of a detention reservoir for flood control reduces downstream discharges and water surface elevations and makes other control measures less costly. The multi-purpose reservoir is particularly well adapted to a comprehensive water resource development program. Several benefits may be derived from a relatively small increase in the construction cost of the dam and reservoir. Unfortunately, there are some drawbacks to use of multi-purpose reservoirs which include flood storage. The major problem is that alternate detention and release of flood waters cause great variation in water surface elevation. This fluctuation in elevation is somewhat incompatible with use of the reservoir for recreation or as wildlife habitat, which require a relatively stable pool elevation. Usually this difficulty is overcome by cycling the reservoir pool to provide relatively high, stable elevations during the summer months for recreation and conservation, and lowering the pool during the winter months in anticipation of the spring runoff.

Another difficulty encountered in Illinois which prohibits wide-scale construction of detention reservoirs is the lack of suitable sites. Use of reservoirs is limited to locations where topography and geology are suitable for construction of a dam and where sufficient storage capacity is available in the reservoir valley reach to meet all storage needs. Such reservoir sites are limited in Illinois, particularly in the northeastern metropolitan section, where urban encroachment of the flood plain is rapidly occupying the few remaining sites that should be preserved for reservoirs. A prime example of a multi-purpose reservoir that includes provisions for flood water impoundment, recreation, and low-flow augmentation is the Naperville Reservoir, now under construction on the West Branch of the DuPage River.

Channel improvements have been used extensively in Illinois to reduce flood damage. The purpose of such improvements is to increase the hydraulic capacity of the channel by cleaning, straightening, widening, and deepening it. This increases the velocity and quantity of flow and reduces flood water elevations below damaging levels. Channel improvements are particularly applicable in urban and industrial locations in headwater areas, where land use and costs, or lack of suitable sites, may preclude use of reservoirs or other structural measures. The disadvantage of a channel improvement project is that it disrupts the natural stream regime, with possible adverse effects upstream and downstream. It also destroys some of the esthetic value of a meandering, tree-lined channel. A typical example of a channel improvement designed for flood control is on lower Salt Creek in Cook County.



Alpine Dam on Keith Creek at Rockford which created an impounding reservoir.

Levees or flood walls have also been used extensively in Illinois to reduce flood damage. The purpose of levees or flood walls is to confine flood flows to a restricted channel or floodway between levees and to prevent overflow onto adjacent flood plains. Levees are particularly applicable in agricultural areas where land values are such that it is possible to build floodways between the top of bank and the levee to help retain the flood flow. Flood walls are normally used only in urban and industrial areas where the extent and type of encroachment on the flood plain demands that protection be provided, despite the high cost of flood-wall improvements. The disadvantage of the levee and flood wall is that it offers visible evidence of protection and thereby encourages continued or even increased development of the flood plain. These structures are designed to withstand a flood of a certain frequency or return interval. Levees and flood walls may be designed for the flood of record, regardless of its estimated recurrence interval, or they may be designed for a 10-year, 50-year, or 200-year frequency flood, depending on the value of the area that is to be protected and the cost of providing such protection. Agricultural levees are normally designed to protect against a 10- to 25-year frequency flood, while urban levees or flood walls are designed to protect against a 50-year to maximum probable flood. The layman is normally unaware of the limitations imposed in the determination of the levee or flood wall height and strength. Some of the levees or flood walls may have been constructed years ago. The man who uses the flood plain land so protected places himself in a doubly hazardous position. Examples of agricultural levees may be seen on the Illinois River or Mississippi River. An excellent example of a flood wall is located at Beardstown on the Illinois River.

Diversion or by-pass channels or conduits are used to divert all or part of flood flows away from or around a flood-prone area. This type of improvement is of limited value in Illinois because of land acquisition and construction costs. An example of a diversion conduit is located on Salt Creek in Cook County. The Post Creek cutoff that diverts the upper Cache River into the Ohio River in Pulaski County in southern Illinois is an example of a diversion channel.

Emergency clay levee in East Dubuque, now a permanent levee system.

Starved Rock Seawall under construction.

REGULATORY MEASURES

Regulatory measures help reduce flood damage by preserving the flood-plain lands to accommodate flood waters. This approach requires the enactment or amendment of zoning ordinances, subdivision regulations, building codes, encroachment limits, and other controls on the use and development of property on the flood plain. Under Illinois law, the local community or county has the power to zone, to regulate subdivisions, and to establish building codes. Encroachment limits may be set by either the local or State government. Illinois legislation transferring these powers from the State to the cities and villages and to the counties was merely enabling in intent. The enactment of such controls by local governments is not mandatory. As a result, many areas of the State have not properly exercised these powers. Inclusion of regulatory measures aimed at flood damage reduction in any or all of these local control authorities would serve as an extremely valuable tool in flood prevention.

Zoning ordinances prescribe the manner in which all privately-owned land within the jurisdictional boundaries of the governing body may be used. Zoning is concerned with the use and conditions of use of land and not its ownership. Zoning ordinances and other land use controls generally are adapted to implement and enforce a comprehensive plan for development of a municipality or county. Provisions may be included in these ordinances to delineate lands subject to inundation and to prescribe permitted uses of such lands to reserve the flood-plain lands for passage of flood flows with minimal damages. DuPage County, in 1957, and Lake County, in 1966, enacted flood-plain zoning ordinances that establish flood accommodation zones.

Subdivision regulations set the requirements and design criteria for a new subdivision in accordance with a municipal or county comprehensive plan. Essentially, these regulations establish minimum requirements for lot sizes, streets, utilities, schools, and parks to ensure coordinated land development. These regulations can require that lands subject to flooding be designated for specific, nondamaging uses. A 1965 amendment to the Illinois Recorders Act provides that no plat of a subdivision shall be recorded, if property within the subdivision lies within 500 feet of a surface watercourse draining an area of 640 acres or more, unless the recorder has on file a letter from the Illinois Department of Public Works and Buildings which describes the flood hazard of the area. This review of a subdivision plat does not prohibit sale of land subject to flooding; the State's comment is intended only to inform the subdivider and potential buyers of the land that a flood hazard does or does not exist. Many municipalities and some counties have included provisions in their subdivision regulations establishing controls over flood-prone lands. Unfortunately, some of these provisions are inadequate and in many areas there are no such regulations.

Building codes establish minimum standards for the construction of buildings and other structures for the protection of the health, safety, and general welfare of the public. It is unrealistic to expect that buildings will be absolutely prohibited in areas subject to flooding. Special provisions can be incorporated into building codes regulating construction of buildings in flood-prone areas. These provisions should establish minimum elevations for footings or first floor levels, should prohibit basements, should require reinforcement to withstand water pressure and velocity, and should require particular attention to foundation construction.

Encroachment limits delineate the areas within which no construction should be allowed except upon unusual approval by the regulatory agency. The purpose of such limits is to preserve the flood carrying capacity of the stream channel and its adjacent flood plain. Ideally, such encroachment limits should include a flood way where no construction is permitted and a restricted zone where construction is limited to low-damage use. The State exercises jurisdiction over the stream channels, and State law requires that a permit be secured for any construction of bridges, culverts, or headwalls within the channel banks. Jurisdiction over the adjacent flood-plain lands is a local responsibility and permissible uses of these lands may be established by local ordinance. The DuPage and Lake County zoning ordinances designate flood-plain lands and refer to known past flood heights.

SUPPLEMENTAL MEASURES

Other measures reduce flood damage, but do not require enactment of enabling statutes or ordinances. These include flood forecasting of impending high flows, temporary evacuation of flood-plain lands prior to and during flood flows, warning signs posted on flood-prone properties, and flood-proofing of existing structures. These measures help to lessen damages during flood periods. At present, forecasting of floods on the larger rivers and streams of Illinois is a valuable tool. Several days must elapse between concentrated rainfall and flooding for forecasting to be effective, to allow time for evacuation and emergency flood protection works. Unfortunately, the applicability of flood forecasting is extremely limited on the smaller watersheds of the State, where the time lapse between precipitation runoff and peak flow is quite brief. Refinement in current radar identification of intense precipitation centers, in conjunction with immediate-reading precipitation and streamflow gages, will serve to increase the benefits of the warning technique. Warning signs delineate lands that are subject to inundation, thus insuring that prospective purchasers or builders realize that a flood hazard does exist. This practice is not as widespread as is desirable because of the adverse effect on property values. Flood-proofing is actually a combination of structural improvements that can be undertaken to minimize damages to flood-plain buildings. Such action is most effective in new construction, where provisions can be included in the design plans to insure that the building is waterproofed, that electrical lines and appliances are raised above flood levels or otherwise protected, and that sump pumps are strategically located to handle storm and waste water. Flood-proofing measures may also be used on many existing structures.

COMPREHENSIVE PLANNING

Because of the many specialized flood control measures that may be employed to achieve reduction of flood damages in Illinois, it is essential that any flood control investigation, whether of a 50-square-mile watershed or of a major basin of thousands of square miles, be comprehensive in scope. All aspects of water resource development which are consistent with the objectives of the study and within the economic capability of the project must be considered in the investigation. The very nature of water—a migratory resource that cannot be contained by political boundaries—requires that the final plan reflect the influence of all levels of government—municipal, county, State, and Federal.

Diversion channel on the West Branch of Dry Run Creek in Peoria.

All governments which have jurisdiction relating to the structural or regulatory measures employed must be represented. Further, the investigation should be long-range to anticipate future changes in the area concerned so that programs adopted now do not adversely affect continued development and economic growth of the area.

The accumulation of basic data and the engineering studies and analyses required prior to design of structural flood control measures are identical with the investigations required prior to adoption of regulatory flood accommodation measures. In both instances it is necessary to go beyond the analyses of past problems and floods. The nature of future floods must be predicted in order to accurately delineate and map potential flood hazard sites on the flood plain.

It is at this point that the work of the flood control engineer and the community or regional planner must be coordinated. Criteria must be established to serve as guides to development of a unified, cohesive program of improvement for the community and the watershed and its component sub-areas. The program must be commensurate with the existing and projected flood damage reduction needs and with financial capability. The properly prepared plan for community, county, or region, when implemented by ordinances and regulations, will control land occupancy throughout the area of authority. The plan will materially reduce flood control costs and at the same time improve the entire community.

In Illinois, there has been a notable lack of interest at the local level in enacting regulatory measures to preserve the flood-plain lands to accommodate flood water as a method of flood control. Even in those communities and counties where flood-plain regulations have been enacted, misunderstanding of the purpose of such regulations or lack of proper enforcement has resulted in continued flood problems. One particular instance of ineffective regulation is in a county which prohibits construction of a building foundation less than 3 feet above the established flood crest elevation, but makes no provisions for horizontal protection of the channel or flood plain. Because of the inadequate regulations, property owners have filled the flood plain to the necessary elevation to meet the letter of the law, but have still evaded the intent of the ordinance, which was to preserve the land as a flood way.

Although the preceding discussion has stressed the need for regulatory flood control measures and their application at the local level, it should not be construed that such measures are meant as a substitute for structural flood control measures. In actuality, the structural measures are the backbone of flood control. The regulatory measures supplement the structural measures by preserving stream channels and overbank flood ways for passage of flood flows.

GOVERNMENTAL ORGANIZATIONS IN FLOOD CONTROL

Flood control activity in Illinois begins with the private property owner and individual citizen. It is the individual citizen who bears the brunt of a flood. He bears the cost of floods in direct damages to his home, property, or crops, or in higher taxes for the reconstruction or rehabilitation of public facilities, or in higher costs for private goods and services. Many persons not directly damaged by flood waters are apparently unaware that the high cost of flood damage is a matter of financial concern to every citizen of the State.

The principal tenet of Illinois drainage law is that land may be drained in the general course of natural drainage. All drainage and flood control efforts must be in general accord with this tenet and give suitable recognition to the property rights of others.

Individuals may, either singly or collectively, undertake certain remedial measures to protect their property from flooding. Such action is common in Illinois and normally consists of the construction of single-purpose structural measures—channel improvements, levees, temporary impoundment reservoirs (such as farm ponds), seawalls, bulkheads, or land-fill. In most instances, these private improvements are limited in size and effectiveness by economic considerations and lack of adequate engineering data and design. In many cases such projects do serve to prevent inundation from the more frequent minor floods.

When the problem is too complex or the cost of the remedy too great, the individual property owner has recourse to governmental agencies for help in solving a flood problem. The laws and governmental agencies concerned with water resources are described in detail in Chapter IX.

FLOOD AREAS IN ILLINOIS

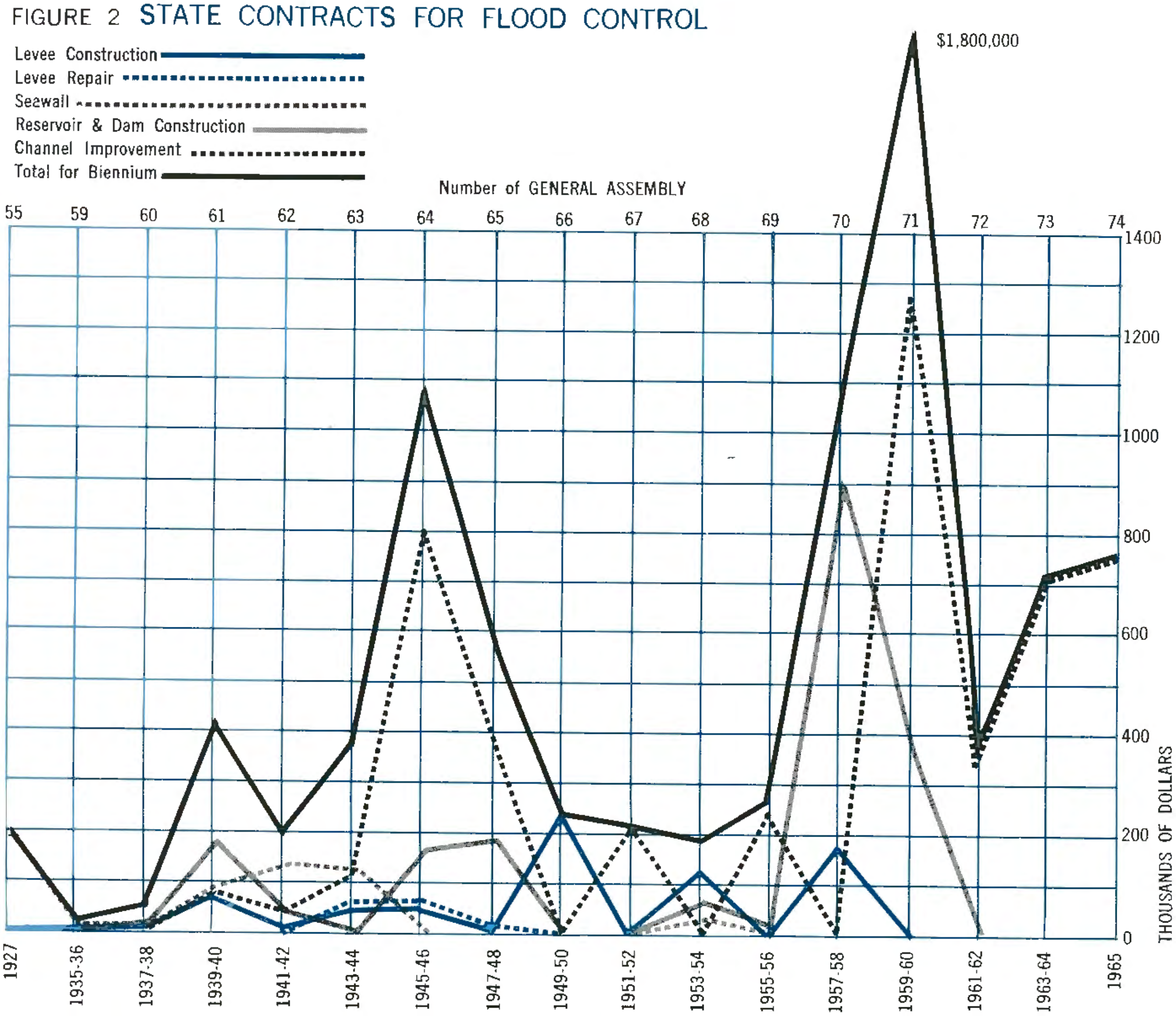
More than 4 million acres of bottom lands in Illinois is subject to flooding, about 11 percent of the land area of the State (Figure 3). This percentage of flood-prone lands is twice the national percentage, which has been determined to be in excess of 5 percent.

Federal and State units of government have prepared, issued, and filed reams of reports, exhibits, construction cost estimates, and recommendations for flood control projects along the major rivers and larger tributaries of the State. In most cases these improvements have not been made because appropriations were not provided, which in turn indicates a definite lack of interest at the local level.

The most important single factor which is lacking in the Illinois flood control program is money. The Division of Waterways has recommended more than $101 million for flood control projects to the General Assembly. During the period from 1936 to 1965, only $7,919,700 had been appropriated (Figure 2). The U. S. Congress in turn has authorized flood control projects of the U. S. Army Corps of Engineers totaling nearly $361 million for Illinois. Only about $86 million was spent for construction. The average annual expenditure from these two sources is a mere $3,140,000, or about one-tenth of the annual flood damage of approximately $30 million.

It can hardly be said that Illinois has an aggressive flood control policy.

FIGURE 2 STATE CONTRACTS FOR FLOOD CONTROL



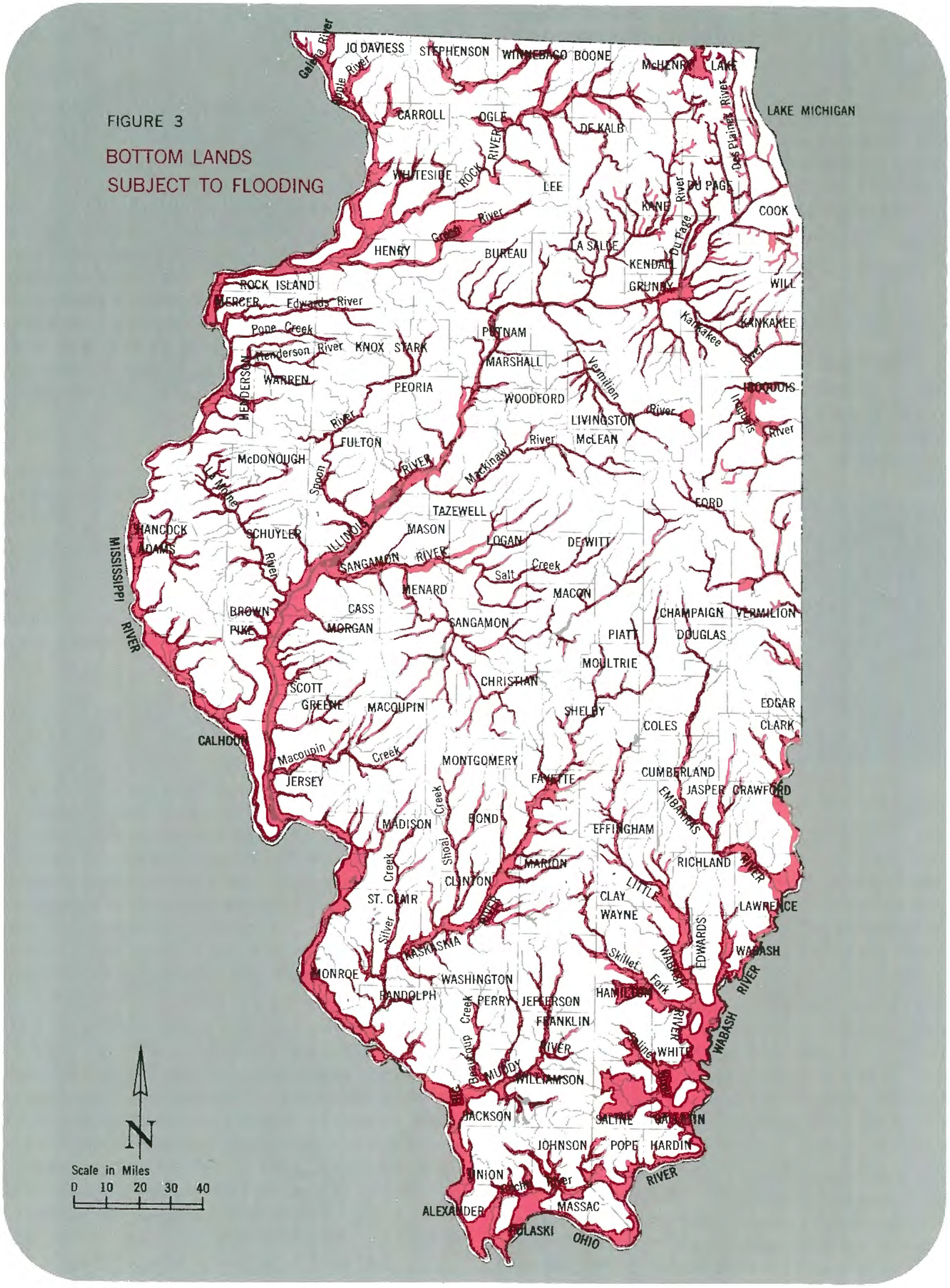


FIGURE 3
BOTTOM LANDS
SUBJECT TO FLOODING
LAKE MICHIGAN
MISSISSIPPI RIVER
OHIO RIVER
WABASH RIVER
ILLINOIS RIVER
Scale in Miles
0 10 20 30 40
N

The flood control agencies do not encounter resistance from committees of the legislatures for planning and authorization, but do encounter apathy from the citizens of the State to see that authorized projects are funded and constructed.

Illinois flood control does not need more repetitive reports. It does need, and on the basis of sound financial judgment it requires, greater appropriations at local, State, and Federal levels to construct flood control and multi-purpose projects compatible with comprehensive watershed development of the water resources.

MAJOR DRAINAGE BASINS

To facilitate the discussion and presentation of flood conditions and problems in Illinois on a regional basis, the State has been divided into five major drainage basins as shown in Figure 4. The basins and major flood year and flood damage are as follows:

Region	Basin	Recent Major Flood Year	Flood Year Damage
I	Upper Mississippi River	1965	$25,000,000
II	Lake Michigan and Upper Illinois River	1954	$ 8,000,000
III	Lower Illinois River	1943	$31,000,000
IV	Lower Mississippi River	1957	$ 8,000,000
V	Ohio and Wabash River	1961	$ 6,500,000

Factors which cause or contribute to flooding—climate, physiography, and land use—are covered exhaustively elsewhere in this report. Thus, they are discussed here only by regions and as they may be pertinent to the particular situation. Individual maps are included in each regional analysis. The maps give the following information:

On the maps entitled Bottom Lands Subject to Flooding, the areas shown to be subject to flooding are those lands that were inundated, or would have been inundated if existing protective measures had proven ineffective at the time of the flood. Flood height elevations used in delineation of these areas came from available historical information and various water agency reports. When the validity of any of the information was in doubt, it was discarded or modified to conform with results from verifiable data. No attempt has been made to ascertain the smaller tributary or headwater areas subject to inundation. The maps and the data derived and analyzed in their preparation are conservative in delineating areas subject to inundation. This is particularly evident when it is realized that most of the flood height values are of fairly recent origin and do not reflect the flood of greater magnitude which will inevitably occur in the future.

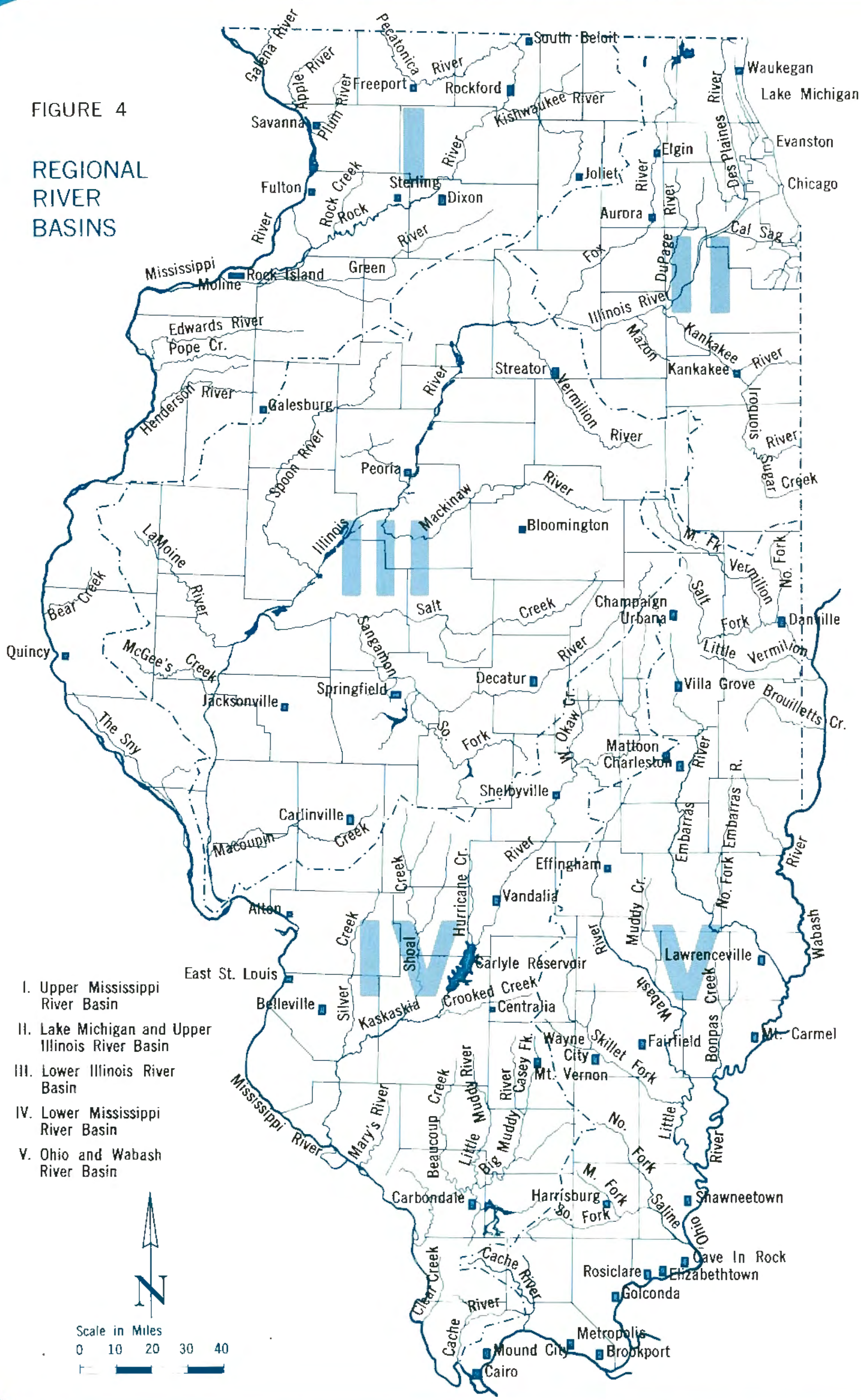
On the maps showing State and Federal Control Projects and the location and current status of Public Law 566 Small Watershed Programs, the projects shown do not include remedial construction or channel cleanout projects undertaken by the other agencies. It was not possible to obtain accurate data to illustrate the local and private effort, and in most cases these works are minor in nature. Data were taken from **Water Resources Development by the U. S. Army, Corps of Engineers, in Illinois,** January 1965; **Progress Report of P. L. 566 Watersheds Projects, State of Illinois,** July 1, 1966; and **Summary of Water Resources Projects in Illinois, Division of Waterways,** 1964-1965.

In addition to the various studies and reports to which reference is made in the regional descriptions, the State has also participated in Comprehensive River Basin Studies for the upper Mississippi and Ohio River Basins. These basins cover the entire State, with the exception of a small fringe area along the Illinois shoreline of Lake Michigan, which will be investigated later as part of the Great Lakes-St. Lawrence Basin.

These comprehensive basin studies are being conducted under the general leadership of the U. S. Army, Corps of Engineers, as authorized by the Congress. The Corps is making the studies in cooperation with the State and Federal agencies concerned with water and its related resources. The basic objective of the basin studies is to formulate a plan which will be the framework and guide for future planning for the optimum use, or combination of uses, of water and related land resources to meet foreseeable short and long term needs. States represented on the Upper Mississippi River Coordinating Committee for the study are Illinois, Indiana, Iowa, Minnesota, Missouri, South Dakota, and Wisconsin. States represented on the Ohio River Coordinating Committee are Illinois, Indiana, Kentucky, Maryland, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. Federal agencies represented on both committees include the Department of the Army; Department of Agriculture; Department of Health, Education, and Welfare; Department of the Interior; Department of Commerce; and the Federal Power Commission. Target date for completion of most of these studies is 1970. The Ohio River study report is due in early 1967. Following are the regional analyses:

FIGURE 4

REGIONAL RIVER BASINS



REGION I — THE UPPER MISSISSIPPI RIVER BASIN

The upper Mississippi River Basin lies in northwestern Illinois, between the mouth of the Illinois River and the Illinois-Wisconsin state line, and covers approximately 10,105 square miles, or about 17.4 percent of the total area of the State. Figure 5 shows the location of the Basin, its configuration, counties, and major towns and villages. The economy of the region is agricultural, except for the urban-industrial centers of Rockford and the Quad Cities. A few other communities have light industries.

The topography generally consists of a rolling upland prairie, steep bluffs, and flood plains of varying width along the major streams and tributaries. The major exceptions to this pattern are the generally rugged hills and narrow valleys found at the extreme north and south ends of the Basin in Jo Daviess and Calhoun Counties, and the Green River lowland area, which is relatively flat and has poor natural drainage.

The drainage system throughout the Basin is well developed, with the exception of the Green River lowlands which are largely drained by artificial ditches. Levees and artificial drainage are also employed in the flood-plain areas along the Mississippi River.

FLOOD HISTORY

Major floods on the Mississippi, Rock, and Pecatonica Rivers usually occur after prolonged periods of general rainfall or sudden winter or spring thaws with resultant snow-melt runoff from the large tributary areas. Floods normally occur during the spring and are often severely aggravated by ice jams, although serious flooding has occurred in other seasons of the year. Floods on minor streams in the Basin generally result from intense thunderstorms of short duration and limited areal extent. Table 1 gives flood data based on the records of some of the stream gaging stations in the Basin. Figure 5 delineates the bottom lands subject to flooding on the main stem and larger tributaries for the indicated flood events. Approximately 722,800 acres, about 11.2 percent of the Basin area, is subject to such flooding. More than 400,000 acres of this land has been provided, or is proposed to be provided, varying degrees of protection by completed or authorized Federal and State projects. The remaining 322,800 acres is protected by local improvements, is farmed on a marginal basis, or is used as pasture or timber lands.

Historical evidence and gaging records indicate that, during the past 150 years, a notable flood has occurred at least once every decade on the main stem of the Mississippi River. Since the spring flood of 1965 exceeded all past floods in this region, it is described as an illustration of cause and effect of main-river flooding in the Basin.

Flood of April 1965

The flood of April-May 1965 followed an unusually severe winter in the upper Mississippi River watershed of Minnesota, Wisconsin, and northern Iowa, accompanied by an adverse sequence of meteorological events.

Heavy accumulation of snow cover on the ground in the upper watershed had prompted early forecasts of possible spring floods on the Mississippi River. Conditions throughout the area were aggravated in late March, when a snow storm blanketed the entire watershed with more snow 6 to 12 inches deep. Snow cover at Duluth, Minnesota, increased from a depth of 32 inches to 42 inches during this period.

TABLE 1 REGION I — UPPER MISSISSIPPI RIVER BASIN

Flood Data For Selected Gaging Stations Stream and Station	Drainage Area (Sq Mi)	Years of Record	Gage Zero (Ft msl)*	Date	Maximum Gage Height (1) (Feet)	Discharge (cfs)	Duration Days out of Bank	Return Period (Years)
1. Apple River near Hanover	224	33	591.00**	1/5/46	26.12	12,000	3	17
2. Plum River below Carroll Creek near Savanna	231	25	580.00	1/6/46	28.74	11,600	3	25
3. Mississippi River at Clinton, Iowa	85,600	92	566.29	4/28/65	24.85	307,000	32	100+
4. Pecatonica River at Freeport	1,330	51	743.18	3/16/29	23.96	18,400	6	45
5. Kishwaukee River at Belvidere	525	26	738.34	1/24/38	16.9	ice jam	unknown	—
6. Rock River at Como	8,700	51	606.83	2/7/38	17.51	ice jam	17	—
7. Green River near Geneseo	958	29	580.66	2/20/51	16.14	ice jam	5	—
8. Edwards River near New Boston	434	31	529.92**	10/13/54	21.46	7,020	5	11
9. Henderson Creek near Oquawka	428	31	541.67**	4/25/50	28.17	16,500	4	65
10. Mississippi River at Keokuk, Iowa	119,000	88	477.83	5/1/65	22.14	327,000	36	100+
11. Bay Creek at Nebo	162	26	462.56	8/16/46	19.31	23,500	2	16

* Adjustment 1929 unless noted otherwise. ** Adjustment 1912.

(1) To obtain water surface elevation, add gage height to gage zero

REGION I — UPPER MISSISSIPPI RIVER BASIN

FIGURE 5 BOTTOM LANDS SUBJECT TO FLOODING

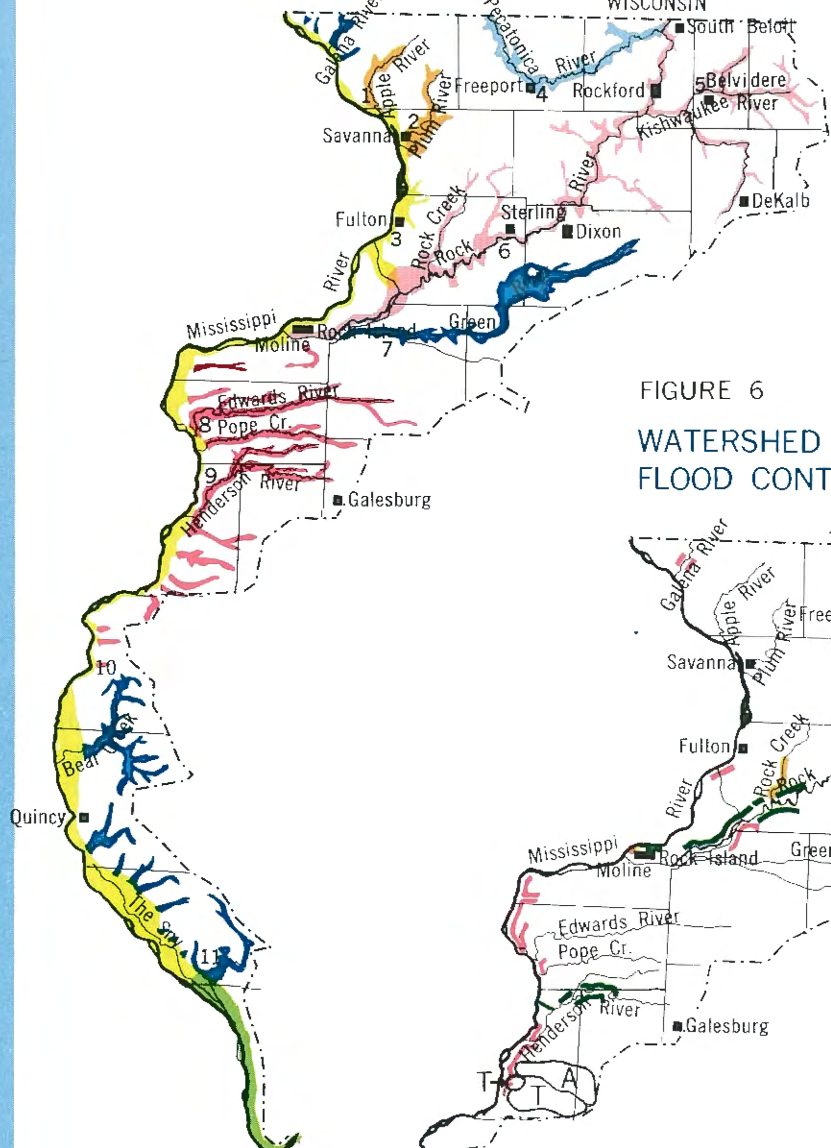
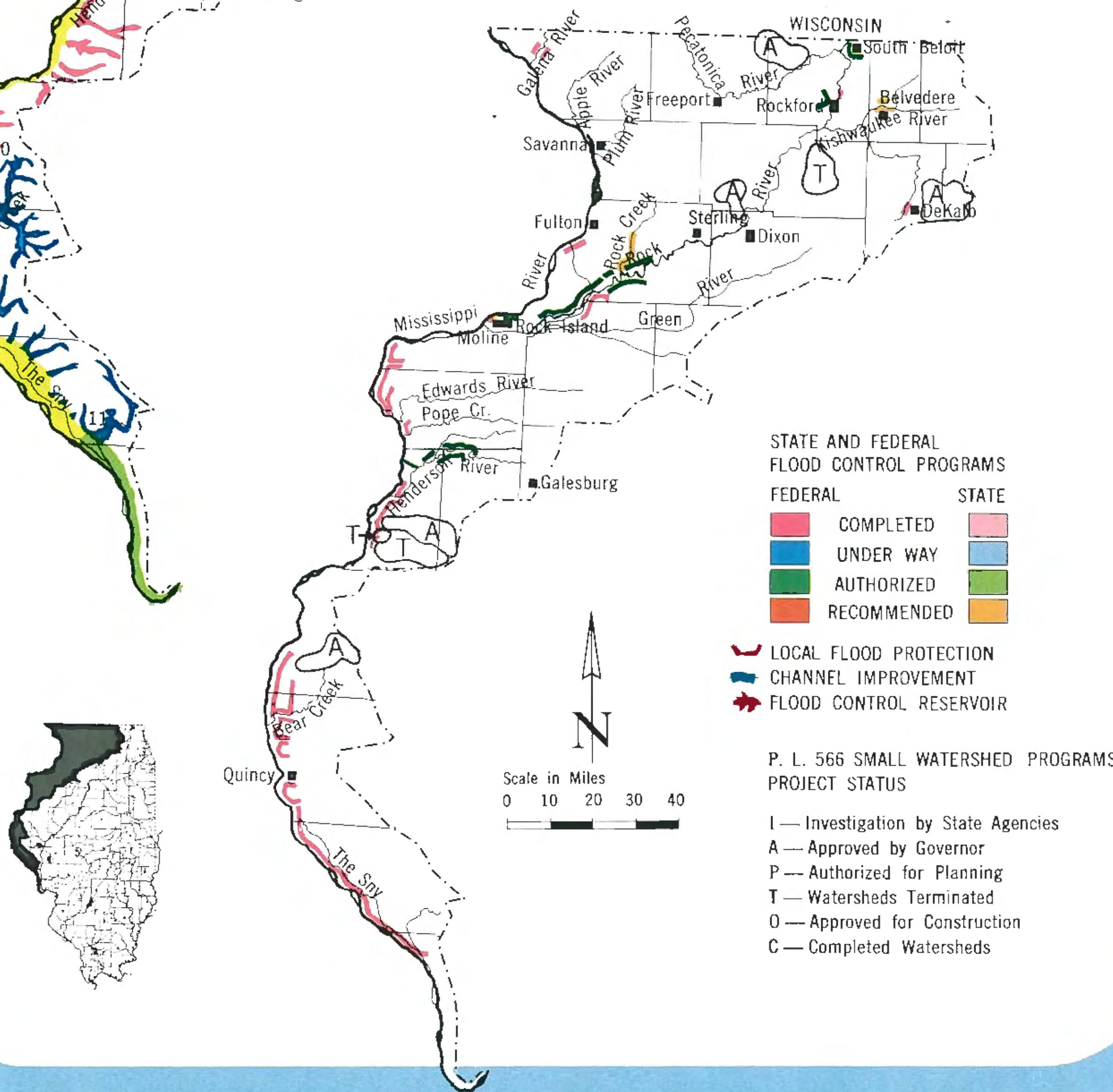


FIGURE 6

WATERSHED LOCATION AND STATUS FLOOD CONTROL PROJECTS



On April 1 the U. S. Weather Bureau issued a forecast estimating that the water content of the snow on the ground was equivalent to as much as 8 inches in depth. Early in April a warming trend set in, accompanied by widespread precipitation and thunderstorms over the area. The combination of rainfall and snow melt on the still frozen ground surface resulted in almost total runoff into the ice-laden channels of the Mississippi and its tributaries. The sudden surge of runoff waters, continuing rainfall, and tornadic storms over the watershed combined to create record-breaking flood crests on the Mississippi River, exceeding previous high flood stages from Minneapolis-St. Paul downstream to near Louisiana, Missouri.

In Illinois and Iowa, the heaviest rainstorms were recorded from April 4 to 6 and April 24 to 25. In the storm of April 4 to 6, 1 to 2 inches of rain fell across eastern Iowa, eastern Missouri, and most of Illinois. In the storm of April 24 to 25, more than 1 inch fell over most of Iowa, southern Wisconsin, and the northern three-fourths of Illinois. More than 5 inches was recorded in one region in southeastern Iowa. This storm occurred in conjunction with a stationary front located across northern Missouri and southern Illinois. The heaviest rain, a frontal wave developed on the air mass, moved up the Mississippi valley on April 25.

The snow-melt flood crest reached East Dubuque on April 26, Rock Island on April 28, Gulfport on April 30, Quincy on May 1, and Grafton on May 6. The flood crest was extremely flat with near crest conditions for 48 hours before and 48 hours after actual crest. The rainfall floods from the Des Moines and Iowa Rivers were in the Mississippi ahead of the snow-melt flood. Thus, the Mississippi was near crest for a week ahead of the snow-melt crest, which was only slightly higher. In the Quincy area, because of levee failures, the highest stage occurred before arrival of the snow-melt crest.

Early warning of a potentially dangerous flood situation allowed many cities to mobilize their forces and initiate construction and protective works even before the snow-melt in the upper Basin had begun. This early preparation allowed time for the great effort necessitated by the magnitude of the flood as it developed. Public bodies, private corporations, and thousands of volunteer students and individuals worked together in a heroic effort. Most of the urban centers and a number of the agricultural districts were spared tremendous flood damages.

Levees failed in six districts and parts of two other districts were inundated, flooding more than 47,000 acres of land. In the Quad-Cities area on the Illinois side of the River, at least a dozen major industries were flooded and more than 2000 families were evacuated. Sewerage plants and water treatment works were threatened and in a few cases inundated. Highway bridges over the Mississippi River at Burlington, Muscatine, the Quad Cities, Fulton, Savanna, and East Dubuque were closed. Illinois 84 and U. S. 34 were badly damaged.

Total damage from the flood in Illinois, both private and public, is estimated to have been in excess of $25 million.

State and Federal Flood Control Projects

Figure 6 shows the location, type, and current status of flood control measures employed in the upper Mississippi River Basin by State and Federal flood control agencies. Approximately $25 million in Federal, State, and local funds has been spent to construct, maintain, and repair these structures. Although exact figures are not available, it is estimated that at least as much money has been spent by private levee or drainage districts in the Basin.

The Corps of Engineers has various types of flood control projects throughout the Basin that are either under construction or pending construction, awaiting commitment of the local sponsor's contribution and the allocation of funds by Congress. The cost of these projects shown in Figure 6 as completed or underway is estimated at more than $43 million in Federal and non-Federal funds. In addition to the active projects, others are authorized but not funded and are in various stages of investigation. These would require the expenditure of more than $23 million. The total cost of projects in the upper Mississippi River Basin which are funded and authorized by the Corps of Engineers is approximately $66 million.

As of July 1, 1966, there were eight P. L. 566 watershed projects in the Basin. Three of these projects have been terminated as unfeasible or for lack of local interest and sponsorship. For the other five watersheds presently under investigation, Federal and local cost sharing data are not available.

The Illinois Division of Waterways has conducted flood control studies at Freeport, Rockford, Belvidere, and along Rock Creek. In addition, the State has used funds appropriated by the General Assembly to construct flood control improvements at Rock Island, Quincy, and Rockford. The cost of these projects is included with the Federal and local expenditures discussed above.

Existing Flood Problem Areas

Virtually all of the agricultural or urban areas on the larger streams in the Mississippi Basin that suffer major flood damages have been programmed for improvement or study. The only areas in the Basin which do not now have flood control projects under consideration are those where local urban floods result from flash flows and those which have upper watershed drainage and flood problems. Studies of these problems may be initiated by the Federal, State, or local agency following receipt of a request for such action from a responsible local sponsor. In general, where there is indication of local interest, the studies are complete or underway.

Potential Flood Problem Areas

Expansion of the majority of the urban centers along the Mississippi River and Rock River can be expected. Effective city and county zoning will be required, along with a realistic expansion of storm drainage systems to prevent what is now minor flooding from becoming major floods. This will be true even though it is assumed that adequate protection will be provided against major floods from the Mississippi River and the Rock River.

Industrial development of the Mississippi River flood plain can be expected at East Dubuque, especially upon completion of improvements of U. S. 20 to Rockford. Although some protection from the Mississippi River floods can be provided by effective zoning laws, comprehensive development of adequate interior and hillside drainage facilities will also be required.

Expansion of the Cattail Levee System to include the communities of East Clinton and Fulton would likely make them more attractive for industrial development. Industrial expansion and subsequent development of housing in the flood plain would require expansion of interior drainage works and improvement of the levee system to prevent inundation.

Continued expansion of the metropolitan areas of the Quad Cities and Rockford will bring heavy pressure for the development of the flood plains of not only the larger streams, but also of the many small creeks. Only effective zoning laws and an aggressive expansion of urban drainage systems can prevent a spiraling flood damage situation—and this assumes that projects now recommended or authorized are actually built. Conversion of South Quincy Drainage and Levee District into an industrial park can be expected, which will make it necessary to upgrade that district to a level to preclude inundation. The Quincy metropolitan area will also require effective zoning and realistic expansion of urban drainage systems.

Student volunteers build an emergency sandbag levee during the 1965 Mississippi River flood.

REGION II — LAKE MICHIGAN AND UPPER ILLINOIS RIVER BASIN

The Lake Michigan and upper Illinois River Basin in northeastern Illinois upstream of the junction of the Illinois and Fox Rivers at Ottawa covers approximately 8391 square miles, including Lake Michigan, or about 14.5 percent of the total area of the State. Figure 7 shows the location of the Basin, its configuration, counties, and some of the larger towns and villages.

Geographically, hydrologically, and hydraulically, this region is a river basin because all flows emanating from, or tributary to, the region have a common discharge point in the Illinois River at Ottawa. The only exception to this is the very minor drainage which flows directly to Lake Michigan. In most cases these tributaries do not present a flood problem and are considered as an adjunct to the greater region.

The terrain, drainage conditions, land use, and economic development make it desirable to consider the Basin as two separate, but physically related, watersheds as described below. This distinction will not be recognized when the subject matter is common to both subregions.

Subregion A. This area is designated as the Northeastern Illinois Metropolitan Area and is comprised of Cook, DuPage, Kane, Lake, McHenry, and Will Counties (Figure 7). The region is predominantly urban. Major land use is for residential, commercial, industrial, and transportation purposes. The extremely flat topography of most of Cook County gradually merges into a belt of morainal ridges interspersed with broad, shallow valleys with large areas of swamps and lakes. The latter description applies to DuPage, Lake, McHenry, and parts of Kane and Will Counties. The natural drainage system through most of the area is relatively poor with flat channel gradients and low banks. The flow of two streams—the Chicago and Calumet Rivers, which formerly discharged into the Great Lakes-St. Lawrence River Basin—has been reversed by canalization. The only Illinois streams now discharging into Lake Michigan are a few small, intermittent tributaries along the Lakefront north of Wilmette. There is also some drainage into the Lake from the Calumet River below O'Brien Lock near 130th Street.

Subregion B. This area includes the remainder of the Basin—the perimeter counties surrounding the Chicago Metropolitan Area on the west and south. The major streams are the outlet channels for all drainage from the entire Basin. This subregion has been designated as the Outlet Area. The economy of this area is agricultural, except in a few urban centers and along the Illinois River, where industry is locating to take advantage of the bountiful water supply and river transport facilities. The topography ranges from rolling upland plains in the west to almost level prairies in Iroquois County. The drainage system is entrenched in the glacial plains, and the major streams have good gradients in incised valley sections. Extensive artificial ditching and tiling have been required in the prairies of Grundy, Iroquois, and southern Kankakee Counties. There are few bottom-land levees because of the relatively narrow valley sections in the area.

Flood History

Major floods on the Fox, DesPlaines, Kankakee, and Illinois Rivers usually are caused by prolonged periods of general rainfall or sudden winter and spring thaws, with resultant snow-melt runoff from upper watershed areas accompanied by ice floes. Flooding on the tributary streams may result from either protracted general rainfall or from intense thunderstorms of short duration and limited areal extent. Essentially, it is the protracted general rainstorm that results in the most severe flood damages to both urban and agricultural lands of the region. Table 2 presents flood data from some of the important stream gaging stations in the Basin.

TABLE 2 REGION II — LAKE MICHIGAN AND UPPER ILLINOIS RIVER BASIN

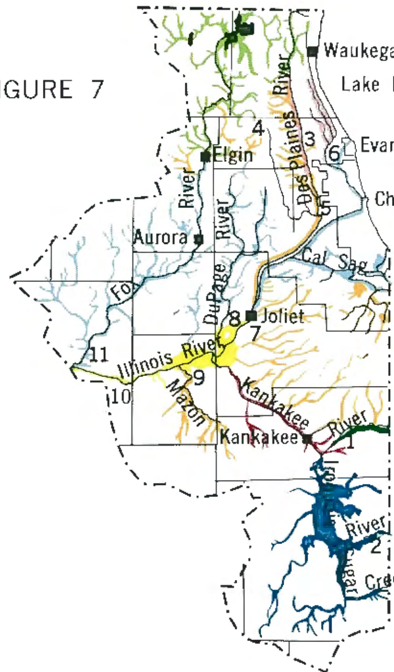
Flood Data For Selected Gaging Stations Stream and Station	Drainage Area (Sq Mi)	Years of Record	Gage Zero (Ft msl)*	Date	Maximum Gage Height (1) (Feet)	Discharge (cfs)	Duration Days out of Bank	Return Period (Years)
1. Kankakee River at Momence	2,340	49	610.18	1/25/30	8.09	ice jam	13	—
2. Iroquois River at Iroquois	682	20	614.34	6/13/58	26.31	10,400	14	40
3. Weller Creek at DesPlaines	13.1	14	635.02	7/13/57	12.37	668	2	9
4. Salt Creek near Arlington Heights	32.5	14	681.32	3/30/60	9.37*	721	6	8
5. DesPlaines River at Riverside	635	21	594.68	1/25/60	8.89	ice jam	14	—
6. North Branch Chicago River at Niles	102	14	601.99	7/13/57	9.28	1,850	2	8
7. Hickory Creek at Joliet	107	20	527.00	7/3/57	12.77	15,200	2	50
8. DuPage River at Troy	325	24	564.62	10/11/54	11.06	12,000	7	35
9. Mazon River near Coal City	470	25	527.41	7/15/58	19.70	17,600	3	14
10. Illinois River at Marseilles	7,640	45	462.91	1/21/16	25.4	ice jam	unknown	—
11. Fox River at Dayton	3,570	49	462.30	1/25/60	36.47	ice jam	14	—

* Adjustment 1929 unless noted otherwise.

(1) To obtain water surface elevation, add gage height to gage zero.

BOTTOM LANDS SUBJECT TO FLOODING

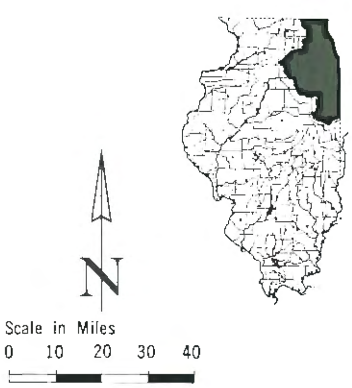
FIGURE 7



FOR FLOODS OF RECORD ON INDIVIDUAL STREAMS

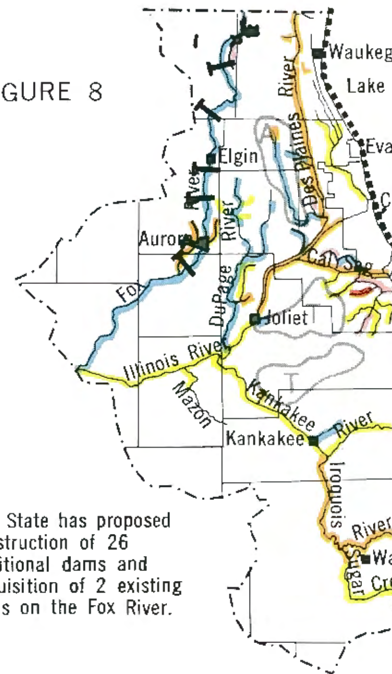
- 1831
- 1883
- 1913
- 1924
- 1930
- 1938
- 1954
- 1957
- 1960

NUMBERS REFER TO STREAM GAGING STATIONS IN TABLE 2



WATERSHED LOCATION AND STATUS FLOOD CONTROL PROJECTS

FIGURE 8



The State has proposed construction of 26 additional dams and acquisition of 2 existing dams on the Fox River.

STATE AND FEDERAL FLOOD CONTROL PROGRAMS

PROJECT STATUS

FEDERAL		STATE
	COMPLETED	
	UNDERWAY	
	AUTHORIZED	
	RECOMMENDED	
	UNDER STUDY	

PROJECT DESIGNATION

- LOCAL FLOOD PROTECTION
- CHANNEL IMPROVEMENT
- FLOOD CONTROL RESERVOIR
- STATE OWNED DAM
- STATE AND FEDERAL LAKE SHORE PROTECTION (Existing and Proposed)

P. L. 566 SMALL WATERSHED PROGRAMS PROJECT STATUS

I — Investigation by State Agencies
A — Approved by Governor
P — Authorized for Planning
T — Watersheds Terminated
O — Approved for Construction
C — Completed Watersheds

Figure 7 delineates the bottom lands on the rivers and streams in the total basin which are subject to flooding. Approximately 380,530 acres, or about 8.7 percent of the Basin area, has bottom-land flooding.

Flood of October 1954

The flood of October 1954 was one of the largest ever to occur in the Lake Michigan and upper Illinois Basin and graphically illustrates the complex flood problem of the greater Chicago area. An extensive storm frontal system with two cyclonic wave formations passed through the northeastern part of Illinois on October 9 and 10, 1954. It was accompanied by heavy rain and thunderstorms. The heavy rains associated with the first cyclonic wave began the evening of October 9 and ceased during the forenoon next day. On the afternoon and evening of October 10, squall line activity in advance of the second cyclonic wave produced further heavy rains over the same area. These rains produced 6.7 inches, the greatest recorded amount of precipitation for a 48-hour period in the 69 years of Chicago Weather Bureau records.

Runoff from the historic rainfall produced severe flooding of all streams in the Chicago Metropolitan Area, exceeding all known recorded and historical floods. At Chicago, the Chicago River was diverted into Lake Michigan for the first time since the control works near Lockport were built in 1900. Flood water from the South Branch of the Chicago River and the Chicago Sanitary and Ship Canal put the two largest electric generating plants of the Commonwealth Edison Company out of operation. Loss of the 350,000 kilowatt output of these plants forced shutdown of factories and caused a 50 percent reduction in available electrical energy over a widespread area, including the downtown Loop area.

In Cook County alone there were 57 underpasses filled with water and 67 other highways were closed to traffic. Outside of Cook County, many major highways and secondary roads were impassable. Midlothian was surrounded with water, temporarily isolating 4400 families. Harvey, including the business district, was partially inundated. The steel plants and oil refineries in Blue Island were damaged. The Steel and Wire Plant in Joliet was shut down for two days by flood waters from Hickory Creek. Newspapers reported 5600 basements flooded in LaGrange and Western Springs, and the towns of Lisle, Warrenville, and Plainfield along the DuPage River were damaged extensively by the flood.

Total damages attributed to the October 1954 flood exceeded $8 million, of which approximately $1 million was agricultural loss.

State and Federal Flood Control Projects

Figure 8 shows the location, extent, and status of flood control measures employed in the Lake Michigan and upper Illinois River Basin by State and Federal flood control agencies.

The Corps of Engineers report does not indicate that the Corps has constructed any flood control projects in the Basin. Actually, most of the extensive navigation projects built by the Corps in the region do have inherent flood control benefits. These channel improvements are particularly valuable in the flat terrain of Subregion A. The Corps has several flood control study projects that are in progress or are programmed for initiation upon allocation of funds. Some of the streams programmed for study are the Fox River, the Kankakee River, the Little Calumet River, the DesPlaines River at North Libertyville, and the Calumet Union Drainage System. These studies are in addition to the Flood Plain Information Studies, which the Corps has completed for the DesPlaines and Little Calumet Rivers and has in progress for the North Branch of the Chicago River.

There are three P. L. 566 Watershed Projects in the Basin, as of July 1, 1966, all in Subregion A. The Salt Creek study, including portions of Cook and DuPage Counties, has been studied and a project report completed. The others have been suspended.

The Division of Waterways has completed numerous studies and investigations of the flood and drainage problems in many parts of the Basin. Studies have been completed and reports published of the flood control needs on the Fox, DuPage, DesPlaines, and Iroquois Rivers, and on the Salt, Silver, Hickory, Weller, Willow-Higgins, Addison, Flag, St. Joseph, Thorn, Indian, and Soldier Creeks, and on Lucas Ditch. In addition, studies are in various stages on the North Branch of the Chicago River and the Kankakee River, and on Kress, Spring, Lilly Cache, Blackberry, and Stony Creeks.

When they have been authorized and funded by the General Assembly, the State has constructed several flood control improvement projects. The State has completed, or has in progress, flood control projects involving the expenditure of more than $10 million for improvements on many of the streams in the Basin.

No effort has been made to determine the amounts spent on flood control improvements within the Basin by individuals or by local governmental units. The complexity of the works involved and the multiplicity of agencies performing such works prevent a reasonable tabulation of expenditures to date.

Existing Flood Problem Areas

To most adequately describe the existing flood problems in this basin, it is necessary to comment on the two subregions individually.

Subregion A — Northeastern Illinois Metropolitan Area

Many studies, investigations, and reports have been made of the flood problems in this area. In general, these reports conclude that flood problems result from 1) inadequacy of the natural stream channels to retain or discharge the runoff resulting from intensive or prolonged precipitation and, 2) the works of man that increase the rate and quantity of runoff to the stream channels and, at the same time, reduce the capacity of these streams to carry the runoff. This has been caused by continued encroachment and construction on the channel beds and flood ways.

Most of the flood damage or flood hazard sites in the Metropolitan Area have been identified and solutions have been proposed. Basically, the projects include a program of clearing, cleaning, widening, and deepening of the channel to improve its capacity for carrying flood flows and improving outfall conditions for the numerous tributary storm sewers. The major storm sewers are frequently surcharged in flood periods; the result is basement and street flooding some distance from the obstructed outlet.

In most instances, the suggested solution to flooding also proposes construction of detention reservoirs for temporary storage of flood waters. Unfortunately, topographic and geologic considerations limit the number of suitable sites in this area. Many of the sites have been lost to urban development, and the land is so costly that channel improvement is the most economical method of flood control. The desirability of detention reservoirs in the flood control program cannot be over emphasized. Where adequate sites are available, the detention reservoir is an extremely valuable method of flood control. It reduces channel or levee requirements downstream and brings highly significant benefits by including a permanent conservation pool or low-flow augmentation storage. Strenuous efforts should be expended to preserve all remaining sites for future development.

In addition to the conventional methods of flood control by storage and channel improvement, several unconventional methods have also been proposed and are under study. One such proposal is that flood flows be used to recharge ground-water reservoirs. This procedure can have only limited ap-

The flood of October 1954 on Stony Creek inundated a residential area of Alsip in southern Cook County.

plicability in a river basin, because it would require construction of surface detention reservoirs to hold the water for special treatment before it could be pumped or drained into the aquifer. Purification of flood waters is necessary to maintain porosity of the aquifer and to prevent pollution of the ground water.

A second flood control method now under consideration proposes the construction of leveed detention reservoirs on the flood plain adjacent to the stream channel. This type of detention reservoir must have high capacity pumps capable of moving large volumes of flood water to the reservoir in a relatively short period of time. It is believed that such pump-in detention reservoirs have limited application in the Northeastern Illinois Metropolitan Subregion because of high costs of pumping equipment.

A variation of the pump-in reservoir is the pump-out reservoir. In this kind of detention storage, the reservoir is below the level of streamflow. During flood periods, excess waters from the stream are allowed to flow into the reservoir by gravity over a suitable control works. When water surface levels in the downstream channel have lowered, the detained flood water is pumped from the reservoir to the outlet stream channel. The chief advantage of the pump-out system is the reduced cost for pumping equipment. This method has the same disadvantages as the pump-in reservoir. Land costs are usually high, property is removed from tax rolls, and a relatively high degree of maintenance is required. The Chicago Metropolitan Sanitary District and the Illinois Division of Waterways are cooperating in efforts toward a pump-out storage reservoir on Calumet Union Drainage Ditch in southern Cook County.

Another flood control procedure currently being investigated by the Metropolitan Sanitary District is the construction of a large system of tunnels in the bedrock beneath Cook County. Under this plan, excess flood waters would be discharged to the tunnels, or caverns, in the bedrock for detention storage and would then be conveyed to points of discharge to the surface streams. At the points of discharge, large pumping stations would be provided to lift the water up to the elevation of the surface stream for disposal to the Illinois River. A unique feature of the plan is a pumped-storage hydroelectric capability at the point of discharge. Preliminary study of the scheme by the Metropolitan Sanitary District indicates that the method appears to have great promise. Sufficient data are not available at this time to properly evaluate the scheme.

The Division of Waterways is studying improvements to the Sanitary and Ship Canal which, if economically feasible, would be of great benefit to the flood control program of the Metropolitan Subregion. Under this program, new locks and dams would be constructed near Western Avenue and Lockport, the existing Lockport Lock and Dam and Brandon Road Lock and Dam would be abandoned, and parts of the Ship Canal and Calumet-Sag Channel would be deepened. As visualized, normal water surface in the Sanitary and Ship Canal and in Calumet-Sag Channel would be lowered approximately 10 feet. This would provide a tremendous increase in the available flood storage volume and a significant increase in the hydraulic capacity of the channel for flood water movement. Problems involving shipping interests appear to be very costly, as are complications from relocation of utilities and water intakes. Such a project would not only improve flood control but would also benefit navigation. Movable bridges along the Canal could be eliminated, a factor of major importance to railroads in the area and to Joliet. Preliminary evaluation indicates the program is promising, and the study is continuing.

Seawall at Camp Logan damaged by wave action in November 1963.

In June 1966, the Director of the Illinois Department of Public Works and Buildings convened a meeting at which the President of the Metropolitan Sanitary District, the President of the Cook County Board of Supervisors, and the Mayor of Chicago all pledged their support of a Flood Control Coordination Committee. The Committee has been formed. Its principal work will be to determine areas of responsibility in the Cook County area. It is anticipated that these agencies will work toward the adoption and implementation of a single cooperative program of flood control.

Whatever the structural measures used to reduce flood damage, it is essential that regulatory measures and controls be adopted and enforced throughout the six-county area to prevent further encroachment of the flood plains and creation of new flood damage areas. Most existing flood-plain regulations pertain to permitted elevations of occupancy and do not attempt to delineate open flood plains for flood movement. This deficiency must be corrected. At present, flood-plain regulations are the responsibility of county, city, and village governments. If recommended measures fall short or the municipalities do not accept this responsibility, the General Assembly should consider revoking their authority to do so and assigning jurisdiction to the State Government.

Continued implementation and construction of presently recommended flood control measures and adoption of specifically stated and rigidly enforced regulatory measures should alleviate conditions which cause flood damage in this area.

Subregion B — Outlet Area

Flood control surveys of the lower Fox and the Iroquois Rivers have been completed. A comprehensive water resource study of the Kankakee-Iroquois Watershed by the Illinois Department of Public Works and Buildings is in progress. Studies of many of the smaller tributaries have been completed as part of a continuing program.

Of particular interest is a flood control study of the main stem of the Illinois River between Lockport and Hennepin being made by the Division of Waterways under special authority from the General Assembly. The study involves topographic and hydrographic surveys, and mapping of the River through this entire reach as a basis for engineering studies of present and anticipated flood and low flow conditions on the River. The Division is constructing a hydraulic model of the River which will simulate the flow of the River. The hydraulic model will be used to test various improvement plans and to verify the engineering computations. This study is being conducted in anticipation of larger future flood flows on the River from expanded drainage facilities on all of the contributing watersheds. Such anticipatory studies will give the State a distinct advantage in planning and programming future flood control works on the Illinois River.

Potential Flood Problem Areas

It is expected that most future flood problems in the Lake Michigan and upper Illinois River Basin will develop in Kankakee, Grundy, and Kendall Counties as urbanization continues outward from Chicago. New industries along the Illinois River are indicative of this trend. Residential development is expected in the near future.

Implementation of present flood control programs, supplemented by regulatory measures, should alleviate flood conditions in the six counties in the Northeastern Illinois Metropolitan Area. However, in this area of high land costs and increasing land use demands, all flood control programs must be continually studied and modified to take advantage of such new proposals or technological advances as are economically feasible.

Lake Michigan Shoreline

Although it is not specifically a flood problem, there is a severe erosion problem along the Lake Michigan shoreline north of Evanston to the Illinois-Wisconsin state line.

Public and private beaches are being degraded by shore currents and valuable bluff properties eroded by wind-driven wave action. Since 1950, the Department of Public Works and Buildings has maintained observation stations to record barometric pressures, lake stages, wind direction and velocity readings, and wave heights and intervals. This information is analyzed and periodically published in reports to help Federal, State, local, and private interests design protective measures to prevent the loss of public and private properties.

The State has no program to protect private properties from damage by wave action. By State statute the bed of Lake Michigan is held in trust for the people of Illinois, but the law does provide means for owners to protect their property. Recent storms along the Lakeshore indicate the need for studies to develop a strong State policy which would resolve areas of uncertainty, particularly involving the rights and responsibilities of riparian landowners and the State.

REGION III
LOWER ILLINOIS RIVER BASIN

The lower Illinois River Basin lies in the heartland of the State, covering approximately 17,880 square miles, or about 30.9 percent of the total area of the State. Figure 9 shows the location of the Basin, its configuration, counties, and major towns and villages. The agricultural economy of the region is based in the flat upland prairies and reclaimed bottom lands along the Illinois River. The urban-industrial Peoria Metropolitan Area is located in the middle reach of the Illinois River. On the upland prairies of the lower Illinois River Basin are the farm-oriented industrial centers of Bloomington, Lincoln, Decatur, Jacksonville, Canton, Galesburg, and LaSalle-Peru. Along the Sangamon River, largest tributary to the Illinois, is Springfield, the State Capitol.

Traversing the region from northeast to southwest is the Illinois River, the dominant topographic feature of the area. The Illinois flows at the bottom of a broad glacial valley entrenched in steep river bluffs. From the River bluff to the outer perimeters of the Basin lie the rolling upland prairies, which are separated by well developed tributaries in gentle valleys with moderate bluffs. The prairies with poor natural drainage have been artificially drained through ditches and tiles to the tributary steams. The Illinois River valley below Peoria, originally widespread swamp and lake lands, has been reclaimed by use of river levees, interior ditches, and pumping stations. It now has some of the finest farmland in the State.

Flood History

The Illinois main stem has had disastrous floods for the past 200 years. The great flood of 1844 reached a stage of 26.6 feet at Peoria and was exceeded only by the flood of 1943, which reached a stage of 28.8 feet. The flood of 1943 was the greatest known on the Illinois River and much of the Sangamon River. Significant floods on the main stem recur about once in eight years. Floods on the tributary streams generally occur more often. Minor seasonal floods on both the main stem and tributaries usually develop between February and July. The seasonal floods result in relatively minor flood damages, except when flooding occurs after spring planting on the low-lying farms along the tributaries. Table 3 lists flood data from principal gaging stations in the Basin. Figure 9 delineates the bottom lands subject to flooding on the main stem and larger tributaries. Approximately 963,800 acres, about 8.5 percent of the Basin area, is so affected. More than 191,000 acres of the bottom land has been provided with varying degrees of protection by Federal and State flood control projects. The remaining 772,000 acres is protected by local improvements, especially on tributary reaches. This area is farmed on a marginal basis, used as pasture or timber lands, or has remained in swamp land, sloughs, and lakes, especially on the main stem of the Illinois River above Beardstown.

Flood of May 1943

The flood of May 1943 exceeded all past floods on the main stem and resulted in extremely high water on most tributaries. It is cited here as an illustration of what can occur in the lower Illinois Basin.

Severe storms traversed central and southern Illinois from May 6 to 8, May 10 to 11, and May 15 to 20. These storms were associated with a quasi-stationary front across central and southern Illinois at different times during the month. Precipitation from these storms fell on ground already saturated by April rains. Accumulative runoff from

TABLE 3 REGION III — LOWER ILLINOIS RIVER BASIN

Flood Data For Selected Gaging Stations Stream and Station	Drainage Area (Sq Mi)	Years of Record	Gage Zero (Ft msl)*	Date	Maximum Gage Height (1) (Feet)	Discharge (cfs)	Duration Days out of Bank	Return Period (Years)
1. Vermilion River at Pontiac	568	22	619.45	7/10/51	17.90	13,600	10	35
2. Bureau Creek at Princeton	186	28	555.24	1/24/38	15.88	11,800	2	20
3. Kickapoo Creek at Peoria	296	22	448.37	5/27**	21.41	unknown	unknown	—
4. Mackinaw River near Congerville	764	20	607.01	7/9/51	19.41	36,000	4	55
5. Illinois River at Kingston Mines	15,200	25	428.00	5/23/43	26.02	83,100	56	100+
6. Spoon River at London Mills	1,070	22	508.97	7/22/51	23.73	35,300	4	50
7. Sangamon River at Monticello	550	54	625.89	10/4/26	18.50	19,000	6	33
8. Salt Creek near Rowell	334	22	610.00	2/11/59	24.84	ice jam	6	—
9. LaMoine River at Ripley	1,310	43	431.10	9/26/61	27.43	18,600	8	30
10. Illinois River at Meredosia	25,300	26	418.00	5/26/43	28.61	123,000	56	100+
11. North Fork Mauvaise Terre Creek near Jacksonville	30	14	579.27	6/28/51	10.68	2,870	3	8
12. Macoupin Creek near Kane	875	36	426.77	5/18/43	28.5	40,000	5	30

* Adjustment 1929 unless noted otherwise.
** From information by Corps of Engineers.
(1) To obtain water surface elevation, add gage height to gage zero.

REGION III
LOWER ILLINOIS RIVER BASIN

FIGURE 9
BOTTOM LANDS SUBJECT TO FLOODING

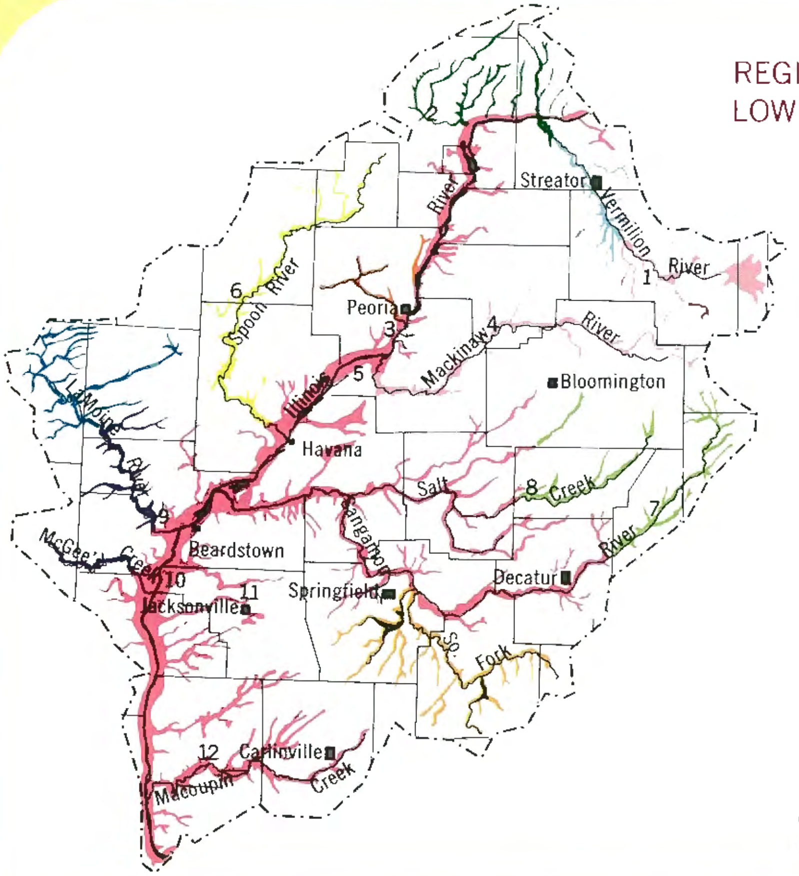
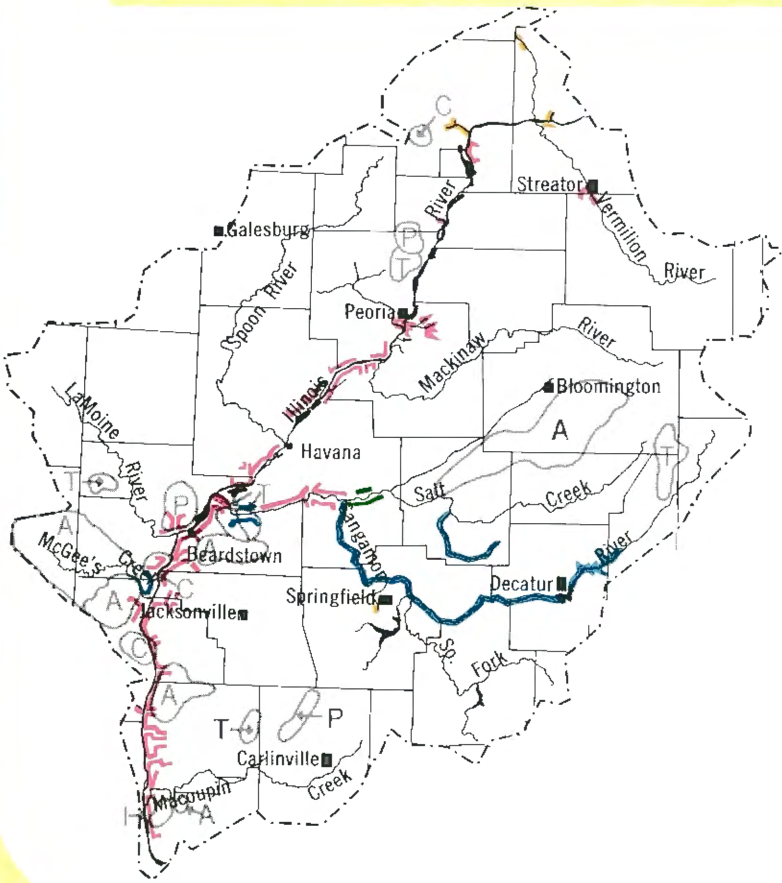


FIGURE 10
WATERSHED LOCATION AND STATUS
FLOOD CONTROL PROJECTS



these storms caused the maximum flood of record on the Illinois River main stem from Starved Rock to the mouth and on most of the streams in the Sangamon River Basin. While not exceeding the flood of record, major flooding occurred on the other tributaries.

The Illinois River was above flood stage for about 34 days at Peoria and for about 55 days at Beardstown. During this time vital World War II industries were either idled or damaged by the flood. In East Peoria, floods on Farm Creek caused heavy damages. On the Illinois main stem, the communities of Liverpool, Snicarte, Browning, Frederick, Valley City, Pearl, Kampsville, and Hardin were partially or entirely flooded. Many homes on the lower river terrace at Streator were flooded.

Excluding the loss of industrial production, the flood damages in the Illinois River Basin were $9.5 million. Of this total, more than $5.5 million was crop losses resulting from inundation of approximately 250,000 acres of farmland. This series of May storms also caused major flooding of streams in other basins. Flood losses in Illinois were more than $31 million from the May 1943 floods.

State and Federal Flood Control Projects

Figure 10 shows the location, extent, and status of Federal and State flood control projects in the lower Illinois River Basin. Approximately $24.2 million in Federal, State, and local funds has been spent to construct, maintain, and repair these structures. Although cost data are not available, it is estimated that approximately $29 million has been spent by private levee or drainage districts on flood protection works in the lower Illinois Basin.

The Corps of Engineers has various types of flood control projects in the Basin that are either under construction or are pending, awaiting local sponsorship and the allocation of funds by Congress. Estimated cost of these projects exceeds $95.5 million in Federal and non-Federal funds. Additional projects, in varying stages of investigation, which would cost an additional $182,000 are also listed. In total, there are approximately $95,682,000 worth of Corps of Engineers flood control projects, either under construction or proposed for possible future construction in the lower Illinois River Basin.

As of July 1, 1966, there were nineteen P. L. 566 Watershed Projects in the Basin. Six of these projects have been found to be economically unjustified or without sufficient local interest. Three upper watershed projects have been authorized for planning, and three have been completed. The remaining seven projects are under investigation to determine engineering and economic justification and local cooperation.

The State has conducted flood control studies at Clark Run, Bureau Creek, Radio City Creek, the Sangamon River at Springfield, Jacksonville Branch, Mendota Creek, Mauvaise Terre Creek, and Macoupin Creek. In addition, the State has completed flood control improvements at Ottawa on the Illinois River, at Streator on the Vermilion River, and on Gimlet Creek and Hardy Creek. The cost of these projects has been included with the Federal and local expenditure discussed above.

Developed Illinois River Bottoms at Beardstown, 1958.

East Peoria during the Illinois River flood of May 1943.

Existing Flood Problem Areas

Most of the agricultural lands and urban areas on the Illinois and the Sangamon Rivers that suffer major flood damages either have completed flood control projects or are programmed for study and improvement. The majority of flood problems in the Basin that are not yet under consideration are agricultural lands along the major tributaries, except the Sangamon River, and on local streams at urban centers.

The Corps of Engineers has made several comprehensive studies of the Illinois River Basin, including the major tributaries. Plans for headwater reservoirs, levees, and channel improvements were developed for all the major tributaries. With the exception of the Sangamon River, these plans were not authorized, because they were not economically justified at the time of the study, or for lack of local cooperation in providing non-Federal funds or rights of way. A plan of improvement on the Mackinaw River is now under study and may prove economically feasible in meeting the desires of local interests.

Potential Flood Problem Areas

Expansion of the existing urban communities, especially the larger urban centers, may be expected to continue. Effective city and county zoning will be required, along with a realistic expansion of municipal storm drainage systems, to prevent what is now minor flooding from becoming major floods.

The Peoria Standard Metropolitan Statistical Area had a 1960 population of 288,833 persons. Demographic studies indicate a projected population of 350,000 by 1980 and 768,000 by 2020. The expected industrial growth and urbanization of the area, principally after 1980, will affect minor creeks and streams in the tri-county metropolitan region and will have special impact on the Illinois River valley and Kickapoo Creek. A comprehensive development of the Kickapoo Creek Basin should be completed by 1980.

Nearly all agricultural levee and drainage districts along the Illinois River and much of the lowlands not acquired for recreation could become industrialized, especially after 1980. Effective zoning at the local level and comprehensive development of adequate interior and hillside drainage facilities will be required.

Sediment loads deposited by flood flows are rapidly filling up backwaters, sloughs, bays, and lakes of the Illinois River bottoms and destroying valuable fishing and recreational areas. The Illinois River and its backwaters are considered to be the best areas for conservation and recreational development in central Illinois. Unless methods and procedures are developed in the near future to drastically reduce sediment loads into the Illinois River, some means of conventional flood protection will be required to preserve these backwater areas.

REGION IV
LOWER MISSISSIPPI RIVER BASIN

The lower Mississippi River Basin lies in southwestern Illinois between the Ohio and Illinois Rivers and covers approximately 10,350 square miles, or about 17.9 percent of the total area of the State. Figure 11 shows the location of the Basin, its configuration, counties, and major towns and villages. The economy of the region is quite diversified, ranging from the heavily developed urban-industrial complex in the East St. Louis area, to the coal mines and quarry operations in the southern Basin, to the farming on the bottom lands and uplands.

The topography, too, is varied. There are flat to rolling upland prairies in the upper portion of the Basin, rugged ridges and valleys in the southern area, and high bluffs along the Mississippi River valley and mouths of some of the major tributaries.

The drainage system is well developed throughout the Basin. Major streams have low gradients with broad, flat-bottomed valley sections. Artificial ditches and tiles drain some of the flat upland areas and many of the leveed and reclaimed bottom lands along the Mississippi River and its larger tributaries.

Flood History

Major floods on the main stem of the Mississippi River are caused by flood waters from upstream sources such as the upper Mississippi, Missouri, or Illinois Rivers. Floods on the other streams in the Basin result from 1) backwater flooding from high stages on the Mississippi River, often aggravated by local rainfall and runoff; 2) periods of protracted rainfall over wide areas, usually in the spring, resulting in heavy runoff; and 3) flash floods, particularly along the bluff lines and in the hill country after intense thunderstorms of short duration. Table 4 lists flood data from some of the gaging stations located in the Basin. Figure 11 delineates the bottom lands subject to flooding on the main stem and larger tributaries. Approximately 966,655 acres, about 14 percent of the Basin area, is in this category. More than 330,000 acres of this land is protected in varying degree by completed or authorized Federal and State flood control projects or such projects are proposed. Most of the remaining area is timber bottom land of the major tributaries where the flat channel gradient, low banks, and level flood plains, combined with frequent and prolonged periods of inundation, have prevented economic development of the land.

The floods of April, May, and June 1957 are examples of the various types floods that do occur in this Basin.

Spring Floods of 1957

During April, rain fell over most of the lower Mississippi Basin for about 15 days with the rainfall well distributed through the month. The most intense rains occurred from April 1 to 8. These averaged about 4 inches over the Kaskaskia River Basin, 6.5 inches over the Big Muddy Basin, and 5.5 inches over the Cache River Basin. These rains caused moderate flooding on the Kaskaskia River and large floods on the Big Muddy and Cache Rivers. The highest stage of the year, 1.3 feet below the maximum of record, was recorded at Murphysboro on the Big Muddy River.

General precipitation was recorded between May 9 and May 25, with a narrow band of rainfall of 6 to 9 inches straddling the divide between the Big Muddy and Cache River Basins from May 21 to 23. For the period from May 16 to 25, rainfall over the Kaskaskia River Basin averaged from 3 inches in the upper watershed to 9 inches at

TABLE 4 REGION IV — LOWER MISSISSIPPI RIVER BASIN

Flood Data For Selected Gaging Stations — Stream and Station	Drainage Area (Sq Mi)	Years of Record	Gage Zero (Ft msl)*	Date	Maximum Gage Height (1) (Feet)	Discharge (cfs)	Duration Days out of Bank	Return Period (Years)
1. Mississippi River at St. Louis	701,013	105	379.94	6/27/1844	41.32**	1,300,000	unknown	150+
2. Kaskaskia River at Shelbyville	1,030	29	535.78	6/29/57	22.37	25,900	7	17
3. Kaskaskia River at Carlyle	2,680	32	402.92	5/21/43	33.69	54,400	20	40
4. Shoal Creek near Breese	760	22	413.97	5/19/43	25.6	52,000	unknown	100
5. Kaskaskia River at New Athens	5,220	41	359.50	5/23/43	39.35	83,000	29	40
6. Mississippi River at Chester	712,563	75	341.05	6/30/1844	39.83	1,350,000	unknown	150+
7. Big Muddy River at Plumfield	753	53	358.24	5/10/61	29.67	42,900	12	90
8. Beaucoup Creek near Matthews	291	20	368.15	5/09/61	23.41	18,800	5	18
9. Big Muddy River at Murphysboro	2,170	35	335.5	5/12/61	37.97	33,300***	21	17
10. Mississippi River at Cape Girardeau, Missouri	716,000	70	304.77	7/04/1844	42.53	unknown	unknown	150+

* Adjustment 1929 unless noted otherwise.

** Stage for flood of April 1785 may have been higher, for which discharge was estimated at 1,340,000 cfs.

*** Maximum discharge 5/11/61.

(1) To obtain water surface elevation, add gage height to gage zero.

REGION IV
LOWER MISSISSIPPI RIVER BASIN

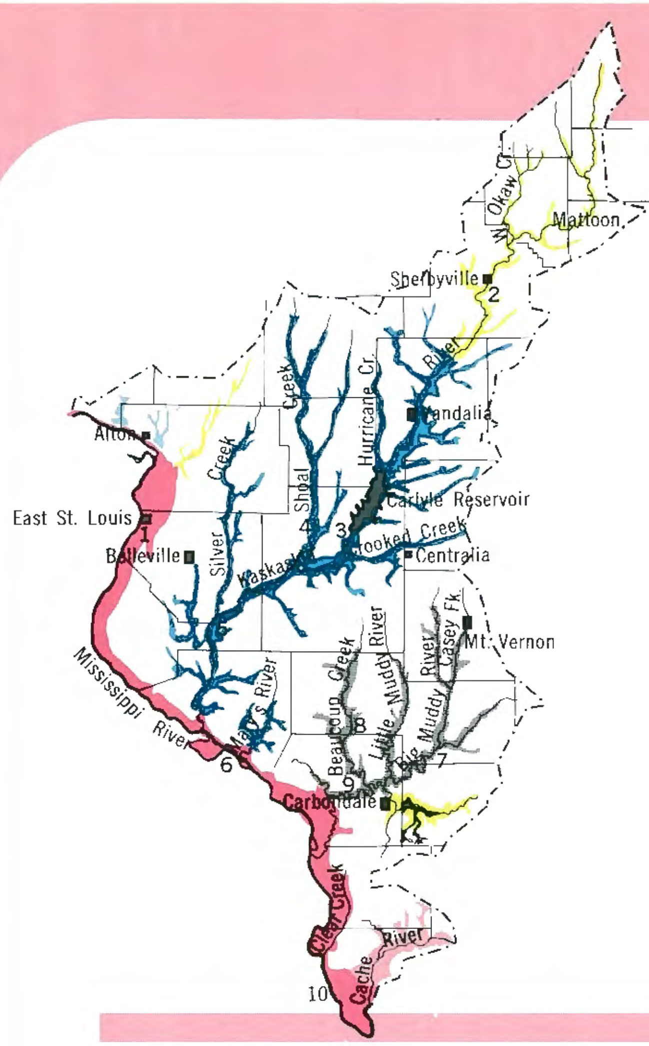


FIGURE 11
BOTTOM LANDS SUBJECT TO FLOODING

FOR FLOODS OF RECORD ON INDIVIDUAL STREAMS

- 1844
- 1937
- 1943
- 1946
- 1957
- 1961

NUMBERS REFER TO GAGING STATIONS IN TABLE 4

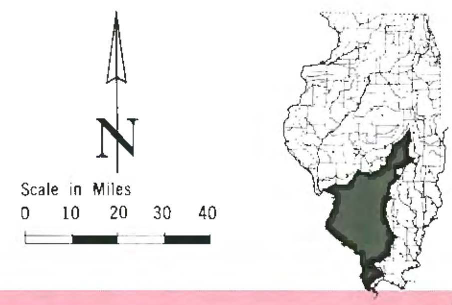


FIGURE 12
WATERSHED LOCATION AND STATUS FLOOD CONTROL PROJECTS

STATE AND FEDERAL FLOOD CONTROL PROGRAMS

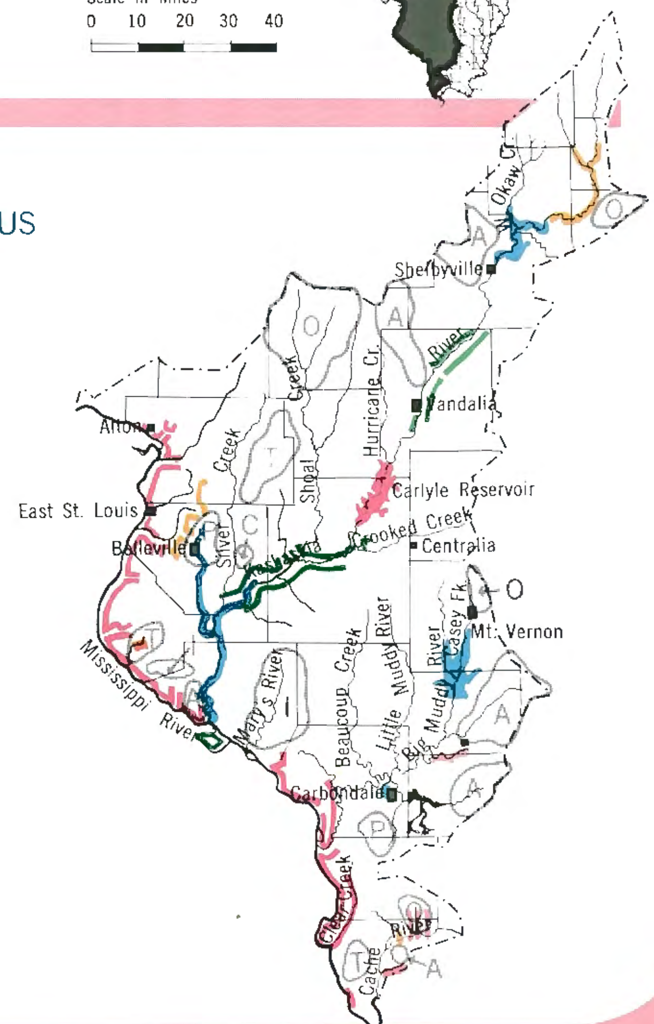
PROJECT STATUS

FEDERAL		STATE
	COMPLETED	
	UNDER WAY	
	AUTHORIZED	
	RECOMMENDED	
	UNDER STUDY	

- LOCAL FLOOD PROTECTION
- CHANNEL IMPROVEMENT
- FLOOD CONTROL RESERVOIR

P. L. 566 SMALL WATERSHED PROGRAMS PROJECT STATUS

I — Investigation by State Agencies
A — Approved by Governor
P — Authorized for Planning
T — Watersheds Terminated
O — Approved for Construction
C — Completed Watersheds



the mouth of the River. The average precipitation was 7 inches over the Big Muddy River Basin and 9 inches over the Cache River Basin. High stages occurred on the three streams.

Rainfall was spotty throughout June, with heavy rain over the Kaskaskia River Basin from June 7 to 15 and June 24 to 28. During the June 7 to 15 period, rains over the Kaskaskia Basin averaged about 7 inches, while those over the Big Muddy and Cache River Basins averaged 1 inch or less. The outstanding feature of the period was the event of June 14 and 15.

On June 14 and 15, 1957, one of the most severe rainstorms of short duration ever recorded in the Midwest occurred in the southwestern part of Illinois and eastern Missouri. In the center of this storm, near Millstadt, 16.54 inches of rain fell in less than 12 hours. More than 5 inches of rain fell on an area of 3000 square miles, and more than 1 inch fell on an area of 22,000 square miles.

A large ridge of high pressure, an extension of the Bermuda High, dominated the southeastern quarter of the United States, with a large cyclonic low pressure center moving slowly across the northern tier of states. Trailing southwestward from this low center was a cold front pivoting about Quincy. Southwestward into Oklahoma was a stationary front. Warm, moist air coming around the high ridge moved northward up the Mississippi River, thence eastward across south-central Illinois. Unstable conditions ahead of the rotating cold front produced the heavy rainfall. This storm resulted in the maximum flood stage for the year at Carlyle and New Athens on the Kaskaskia and caused flash flooding on all tributaries in the vicinity of East St. Louis.

While the rains of June 24 through June 28 averaged between 3 and 4 inches over the Kaskaskia River Basin and less than 2 inches over the Big Muddy and Cache River Basins, a narrow band of rainfall occurred over the upper Kaskaskia River Basin between Pana and Windsor. Maximum intensities were of about 6 inches in five hours and 9 inches in four days. The flood set a new stage of record, 22.4 feet, exceeding the previous high by 1.2 feet. During the 117-day period from April 4 to July 29, the Kaskaskia River was above flood stage at New Athens for 108 days and at Carlyle for 97 days. On the Big Muddy River at Murphysboro, flood stage was exceeded during the 79-day period from March 27 to June 13 for 62 days. Even though rainfall was normal during June in the Big Muddy and Cache River Basins, the wetness of the bottom lands from the April and May rains, together with such rains as did fall during June, prevented planting or harvesting of any significant volume of crops.

Damages caused by the spring floods and prolonged wetness in the Kaskaskia, Big Muddy, and Cache River Basins were primarily to crop lands. An estimated 99,870 acres was flooded and caused \$5,970,000 in damages. Approximately 7000 acres was flooded due to breaching of two levees. Only urban damage in the three basins was to low-lying residences at Marion and Murphysboro in the Big Muddy Basin. Two drownings are attributed to the floods.

Urban damages in the vicinity of East St. Louis from the June 14-15 storm totaled about \$8,051,000. Damages were:

East St. Louis and Vicinity — The East Side Levee and Sanitary District, in which East St. Louis is located, has a considerable amount of hill land draining into it. The drainage is normally collected in and discharged through drainage canals adjacent to the bluff line. The flash runoff from the June 14-15 storm overtaxed the canals and tributary ditches, flooding all lower areas of the flood plain within the District. As a result, many residential areas were flooded, utility services and transportation routes were disrupted, canal bridges were damaged, and streets and sewers were covered with silt. The city engineer of East St. Louis estimated municipal damages to be \$4,895,000. Officials of the East Side Levee and Sanitary District estimated agricultural damages within the District to be about \$327,000.

Debris piled against the Southern Railway trestle across Richland Creek in Belleville during the June 1957 flood.

Belleville — Damages to Belleville resulted from the overflow of Richland Creek, a tributary to the Kaskaskia River, which flows through the center of town. Many of the industrial, commercial, and residential buildings which line the creek bank were severely damaged. Within the City limits, four railroad trestles and thirteen street bridges across the Creek were covered by flood waters and closed. Damage to Belleville has been estimated to be about $2,717,000.

Mascoutah — The storm of June 14-15 overtaxed two local creeks, flooding the main business district and overtopping the local water-supply reservoir and breaching the dam. Damage to Mascoutah resulting from the June 14-15 storm has been estimated at about $34,000.

State and Federal Flood Control Projects

Figure 12 shows the locations, extent, and status of flood control measures employed in the lower Mississippi River Basin by State and Federal flood control agencies. Approximately $54 million in Federal, State, and local funds has been spent to construct, maintain, and repair these structures. Expenditures by private levee or drainage districts, particularly in the tributary valleys and in the slow-draining uplands, are estimated at an additional $30 million.

The U. S. Army Corps of Engineers has listed various types of flood control projects throughout the Basin that are either under construction or are pending construction, awaiting commitment of the local sponsor's contribution and the allocation of funds by Congress. Cost of these projects is estimated at more than $170 million in Federal and non-Federal funds. The same publication lists additional projects in varying stages of investigation which would require the expenditure of an additional $30 million. In other words, there are approximately $200 million worth of Corps of Engineers flood control projects either under construction or proposed for possible future cnstruction in the lower Mississippi River Basin.

As of July 1, 1966, there were nineteen P. L. 566 Watershed Projects in the Basin. Four of these projects have been terminated as not economically justified. One project is completed, two have been authorized for planning, and four approved for construction; the remaining eight projects are under investigation. No breakdown of Federal and local cost sharing for these projects is available.

The State has conducted studies in the Cache, Big Muddy, and Kaskaskia River watersheds. In addition, the State has constructed, or is authorized to construct flood control improvements at West Frankfort, Carbondale, Murphysboro, and on several minor streams in the Basin. Cost of these projects has been included with Federal and local expenditures.

Existing Flood Problem Areas

Flood control improvements are under study, under construction, or completed, on most of the major streams in the Basin, as shown in Figure 12. The completion of the Kaskaskia River Development Project and installation of contemplated Public Law 566 watershed improvements will do much to alleviate existing flood conditions in this watershed. Specific problem sites remain on several of the tributaries where agricultural and urban damages occur. Even with construction of the proposed Rend Lake Dam on the Big Muddy River and improvements at West Frankfort and Carbondale, the Big Muddy River Watershed on the main stem and tributaries still has definite flood and drainage problems. The Cache River and tributaries have been the subject of several studies seeking to develop an economically feasible program of flood control in this Watershed. Although some minor improvements have been completed, the main problem remains. Federal, State, and local agencies have conducted an almost continuous series of studies of the interior drainage problems in the urbanized East St. Louis area. Although construction of improvements is in progress, the measures being taken are remedial and will not solve the entire problem.

Potential Flood Problem Areas

The continued expansion of the urban-industrial complex in Madison and St. Clair Counties may be anticipated. New urban growth is now located along the bluff lines and is developing outward from towns and villages adjacent to the new and improved highways. Effective city and county planning regulations are essential to prevent encroachment on the flood plains of the numerous small streams in this area and to reserve possible flood detention basins along the bluffs. Other urban flood problems are expected to develop in the Carbondale-Murphysboro area and around Mt. Vernon and Centralia. Many of these potential flood problems could be avoided through a program of city and county planning and flood plain regulation.

The current canalization of the lower Kaskaskia River, and the possible canalization of the Big Muddy River, could result in industrial expansion into these basins. Correct evaluation of the situation should be made to prevent use of flood-prone lands for industrial and residential purposes.

REGION V
OHIO AND WABASH RIVER BASIN

The Ohio-Wabash River Basin lies in southeastern Illinois between the mouth of the Ohio River to a point near the Iroquois-Vermilion County line on the Illinois-Indiana border. The Basin covers approximately 11,200 square miles, or about 19.3 percent of the total area of the State. Figure 13 shows the location of the Basin, its configuration, counties, and major towns and villages. The economy of the region is primarily agricultural, although coal, oil, timber, and recreation are important in some specialized areas. Light and some heavy industry is located in the larger communities.

The topography varies from flat to rolling upland prairies in the upper portion of the Basin, with rugged ridges and deep valleys in the lower Basin.

The drainage system throughout the Basin is well developed, except in some areas in the Vermilion and upper Embarras River Watersheds, where extensive artificial drainage measures have been installed to drain wet lands and develop high-production agriculture. The major rivers have low gradients and broad, flat-bottomed, terraced valleys with relatively steep sides. Levees and articial ditches have been constructed on most of the bottom lands.

Flood History

Flooding on the Cache, Saline, Little Wabash, Embarras, and Vermilion Rivers occurs almost every year, usually as a result of storms which have a quasi-stationary front oriented from west-southwest to east-northeast which develops precipitation over a wide area. Upland runoff from these storms usually is fairly rapid. The water accumulates on the broad bottom lands of the major channels. Extensive flooding occurs because the capacity and gradient of the channels are not adequate to discharge the flood flows. Flooding on the main stems of the Ohio and Wabash Rivers, while not as frequent as on the tributaries, has inundated wide areas of agricultural bottom lands along the main stems and in the lower reaches of the tributaries. Upland flooding and damages sometimes follow intense thunderstorms of short duration and limited areal extent; however, runoff from these floods is normally quite rapid and damages are limited to local areas. Table 5 lists data taken from the records of some of the gaging stations in the Basin.

Figure 13 delineates the bottom lands subject to flooding on the main stem and larger tributaries of the Basin. Note particularly the extent of the backwater flooding on the Saline and Cache Rivers from the 1937 flood on the Ohio River. Approximately 1,044,000 acres of land, or about 14.1 percent of the total Basin area is subject to this bottom-land flooding. Federal and State flood control projects, including completed, authorized, and proposed projects, will provide protection in varying degree for approximately 50,000 acres of this land. The remainder is protected by private or local improvements used as pasture or timber lands or left as undeveloped swamp and waste land.

The May 1961 Flood

The flood of May 5 to 11, 1961, in the Ohio and Wabash River Basin illustrates the type of flooding that occurs in this Basin.

During a period of 106 hours from May 5 to May 9, one of the most extensive, intense rainstorms in Illinois history occurred in the central and southern regions of the State. For areas of 10,000 square miles or greater, the five-day storm precipitation totals were the greatest of the past 75 years. Only the storm of August 13 to 17, 1946, had greater average rainfall for areas of 1000 to 5000 square miles.

The 1961 storm had several centers, but the major one was near Flora, where more than 12 inches of rain fell in five days. Relatively heavy falls were

TABLE 5 REGION V — OHIO AND WABASH RIVER BASIN

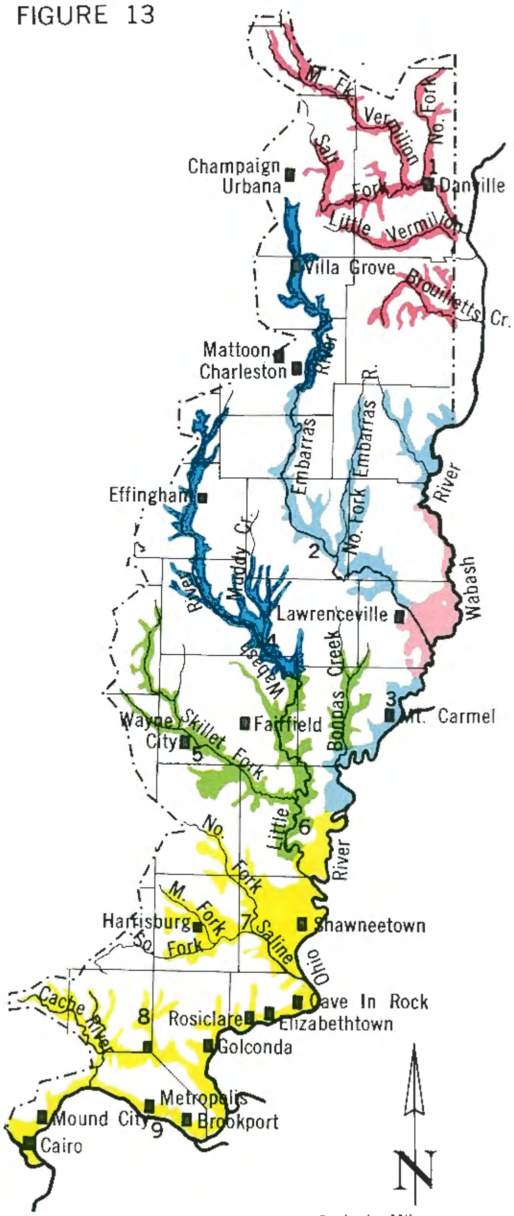
Flood Data For Selected Gaging Stations Stream and Station	Drainage Area (Sq Mi)	Years of Record	Gage Zero (Ft msl)*	Date	Maximum Gage Height (1) (Feet)	Discharge (cfs)	Duration Days out of Bank	Return Period (Years)
1. Vermilion River at Danville	1,279	43	503.33	3/13/39	28.59	48,700	4	60
2. Embarras River at St. Marie	1,513	53	446.75	3/13	25.5	58,000	unknown	35
3. Wabash River at Mt. Carmel	28,600	37	371.46	3/30/13	31.00	428,000	29	65
4. Little Wabash River below Clay City	1,134	50	329.29	1/5/50	26.67	47,000	18	50
5. Skillet Fork at Wayne City	464	47	383.15	5/9/61	26.68	51,000	6	150
6. Little Wabash River at Carmi	3,111	25	339.91	5/12/61	36.70	46,900	26	100
7. Saline River near Junction	1,040	25	320.40	3/19/45	44.03*	37,400	21	40
8. Cache River at Forman	243	40	332.77	3/12/35	17.99	9,630	5	15
9. Ohio River at Metropolis	203,000	32	276.27	2/37	66.60	1,850,000	60	200

* Maximum Stage about 55.8 in February 1937—backwater from Ohio River.
(1) To obtain water surface elevation, add gage height to gage zero.

REGION V — OHIO AND WABASH RIVER BASIN

BOTTOM LANDS SUBJECT TO FLOODING

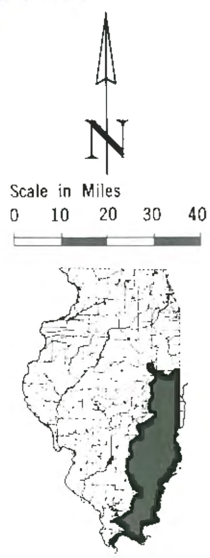
FIGURE 13



FOR FLOODS OF RECORD ON INDIVIDUAL STREAMS

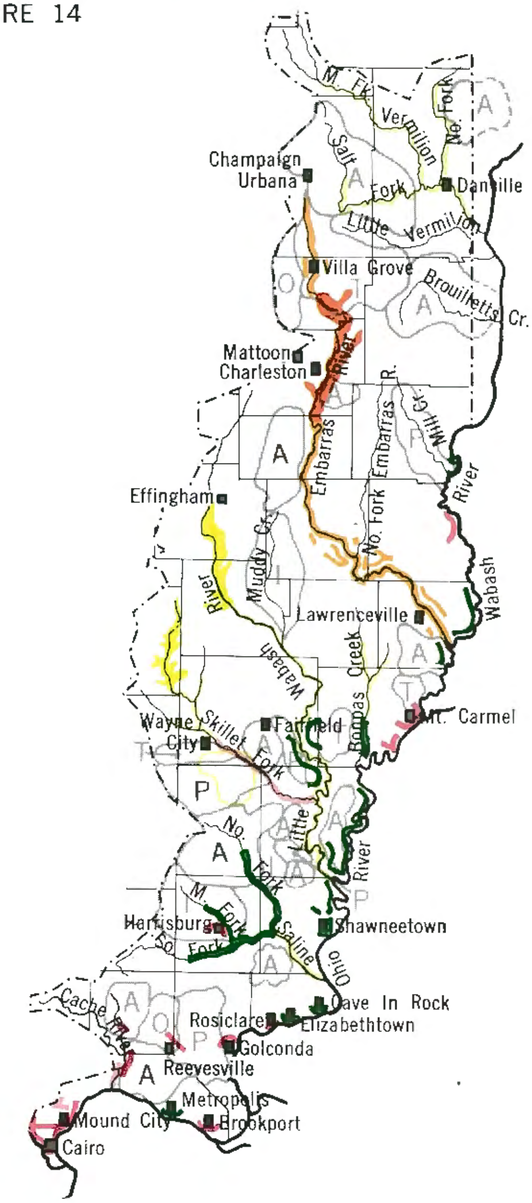
1913
1937
1939
1943
1950
1961

NUMBERS REFER TO STREAM GAGING STATIONS IN TABLE 5



WATERSHED LOCATION AND STATUS FLOOD CONTROL PROJECTS

FIGURE 14



STATE AND FEDERAL FLOOD CONTROL PROGRAMS PROJECT STATUS

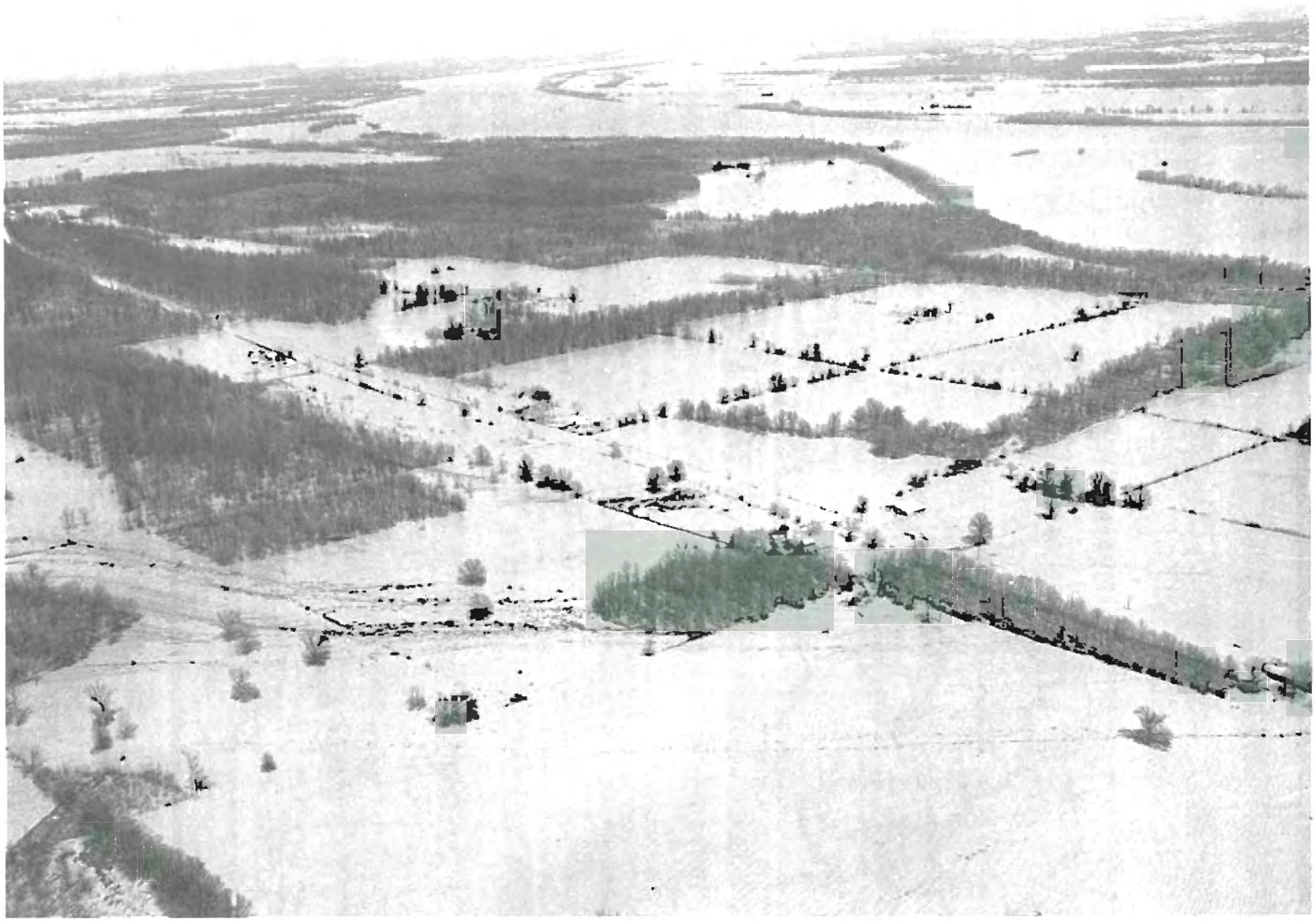
FEDERAL — STATE

COMPLETED
AUTHORIZED
RECOMMENDED
UNDER STUDY

LOCAL FLOOD PROTECTION
CHANNEL IMPROVEMENT
FLOOD CONTROL RESERVOIR

P. L. 566 SMALL WATERSHED PROGRAMS PROJECT STATUS

I — Investigation by State Agencies
A — Approved by Governor
P — Authorized for Planning
T — Watersheds Terminated
O — Approved for Construction
C — Completed Watersheds



Ohio River flood of March 1964 on the Saline in Gallatin County.

recorded over large areas in periods of from 24 to 48 hours, but the rainfall totals for these durations did not reach the excessive levels of the three-day to five-day amounts. The resultant flood was the highest ever recorded on Bonpas Creek and the Little Wabash River below Clay City. The Wabash River and Embarras River had major floods. In total, 53 counties of the State were affected by floodwaters. The communities of Browns, Carmi, Enfield, Maunie, Mill Shoals, and Springerton in the Wabash River Basin were flooded. Almost all highways in the region were closed.

The principal damages from this flood were to bridges and roads, and to farm crops, lands, and buildings. Damages on the Embarras River exceeded $1 million, while on Skillet Fork damages were $2.2 million and on the Little Wabash River nearly $3.3 million.

State and Federal Flood Control Projects

Figure 14 shows the location, extent, and status of State and Federal flood control projects in the Ohio and Wabash River Basin. Approximately $14.2 million in Federal, State, and local funds has been spent to construct, maintain, and repair these structures. Although exact costs are not available, it is estimated that approximately $28 million has been expended by private levee or drainage districts within the Basin for construction of local flood control works.

The Corps of Engineers has various types of flood control projects throughout the Basin that are either under construction or are pending construction, awaiting commitment of the local sponsor's contribution and the allocation of funds by Congress. These projects are estimated to cost in excess of $22 million in Federal and non-Federal funds. Additional projects in varying stages of investigation would require the expenditure of more than $19.5 million. The total value of Corps of Engineers' flood control projects either under construction or proposed for possible future construction in the Ohio and Wabash River Basin is approximately $41.5 million.

As of July 1, 1966, there were twenty-nine P. L. 566 Watershed Projects in the Basin. Four of these projects have been terminated as not economically justified or because of lack of local interest and sponsorship. Two projects have been approved for construction, and four projects approved for planning. The remaining nineteen projects are under investigation.

The Illinois Division of Waterways has completed or has in progress studies in the Saline, Skillet Fork, Little Wabash, Embarras, and Vermilion River watersheds; special studies have been completed at Villa Grove in Douglas County, Bonpas Creek in Edwards and Richland Counties, and Post Creek cutoff in Pulaski County. In addition, the State has constructed, or has appropriation to construct, flood control improvements on Skillet Fork below Wayne City, Post Creek cutoff, the lower Saline River, and the Embarras River at Lawrenceville.

Existing Flood Problem Areas

Few State or Federal flood control projects have been completed in the Ohio and Wabash River Basin, and such projects as have been completed are isolated units, primarily near urban areas. (Figure 14). Some agricultural levee improvements have been proposed on both the State and Federal level to upgrade existing drainage levees or spoil banks to provide protection against a fifteen-year frequency flood. The basic Federal approach to flood control in this Basin has been through the recommendation or consideration of large, multi-purpose main-channel reservoirs. This approach has considered not only the need for flood control in the Basin, but also the need for assured sources of surface-water supply for municipal and industrial purposes and low-flow augmentation, and to satisfy expressed local desires for sites for water-based recreation. While it is true that the multi-purpose reservoirs are needed for these purposes, the flood control storage allocations in the reservoirs are not, of themselves, sufficient to relieve the need for downstream channel and levee improvements for urban and agricultural flood protection. Studies and construction of such downstream improvements should be undertaken concurrently with the reservoir studies and construction. A particular problem exists in the Skillet Fork "bowl" or "saucer" area downstream of Wayne City, where the terrain precludes adequate protection from channel and levee improvements alone. Retardation or small limited-purpose reservoirs on the tributaries should be considered.

Other existing flood problem areas requiring study or construction of improvements in this Basin are at Danville on Stoney and Grape Creeks, Villa Grove on the Embarras River, Carmi on the Little Wabash River, and at Browns and Grayville on Bonpas Creek.

Potential Flood Problem Areas

It is anticipated that the most common future problem in the Basin will result from urban encroachment on the flood plains of the streams, probably along the paths of the major highways and interstate routes which dissect the area.

Enactment of effective city and county zoning ordinances could channel this growth to areas not subject to flooding and confine the flood plain to low-damage uses.

Possible canalization of the Saline or Wabash Rivers could result in some industrial or commercial development of the bottom lands on these rivers. Such development should be closely controlled.

CASE STUDIES

A series of four case studies of typical flood control problems in Illinois illustrates general techniques and methods of improvement. Each of the studies examines a problem common to other areas of the State. The material is presented in this manner to permit greater emphasis and elaboration of certain concepts, problems, and solutions to flooding and flood control. The case studies are:

Case Study 1: Basin Planning. A comparison between main-stem and headwater treatment for flood control on a major hypothetical basin.

Case Study 2: Agricultural Levee District. The development of a bottom-land levee district with its problems of inadequate local funds and future maintenance.

Case Study 3: Urban Occupancy of a Levee District. The conversion of an agricultural district to industrial and residential uses to the eventual exclusion of agricultural activities. The changing level of flood control responsibility.

Case Study 4: Flood-Plain Zoning. An explanation of great urban development of a rural county, the flood control improvements needed, and the consequences of inadequate flood-plain zoning.

CASE STUDY 1. RIVER BASIN PLANNING

The goal of all river basin planning is the optimum development of the water resources of the basin for the varied uses of man, both present and future, at minimum cost. Development of the plan requires analysis of the water uses under present conditions and determination of probable future conditions so that future water uses may be estimated. Preparation of the plan involves not only analysis of streamflow, precipitation, dam sites, and physical construction, but also involves analysis of population trends and estimates, industrial and agricultural production of the region, patterns and zoning of municipal growth, and the effect of transportation routes and costs upon commerce. Further, the planner must exercise judgment in evaluating the analyses of these variables on which the final plan is based.

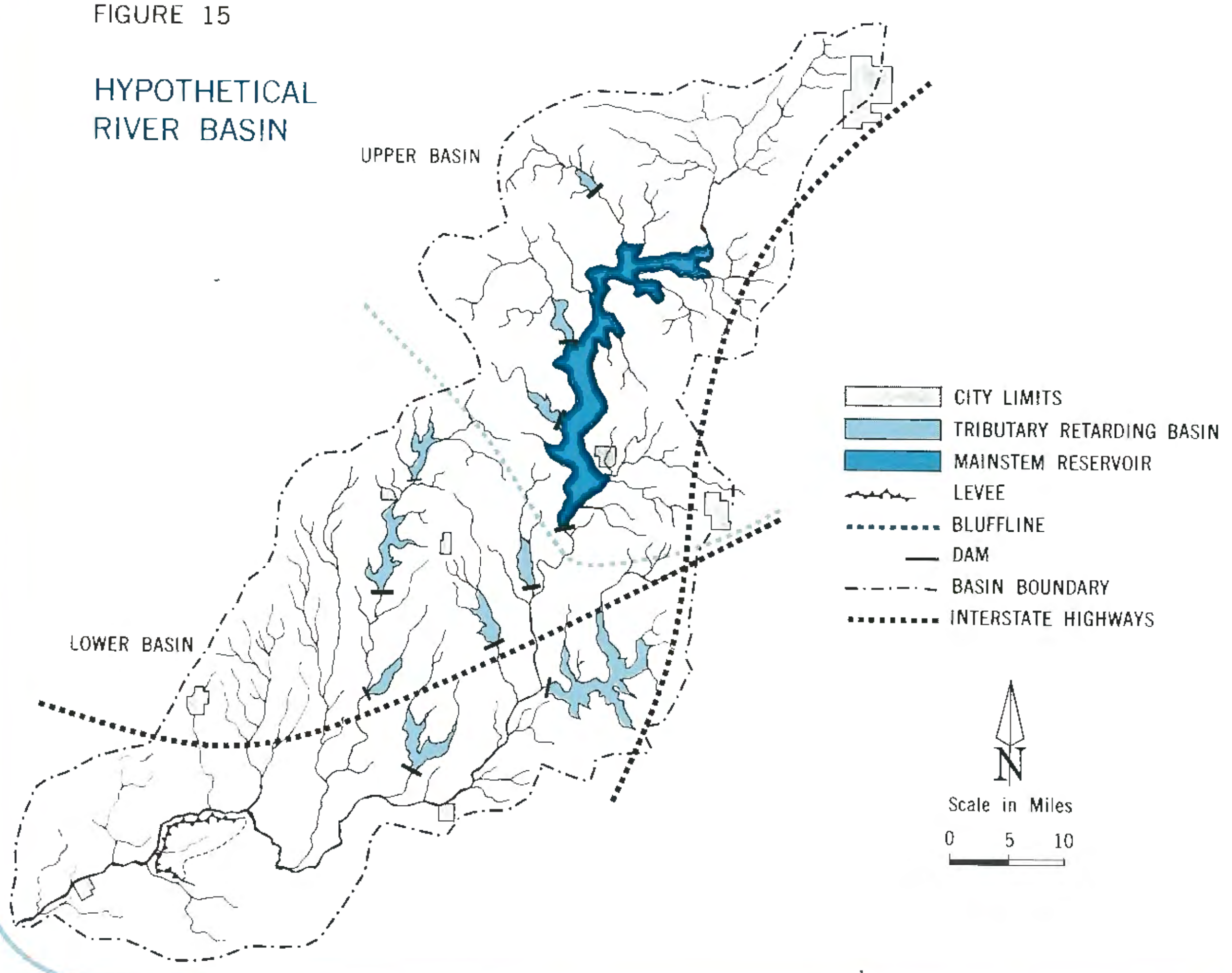
Flood control is only one of the many goals of river basin planning. Since flood control is one of the important elements of water resources development that receives major aid from the Federal Government, it is appropriate that some of the alternate flood control developments for a hypothetical basin should be analyzed here.

In this hypothetical analysis of flood control developments on a river basin, a large main-stem flood control reservoir is contrasted with a headwater retarding basin system and levee district. The purpose of the main-stem reservoir is to reduce flood damages to the bottom land downstream of the reservoir. The headwater retarding basins and levee district plan is developed to demonstrate an alternate means of achieving flood control.

A brief description of the hypothetical basin (Figure 15) will be helpful in understanding the problems and solutions. The basin is long and narrow. The main stem flows generally from northeast to southwest. The area of the basin is 2500 square miles.

FIGURE 15

HYPOTHETICAL RIVER BASIN



The northeastern one-third of the basin, or upper basin, is in the Bloomington Ridged Plain physiographic region. The rest of the basin, or lower basin, is in the Springfield Plain physiographic region. The line separating the two regions is the terminal moraine formed by the glacier of the Wisconsin glacial period.

The topography of the upper basin is generally flat with moderately permeable soils which are highly productive. The lower basin has generally rolling topography with moderately steep slopes and slowly permeable soils which are less productive than those in the upper basin. The upper basin has poorly developed natural drainage. Drainage has been improved by the construction of numerous drainage ditches and the installation of tile under drains, but some drainage and flooding problems still remain. The lower basin has well developed natural drainage and moderately wide flood plains. In the lower basin flooding is a problem on the bottom land.

Ground water of acceptable quality and in sufficient quantity is generally available in the upper basin from drift wells and from buried pre-glacial valleys. Ground water is not generally available in the lower basin. However, sites for surface-water impoundments are plentiful because of the well developed natural drainage.

Approximately 90 percent of the land in the basin is farm land. Cash grain farming is the predominant agricultural enterprise. Less than one-third of the 200,000 inhabitants of the basin live in rural areas.

Approximately one-half of the basin population is in three municipalities in the upper basin. The rest of the urban population is in numerous small towns and villages. There are a few light industries within the basin. Two universities in the upper basin have provided the impetus for population increases in the past and are expected to continue to do so in the future. Numerous highways and railroads serve the area. Two interstate highway routes are under construction.

Stream pollution is not now a serious problem and is not expected to become one, since the State Sanitary Water Board has been functioning for many years and is in the process of formulating stream quality standards. No large increases in sanitary or industrial wastes are projected for the area.

Water-based recreational facilities, while not plentiful, are adequate, except in the upper basin, where streams are small and few suitable reservoir sites exist.

Flood Problem

The disposition of excess surface runoff is a problem over a large part of the upper basin and on the bottom land and flood plains of the lower basin. The problem in the upper basin is caused primarily by inadequate channel slope and may be considered a drainage problem. The problem in the lower basin is caused by inadequate channel capacity of the main stem. Damages result from man's encroachment upon the flood plain.

Three general solutions to the problem of the disposition of excess surface water are available: 1) transportation of the excess water by improving the drainage system. This consists of enlarging, straightening, and deepening drainage channels; 2) storage of some of the excess water and controlled release of the stored water to alter the time-distribution of the runoff to obtain lower discharges and stages downstream from the storage area; and 3) exclusion of excess waters from certain areas by levees.

With present technology and methodology, it is extremely difficult to predict the dollar value of benefits received from drainage improvements such as those needed in the upper basin. There is a well developed, but not necessarily correct, method for computing benefits from flood stage reduction. For these reasons, evaluations of the benefits of various flood control projects are often inconsistent. The relative merits are compared, but no attempt has been made to show the economic justification of either scheme.

Alternate I — Main Stem Reservoir

The proposed large reservoir will be formed by a dam on the main stem near the terminal moraine that separates the upper basin from the lower basin. The maximum pool will extend over 40 miles in the upper basin. The reservoir will control the runoff from 920 square miles or just slightly more than one-fourth the total basin area.

The reservoir will have a small amount of storage allocated to sediment, a small amount of storage for a conservation pool, which will be used for water supply, low-flow augmentation, and a seasonally fluctuating recreation pool. Operation of the reservoir requires that the recreation pool be filled before the recreation season and emptied before the flood season.

The bulk of the storage in the reservoir is allocated to floodwater storage. It is expected that the detention of excess runoff from the upper basin will provide flood stage reduction on 80,000 acres of bottom land in the main-stem valley below the dam. The greatest amount of flood stage reduction will be provided for storms which occur over the upper basin, because the reservoir has no capability for modifying flood flow from storms which occur below the drainage area tributary to the reservoir. The reservoir's effect on flood stage reduction diminishes downstream.

The proposed dam will be 107 feet high and 2200 feet long. The maximum depth of water will be 88 feet. The depth of the recreation pool will vary from 43 feet to 55 feet. The maximum surface area of the reservoir will be 21,000 acres. The surface area of the recreation pool will vary from 4500 acres to 8000 acres. Development and control of the shoreline will require an additional 17,000 acres. The total volume of storage is 600,000 acre-feet, of which 540,000 acre-feet is for floodwater storage. The flood storage volume will contain 11 inches of runoff from the basin above the dam.

Alternate II — Headwater Structures and Levee

The plan of action for the control of excess surface waters would include the development of retarding basins on the tributary streams. Numerous sites are available and were investigated. Twelve of the best sites were selected, and the retarding basins were designed to store the 100-year runoff event and spill any excess. The basins control the runoff from 700 square miles. The height of the twelve dams varies from 20 feet to 40 feet. The flood storage capacity is 200,000 acre-feet.

Three sites on one tributary are planned to function as a recreational complex and as retarding basins. The two upper reservoirs are narrow and deep with steep slopes. These two reservoirs will clarify and regulate the water flowing into the lower reservoir. The lower reservoir is relatively shallow and has flat shore slopes. The lower reservoir will be desirable for intensive shore development and for boating and water skiing. The upper reservoirs are better suited for fishing and less intensive shoreline development. The total water surface area of the recreational complex is 9000 acres.

The estimated cost of the flood control features of the recreation reservoirs and of the nine major retarding basins is $14.5 million. The cost of the recreational facility is $4.5 million.

A study of the topography and hydrology of the lower basin reveals that, after the retarding basins are completed, flooding will still occur on a concentrated area of bottom land containing approximately 17,000 acres. The levee used to protect this area is about 16 miles long and has an average height of 9 feet. Interior drainage will be provided by a gravity outlet and by a 350-cfs pumping station that will be used when discharge in the main stream prevents gravity flow. The total cost of the levees and pumping station is $1.5 million.

Table 6 presents a comparison of the benefits of the two alternate plans of development. Careful inspection of the tabular data and the foregoing discussion shows conclusively that the headwater plan is the best solution to the flood control and water resources problems under the assumptions of the hypothetical basin. Not only does Alternate II cost $14 million less than Alternate I, but it also leaves 15,000 acres of land on the local tax rolls and provides flood control benefits to an additional 37,000 acres of land, most of which is located in the agriculturally rich upper basin.

TABLE 6

COMPARISON OF MAJOR FEATURES

	Alternate I Main Stem Reseroir	Alternate II Headwater Plan
Total project lands required	38,000 acres	23,000 acres
Lands permanently inundated	8,000 acres	9,000 acres
Joint use lands	13,000 acres	14,000 acres
Drainage area controlled by major impoundments	920 sq mi	800 sq mi
Flood control storage converted to inches on 2260 sq mi	4.0 inches	3.5 inches
Flood plain lands to be benefited	80,000 acres	117,000 acres
Cost of Flood Control	$19.0 million	$14.5 million
Cost per acre benefited	$237.0	$124.0
Low flow augmentation and future water supply	7 mgd	None
Recreation Areas: Water Land	8,000 acres 30,000 acres	9,000 acres 14,000 acres
Costs over and above flood control	$14.0 million	$ 4.5 million
Total Costs	$33.0 million	$19.0 million

CASE STUDY 2. AGRICULTURAL LEVEE DISTRICTS

Agriculture has been able to develop to a position of great economic importance in Illinois through good drainage practices. As indicated elsewhere in this report, more than 18.4 percent of the Illinois crop capability is based upon artificially drained lands.

Agricultural drainage may be classified as upland drainage and as bottom-land drainage. Upland drainage is discussed in Chapter V.

Bottom land drainage projects usually involve two basic problems. The first is the exclusion of mainstream backwater from the land through the use of levees, and the second is providing a means for removing excess precipitation water from within the leveed area.

Widespread efforts to reclaim the river bottoms by numerous drainage and levee districts organized under the Levee Act of May 29, 1879, were attempted in the period from about 1880 to 1925.

Levees of only moderate heights were originally built by the levee districts because of limited resources. The levees were soon overtopped. They were generally constructed without any knowledge of hydraulic design, with little regard to flood frequency and stage, and without adequate knowledge of the effect of levees on flood stages. Only very limited and spotty historical and recorded gage data on river stages were available. Because of the inadequate development of levee improvements, it was soon necessary for the State and Federal Governments to come to the aid of the levee districts, which had become substantial contributors to the economy. The districts adjoining navigable streams were considered to be within Federal jurisdiction under the commerce clause of the Constitution.

The records regarding levee improvements show efforts to control the successively larger floods. On the Illinois River successive improvements were made after the 1913, 1922, 1926, 1927, 1933, 1936, and 1943 record floods. The 1943 flood is still the flood of record. New levees and rebuilt levees on the Mississippi River below Grafton and and on the Illinois River are now capable of withstanding the floods of 1844 and 1943, respectively, usually with several feet of additional freeboard to protect against wave wash. Each of these floods is currently considered to have a design recurrence interval of 100 years or greater.

Flood Damages

Each flooding of a levee district, while inflicting heavy individual loss and mounting overall flood damage to the State, primarily resulted in crop loss, field damage, residential damage to a dozen or so farm homes and outbuildings, and in some districts damage to a small village of 100 homes or less.

Migration from the farms and small villages to the urban centers during the past twenty years has reduced potential non-crop damage within agricultural levee districts. Moreover, the demand for better housing, the desire to live in communities, and the desire to remove themselves from flood threat has caused many farm families to live permanently on the uplands.

Modernized Districts

Nearly all levee districts along the main stems of the Illinois and Mississippi Rivers are being or have recently been upgraded and modernized to provide adequate protection against main-stem flooding, if the protective works are properly maintained by the drainage district. Interior drainage ditches are generally adequate. The major problem facing these districts is the continued high-grade maintenance effort necessary. A regular maintenance program should be established with provision for adequate professional advice.

Most existing and proposed agricultural levees along the major tributaries of the Illinois and Mississippi Rivers and in the Wabash River Basin are designed to give flood protection against storms with recurrence intervals of from two to fifteen years. Fewer people live on the land in these areas because the levee system is frequently inadequate. Thus, the non-agricultural damage in these areas is usually minimal.

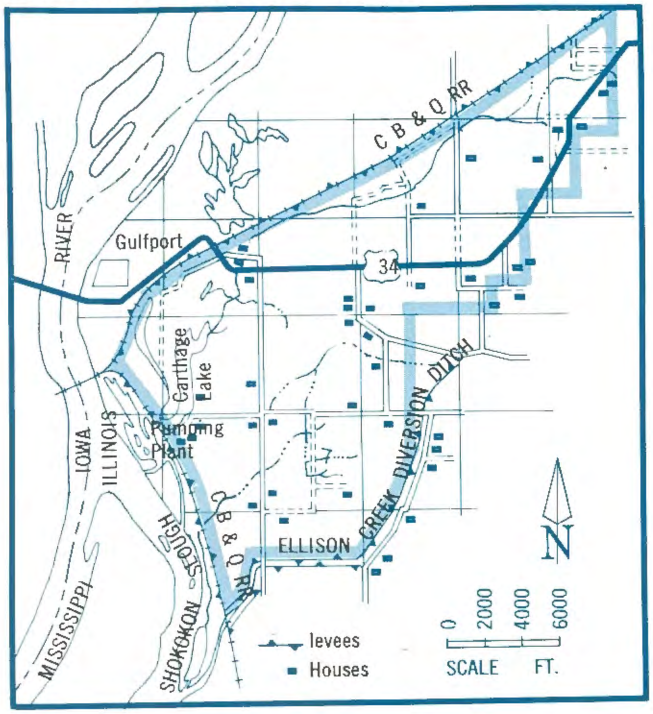
In those agricultural levee districts which have completed main-stem, interior, and hillside flood protection works, the remaining problems will be routine maintenance and land management, particularly the control of silt.

Upgrading of levee districts having main-stem protection against a flood of from two to fifteen years recurrence interval on tributaries of the Illinois, Mississippi, and Wabash Rivers does not appear to be economically desirable at this time. However, continued loss of cultivated acreage to urban development of upland agricultural lands and urbanization of bottom-land agricultural districts, especially along the Illinois River, may soon require upgrading of these low protection levee districts. Continued land use pressures may also require that protection be provided in areas where it is not now economically feasible to do so.

Henderson County Drainage District Number 2

Henderson County Drainage District Number 2 along the bank of the upper Mississippi River in Henderson County across from Burlington, Iowa, has been selected as an example of an existing agricultural levee district which has basically adequate main-stem and interior protection, is not likely to experience significant urbanization, and has typical maintenance problems (Figure 16).

FIGURE 16
HENDERSON COUNTY DRAINAGE DISTRICT NO. 2



It was organized as a private district in 1911 and originally included 7620 acres. The 2.9 miles of the main river levee and 4.3 miles of flank levee protect the district. The levees were originally constructed by local interests to supplement the CB&Q Railroad embankment to keep out flood waters from the Mississippi and from Ellison Creek. The District improvements also include more than 7 miles of interior drainage ditches and an interior pumping station at Carthage Lake, about 2 miles south of Gulfport. The District was flooded in 1924 by a break in the Ellison Creek flank levee.

Under the authority of the Flood Control Act of 1928, the Federal Government improved 4.9 miles of levee in this drainage district during the period from 1930 to 1942. Local interests paid one-third of the cost. Improvements completed to June 30, 1962, cost $315,100, of which $265,100 was non-Federal expense. Net accumulated damages which were prevented from 1932 to date are estimated at $4,718,000. The ratio of benefit to cost for the period is 14.8 to 1.0.

Further improvement of levees in this drainage district was authorized by the Flood Control Act of 1954 and is now underway. The estimated construction costs are $1,060,000 Federal and $105,000 non-Federal. The average annual benefits from this project are estimated at $118,500. Damages that would be prevented if the project flood occurred are estimated at $819,700.

The April 1965 flood on the Mississippi River, with the highest water stages of record in this reach, inundated the drainage district, silted up many of the interior drainage ditches, destroyed sections of local roads, and damaged the pumping plant building and machinery. Most of the farmhouses and buildings were flooded and damaged. Federal aid under Public Law 875 was provided to the District for flood-fighting costs and to restore the interior drainage ditches, public roads, and the pumping plant to a workable condition.

It now appears that, when the present authorized project is completed, the levee system will be at a sufficient height to protect the district from any flood in the foreseeable future. The District expenses will then consist of maintenance and operating costs to maintain an efficient drainage system. These costs will fluctuate with the material and labor price index.

Property owners within the various levee districts will be sorely tempted to press for reduction in the annual maintenance assessment. It is to be hoped that maintenance and operating standards will be held to a high level so that the levee districts will be adequately prepared to meet such unusual flood conditions as those of the 1965 flood. Economic pressures against the landowner are real and significant, as are the desires of utility and transportation units. Nonetheless, without adequate maintenance and operating safeguards, there will be no property to operate.

Henderson County flood, 1965.

CASE STUDY 3. URBAN OCCUPATION OF AGRICULTURAL LEVEE DISTRICTS

In Illinois, early flood control activity was carried out in conjunction with land reclamation for agricultural use along the Mississippi, Illinois, and Wabash Rivers by various levee and drainage districts organized under the Levee Act of May 29, 1879. Two notable exceptions were the East Peoria Drainage and Levee District and the East Side Levee and Sanitary District, which includes East St. Louis and vicinity. These two districts were organized to serve areas partially urban and partially agricultural in character.

Recent growth of certain urban regions along the Mississippi and Illinois Rivers has caused communities to expand into adjacent agricultural levee districts. Such expansion causes problems in finance and maintenance and also changes the flood control needs of the area. Industrial expansion has made the East Peoria Drainage and Levee District almost wholly urban. In the East Side Levee and Sanitary District, the principal values today are overwhelmingly industrial and urban. Wood River Drainage and Levee District; Chouteau, Nameouki, and Venice Drainage and Levee Districts; and Prairie du Pont Levee and Sanitary District in Madison and St. Clair Counties have become predominantly urban. Drainage and levee districts in which there is wide urban development include South Quincy, Pekin, and LaMarsh; and South Beardstown and Valley behind the Sid Simpson Levee project.

Agricultural areas along Rock River in Rock Island County are expected to become urbanized, as are Prairie du Rocher and Edgar Lakes Drainage Districts. The latter two areas will be profoundly influenced by industrial development at the mouth of the Kaskaskia River. Nearly all the levee districts along the Illinois River may experience some industrialization.

Industrial and Urban Growth

Occupation of agricultural levee districts by urban and industrial uses is generally viewed by the local citizenry as a highly desirable development. Lands behind the levees are relatively cheap and are available in large tracts. They are adjacent to economical water transportation and are highly attractive to industry. Industrial occupancy broadens the economic base of the district, and the fiscal health of the nearby urban center is greatly improved. The danger is found in the staggering loss to industry and the surrounding community if the district should be inundated.

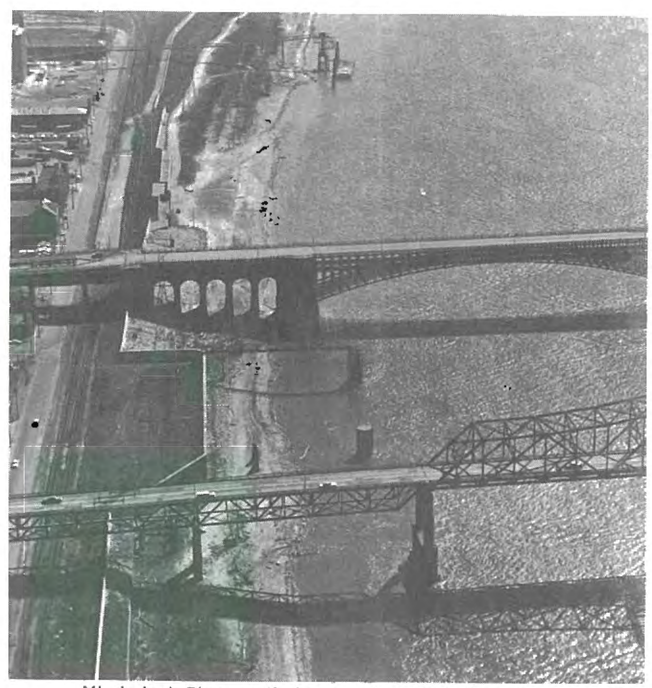
Inundation or near-inundation of an agricultural levee district usually results in the demand for larger levees built at local, State, or Federal expense. Inundation of a fully urbanized district simply cannot be tolerated because of the great economic implications to the region or entire State.

Discussion of the danger of rising potential flood damage by urbanization of agricultural levee districts is not meant to deter industry from considering district locations, nor is it intended to discourage such development. It is intended to caution industry, city, and drainage district officials of the need for increasing the adequacy of drainage district facilities and for developing adequate interior occupancy regulations. It is also intended to establish the fact that complete urbanization usually brings to an end the independent function of the district as an agricultural entity. There comes a point in time when the policy must assume that the district will never be flooded. This is true today of the East Side Levee and Sanitary District at St. Louis. Potential flood damage, if that district were inundated, would exceed an estimated $800 million.

The East St. Louis and vicinity project of the Corps of Engineers is an excellent example to further illustrate the concept of urbanization of levee districts.

East St. Louis and Vicinity Project

East St. Louis and vicinity is contained within a levee protection project authorized by the Federal Flood Control Act of June 22, 1936. It protects



Mississippi River earth levee and flood wall at East St. Louis.

approximately 85,820 acres. The area, located in Madison and St. Clair Counties, is highly developed. The major portion of the area is devoted to industrial, commercial, and residential uses, and the remaining portion to agriculture, including highly specialized production of horseradish.

The project includes that part of American Bottoms between the bluffs on the east and the Mississippi River and Chain of Rocks Canal on the west, and extends from Cahokia diversion channel on the north to Prairie du Pont Creek on the south.

Mississippi River Flooding

The first and most apparent flood problem is that posed by flows in the Mississippi River. The Mississippi threat has been largely alleviated by construction of a series of levees and flood walls. Construction on these progressed sporadically after 1835, but no comprehensive system of levees and drainage canals took shape until the 1903 flood provided the needed incentive to form the East Side Levee and Sanitary District. Construction of a complete system of levees for protection to the 45 foot height on the St. Louis gage was undertaken in 1911 and completed in the 1920s. With passage of the Flood Control Act of 1936, the Corps of Engineers assumed responsibility for providing protection from floods with a frequency of up to 200 years by raising the levees to 47 feet, St. Louis gage, plus 2 feet of freeboard. This work was essentially completed in the 1950s, but restudy of flood flows based on more recent hydrologic and hydraulic data indicated that the 200-year flood could reach a St. Louis gage height of 52 feet, depending upon the amount of deposition material contributed by the Mississippi River and on several other factors.

The present project provides for raising and enlarging the existing levee system by reconstruction of 4.8 miles of upper flank levee, 10.4 miles of river front levee, and 4.6 miles of lower flank levee. Included within the 10.4 miles of river front levee is 3.1 miles of flood wall construction. The project also provides for necessary appurtenant works, consisting of gravity drainage structures at highway crossings, alterations and reconstruction of existing pumping plants, surfacing of service roads on the levee crown, seepage correction measures, and making necessary alterations to railroad tracks and bridges at levee crossings. An additional front protection has been provided by the levee work done as part of the Chain of Rocks Canal project.

The Federal levee improvement work is now virtually complete. The estimated construction cost is $23,121,000 with $1,321,000, or 5.7 percent, being provided by the East Side Levee and Sanitary District.

Interior Drainage Flooding

The second flood problem faced by occupants of the District is local inundation from heavy rains in East St. Louis and the surrounding area. Water falling on the nearby uplands to the east drains to the flood plain at the foot of the bluffs. From this location, runoff must move several miles across the flat gradient of the flood plain to reach Prairie du Pont Creek, a small tributary to the Mississippi River located outside the drainage district. In the American Bottoms, differences in elevation of more than 20 feet are uncommon and in most places the relative relief is less than 10 feet. The Bottoms are scarred with oxbow lakes and marshes which are remnants of the former meandering course of the Mississippi. It is in these broad depressions, usually located well back from the River and commonly near the base of the bluffs, that the drainage from the uplands and the rain which has fallen on the Bottoms must accumulate and travel before reaching the River. Flow velocities are so slow that it takes the water several days to reach the River. It is this kind of flood problem which caused an estimated $5 million in damage to East St. Louis and vicinity in June 1957.

In 1950, seven years before the flood, a report was published by the Waterways Division recommending a plan for hillside diversion at a cost of $12.2 million. Following the spring floods of 1957, the Congress authorized a survey of the interior flood problem. This survey recommends a plan for a project which would cost about $9.3 million. The Waterways Division flood control plan was designed to protect against the maximum flood of record at that time—the 1946 flood. Because of development of the region in the preceding decade and other considerations, the Corps of Engineers flood control plan was designed to protect against a flood with a recurrence interval of only 50 years.

Land Use Patterns and Trends

Figure 17 shows the urban growth of the East St. Louis area. In the mid-1800s, East St. Louis was located at the point where railroad cars were loaded onto ferries for transfer across the Mississippi River to St. Louis. Completion of Eads Bridge in 1875 started the decline of ferry service, which eventually disappeared. The railroads quickly expanded in the area, converging at the Eads Bridge. Later the building of MacArthur Bridge to the south and McKinley Bridge to the north gave two other crossings to the railroads. Extensive tracts of relatively level and cheap land with good railroad access

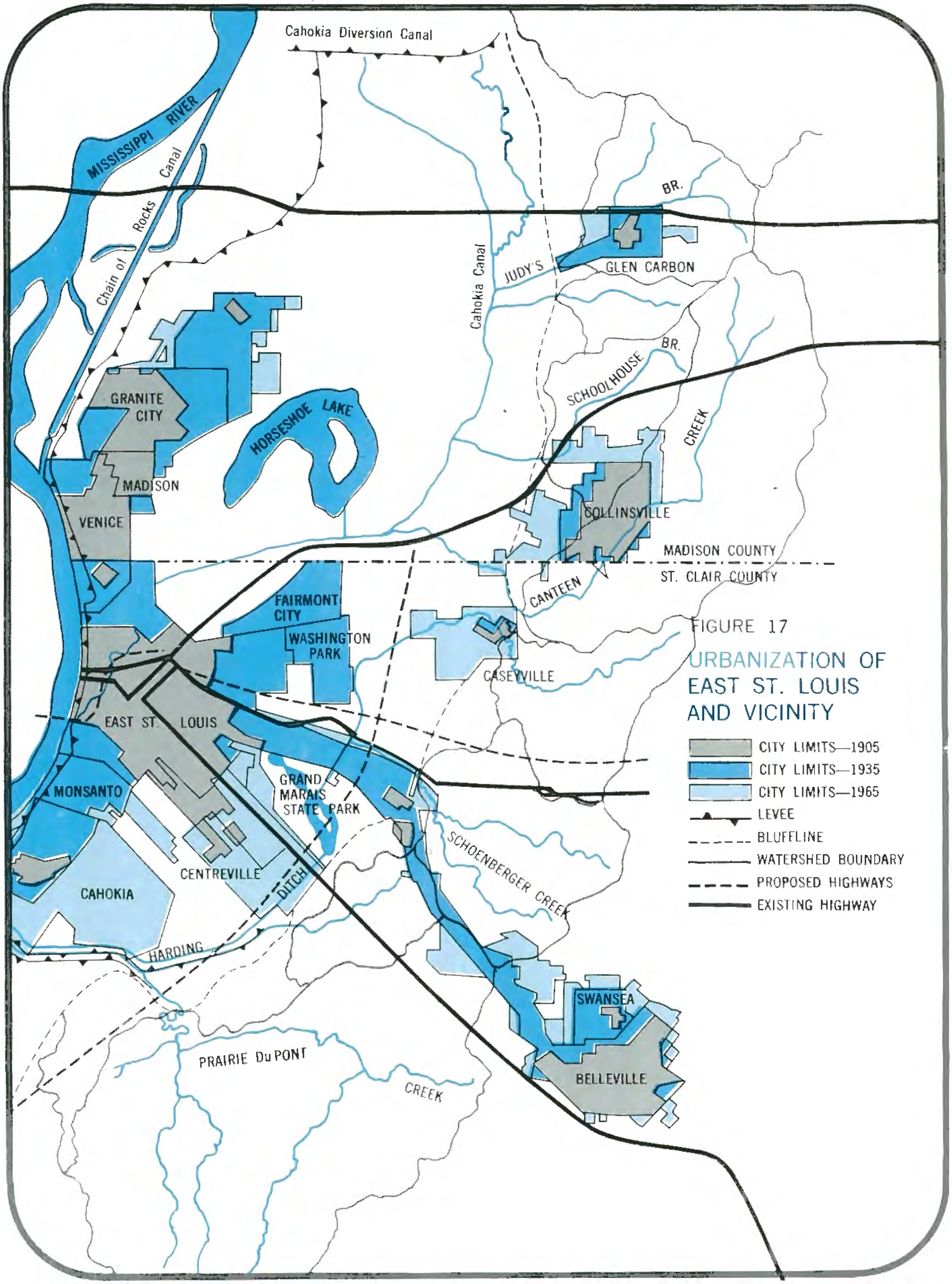


FIGURE 17
URBANIZATION OF EAST ST. LOUIS AND VICINITY

attracted industry to the area. Urbanization was well established by 1900.

Much of the growth and industrial expansion of the area took place between 1900 and 1929. Some industrial expansion has continued since 1929, but most of the recent expansion has been residential. There has been considerable growth of Metropolitan St. Louis in the Wood River area. Improvement of the highway system has developed a large commuter traffic to St. Louis.

From about 1950 to 1960 the activity of the area declined. Some industry relocated outside of the St. Louis Metropolitan Area; the central business district of East St. Louis lost business to suburban shopping centers, and East St. Louis lost population to the bluff communities. The flood of 1957 had no profound effect on the economic factors which contributed to the general decline of the region, but it certainly influenced the decision of a number of residents and small businesses to move out of the bottom land.

From about 1960 to date, the region has slowly acquired new physical facilities, making it once again attractive for development. Virtual completion of the new levee and seawall protective works, coupled with present construction of Interstate 55-70 and the new Poplar Street Bridge directly across from the Jefferson Memorial Expansion Arch, has contributed to the rebirth of the immediate river front in East St. Louis. Completion of Interstate 55-70 and upgrading of U. S. 460 has made the central core area of the region accessible to the growing bluff communities. The scheduled completion by the early 1970s of Interstates 64 and 255 will make East St. Louis more accessible. A river front expressway across St. Clair and Madison Counties to connect with Interstate 255 at Jefferson Barracks Bridge and Interstate 270 at Chain of Rocks Bridge is now in the planning stage. Interstate 270 bypassing East St. Louis and St. Louis is now completed in Illinois across the northern part of the district. East St. Louis is preparing a massive $250 million expenditure for a four-phase program of renewal over the next several years. This program would affect 13,000 people and 4745 buildings, mostly in the southern portion of the City.

The effect on this urban development and growth will be virtually complete urbanization of the East Side Levee and Sanitary District. The northern portions on either side of Interstate 270, now devoted mostly to truck farming, will likely be developed as a residential area. This may also be true of the lands on either side of proposed Interstate 255 in the southern portion. Enlargement of Cahokia Mounds State Park will remove much of the farmland in that area. Residential development adjacent to the park will eliminate the remaining farmlands. Industrial development between the river levee and proposed river expressway would complete urbanization on the western side of the district.

It is essential that a comprehensive plan of interior drainage improvement be completed at the earliest possible date. Potential detention areas should either be purchased or zoned for present use which is compatible with future use as detention storage basins. Loss of detention reservoir sites along the bluff road will seriously jeopardize any effective planning of interior drainage improvement. If detention storage is not available at the time of development, a plan of protection against a flood of a low frequency of five to fifteen years will have to be predicated upon expensive interceptor sewers or unsightly, expensive-to-maintain interceptor ditches.

A plan for control of interior flooding should be completed at the earliest practical date. Implementation of this plan should be concurrent with development of the area.

CASE STUDY 4. FLOOD-PLAIN ZONING

DuPage County in the Northeastern Illinois Metropolitan Area has been selected as an example of the importance of flood-plain regulation as a sound basis for flood control construction. The area is subject to rapid urbanization and has great need for flood control improvements because of present damage and future growth.

DuPage County has a long history of flood and drainage problems resulting from the poor natural drainage pattern and from the inadequacy of the existing natural channels to contain the runoff from the intense thunderstorm precipitation common to this region. In recent years, haphazard occupancy and urbanization of the flood-plain areas adjacent to the main streams in the County, particularly Salt Creek and the East and West Branches of the DuPage River, has greatly increased flood loss and damage to life and health. Existing problems of storm water outlet, low-flow control, waste treatment and disposal, and lack of water-related recreational facilities have been aggravated beyond the point of being nuisance factors. These now are definite problems which require specific and immediate remedial measures to protect present investments and to aid in the continued growth of the County.

The urban trend in DuPage County is illustrated in Table 7, which shows past, present, and projected population growth for the County. The population

TABLE 7

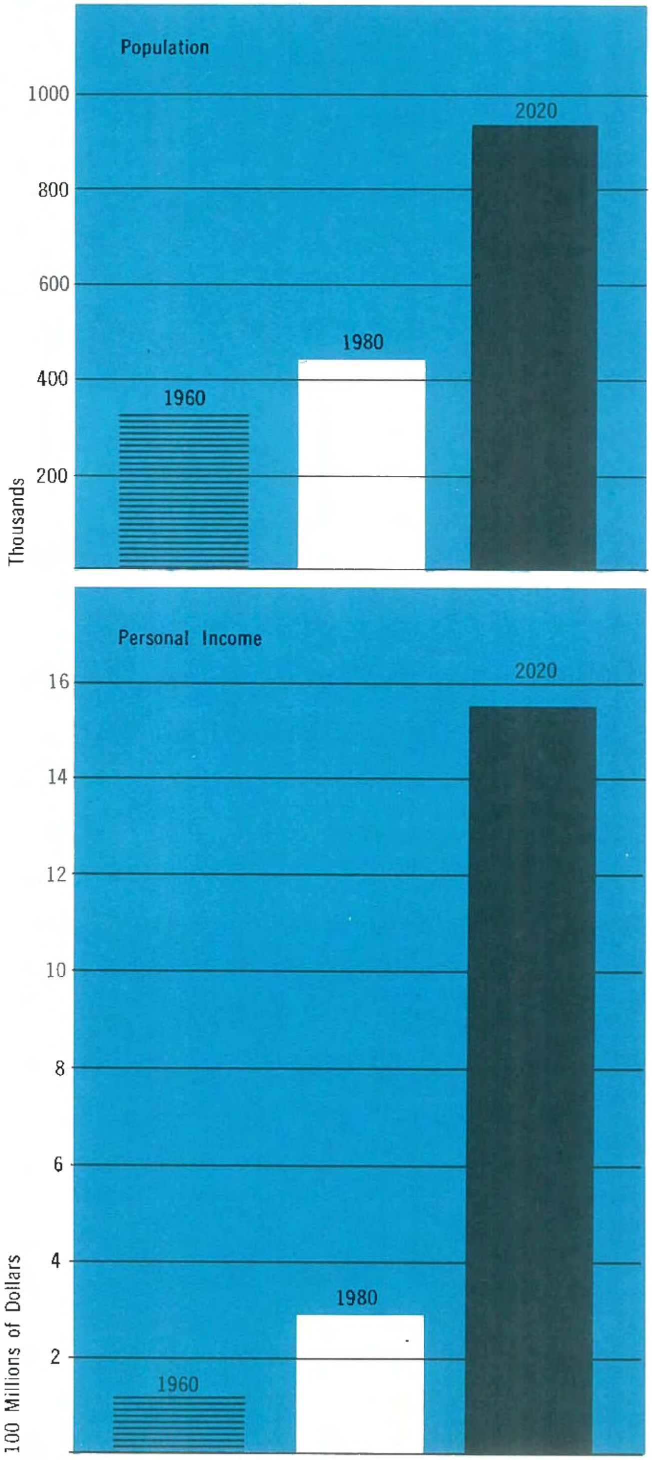
POPULATION GROWTH IN DU PAGE COUNTY

Year	Population	Population Change	Percent of Growth	Population per Sq Mi
1930	91,998	—	—	278
1940	103,480	11,482	12.5	313
1950	154,599	51,119	49.3	467
1960	313,459	158,860	102.8	947
1980*	440,000	126,541	40.4	1,330
2020*	935,000	495,000	112.5	2,825

* Estimates

density has tripled in the last 30 years and is expected to triple again in the next 60 years. Figures 18, 19, and 20 depict the projected future economy, population density, and urbanization. Not shown are the many unincorporated areas of residential growth which surround each town and spread out along the rural highway network throughout the County.

Following damaging floods in 1948 and 1950, county and municipal authorities in DuPage, Will, and Cook Counties asked the State to make extensive surveys



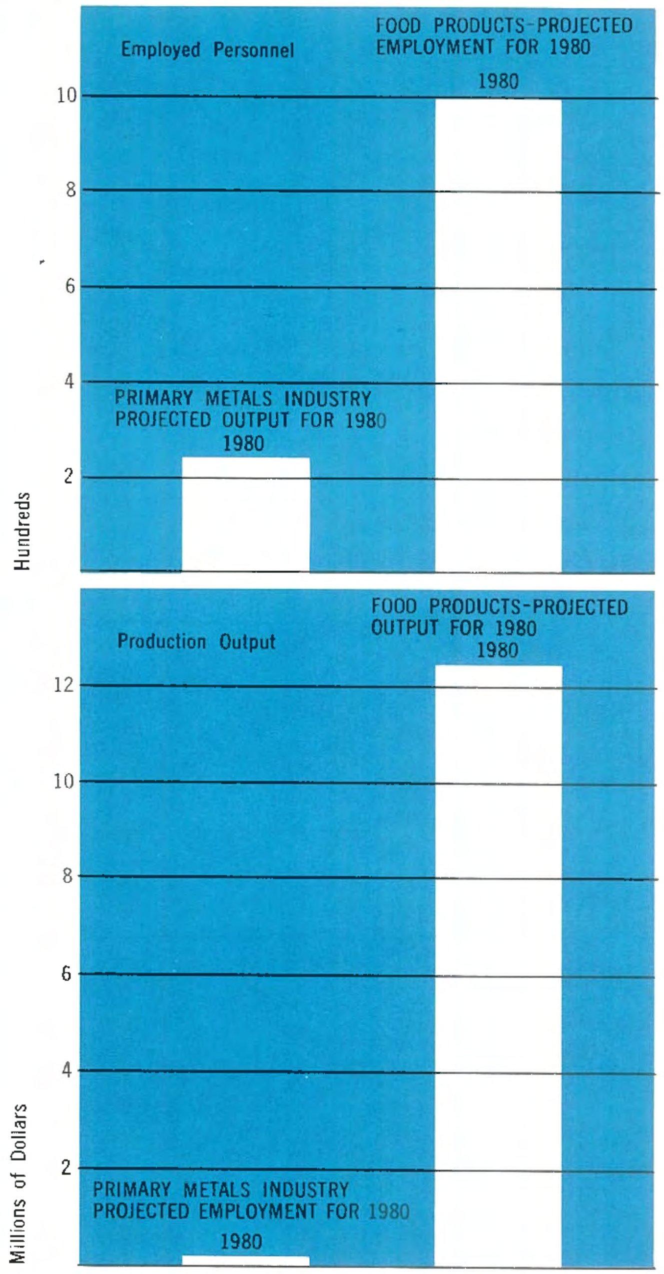


FIGURE 18

DU PAGE COUNTY ECONOMIC INDICATORS

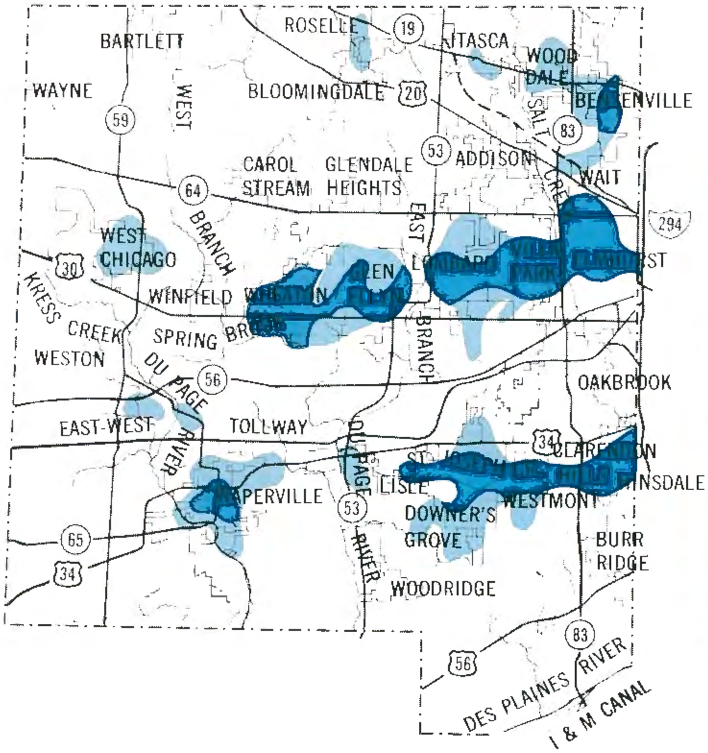
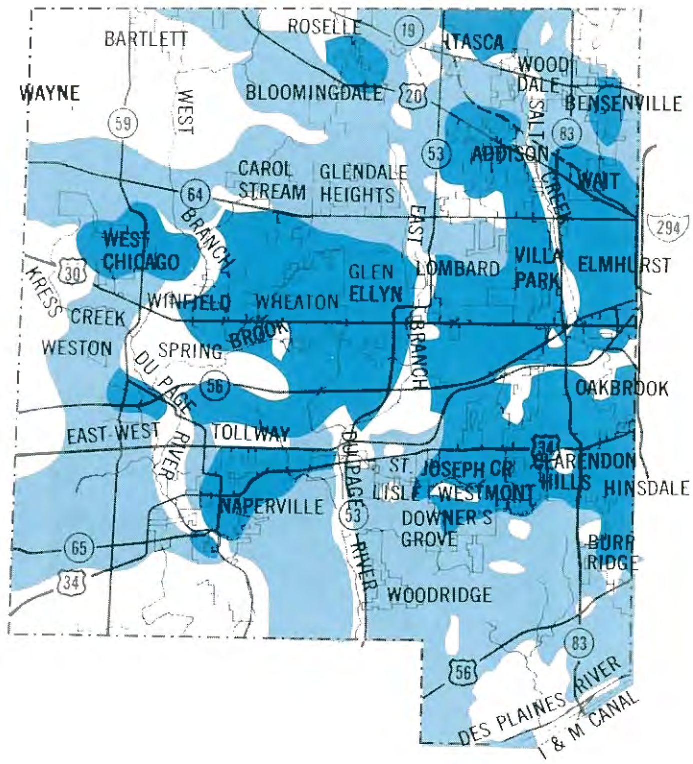


FIGURE 19

DENSITY OF POPULATION DU PAGE COUNTY, 1960

2000 PERSONS PER SQ. MI.
4000 PERSONS PER SQ. MI.



DENSITY OF POPULATION DU PAGE COUNTY, 1980

2000 PERSONS PER SQ. MI.
4000 PERSONS PER SQ. MI.

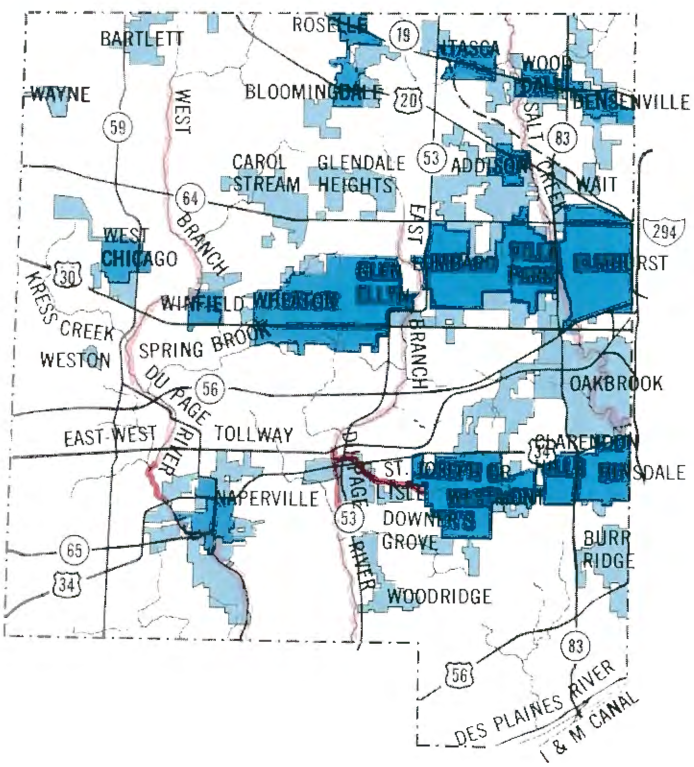


FIGURE 20

URBANIZATION OF DU PAGE COUNTY

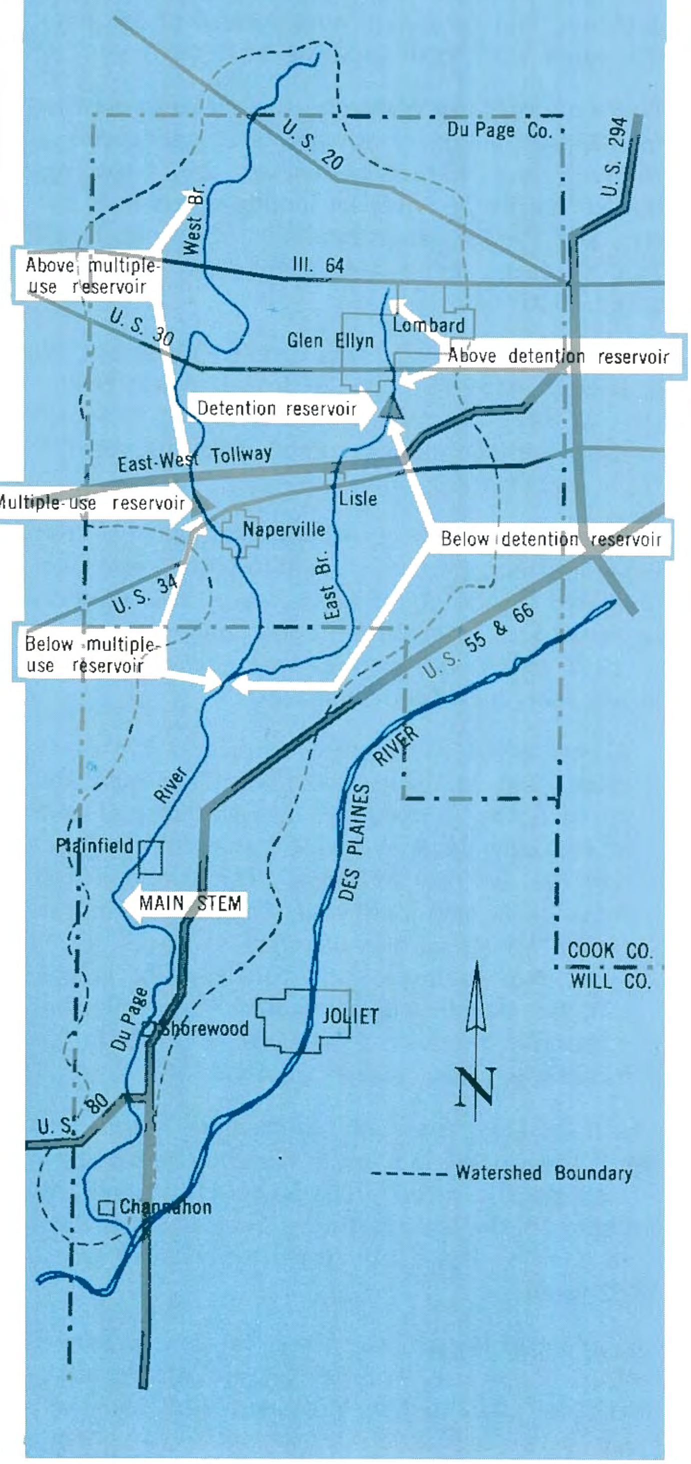
CITY LIMITS—1940
CITY LIMITS—1965
PROPOSED HIGHWAYS
PROJECTS IN PROGRESS
PROJECTS COMPLETED
PROPOSED PROJECTS

and flood control studies of Salt Creek and of the East and West Branches of the DuPage River. Interim reports on these streams were issued in 1955. Damaging floods occurred again in 1954 and 1957, which prompted requests for extension of the original surveys to include tributaries to the main stream and for expansion of the engineering studies to consider other facets of water use in conjunction with the flood control studies. The main-stream comprehensive report on Salt Creek was published in 1958, the DuPage River report in 1962. Basically, these reports recommend a program of channel improvement and some levee and flood wall construction and propose two detention reservoirs on the DuPage River in DuPage County, one just upstream of Naperville on the West Branch and the other upstream of Lisle on the East Branch.

The improved river system proposed by the Division of Waterways is shown in Figure 21. For purposes of this report the project may be summarized as follows:

FIGURE 21

PROPOSED IMPROVEMENT ON THE DU PAGE RIVER



Main Stem of the DuPage River

Channel improvement to 110-foot bottom width and 2:1 side slopes, extensive levees, road relocations, removal of abandoned bridge, concrete headwalls and some flood walls, and interior drainage. Channel length would be 144,300 feet. Estimated cost at 1962 prices is $1,408,000.

East Branch of DuPage River

Below the detention reservoir the proposal is for channel improvement to 50-foot bottom width and 2:1 side slopes, numerous channel cutoffs shortening the channel 1.4 miles, protection of five bridges, removal of a bridge, levees and headwalls, removal of a small dam, and interior drainage. Channel length would be 79,225 feet and estimated 1962 cost would be $1,015,000.

Detention reservoir: Earth dam containing 38,000 cubic yards of earth materials, 19 feet high with 96-inch outlet and 120-foot spillway. Flood detention volume would be 880 acre-feet. The estimated 1962 cost is $151,000.

Above detention reservoir: Channel improvement to 30-foot bottom width and 2:1 side slopes, four bridge alterations, and protection of sewage treatment plants. Bottom width in upper 6697 feet would be 20 feet. Channel length would be 23,567 feet. The estimated 1962 cost is $526,000.

West Branch of DuPage River

Below multiple-use reservoir: Minor channel improvement, removal of abandoned concrete walls, brushing, interior drainage structures. Channel length 41,267 feet. Estimated 1962 cost would be $631,000.

Multiple-use reservoir: Earth dam containing 105,000 cubic yards of earth materials, 26 feet high, with two 96-inch outlet pipes and a 20-foot spillway. Provides flood detention volume of 2900 acre-feet, low-flow augmentation volume of 120 acre-feet, and recreation pool surface of 38 acres. Estimated 1962 cost would be $375,000.

Above multiple-use reservoir: Channel improvement to 100-foot bottom width and 2:1 side slopes at reservoir and 40-foot bottom at upper end, extensive levees and interior drainage, channel cutoff, and bridge improvements. Channel length 78,000 feet. Estimated 1962 cost would be $1,686,000.

The total cost of the DuPage River improvement was estimated at $5,782,000, exclusive of the cost of right of way. The program was designed to accommodate, without damage, flood flows expected to recur about once in 50 years.

Recognition of the flood hazards and damages from the indiscriminate occupation of the flood-plain lands prompted the DuPage County Board of Supervisors to revise and amend the County zoning ordinance in 1957 to include, among other changes, the following section on flood-plain areas:

> "These areas are created to protect the public health and to reduce the financial burdens imposed on the community, its governmental units and its individuals by frequent and periodic floods and the overflow of lands. The boundaries of these areas have been determined from the data in the offices of the Illinois Division of Waterways. No building or structure shall be erected with the elevation of a habitable floor, including a basement, lower than three feet above the established Flood Crest Elevation."

The flood crest elevation referred to in this ordinance is the 1954 high-water elevation as presented on topographic maps prepared in connection with the study of the DuPage River. The same elevations were used in the design project presented in the 1962 report.

The intent of the ordinance was not only to prevent indiscriminate use and occupation of the flood plains, but also to help preserve open space and green belts for future recreational development.

In general, adherence to the intent of the ordinance has been good and the flood plains have been kept open. There are some instances where encroachment has occurred because of a flaw in the zoning ordinance. The ordinance does establish a vertical-height elevation governing construction of a habitable dwelling, but no lateral or horizontal-height limits were established to prevent building on fill material to bring the habitable floor level to the required elevation.

In the case of the East Branch of the DuPage River, a new subdivision built on fill prevented use of the flood plain for the detention reservoir site specified in the report of the Waterways Division. Alteration of the reservoir plan to accommodate the subdivision entailed such extensive levee work that the detention reservoir program was abandoned.

The result of abandoning the East Branch reservoir project was to place an increased burden upon the stream improvements downstream of the reservoir site. Development of the subdivision, which was completely within the law, has precluded the reservoir development on the East Branch of the DuPage River.

Project Underway

The West Branch of the DuPage River is now being developed in accordance with the 1962 survey report. An annual report covering the reservoir development was filed with the 74th General Assembly, and legislation was passed enabling and funding initial work on the reservoir project. The cost of the reservoir project, including right of way, is less than the corresponding channel improvement that would have been required downstream of the site.

The West Branch reservoir will provide an excellent addition to the neighborhood. Arrangements have been completed with the DuPage County Forest Preserve District to maintain flood control lands as part of the District's open-space program. About 400 acres of land will be devoted to open-space use which is compatible with infrequent flooding.

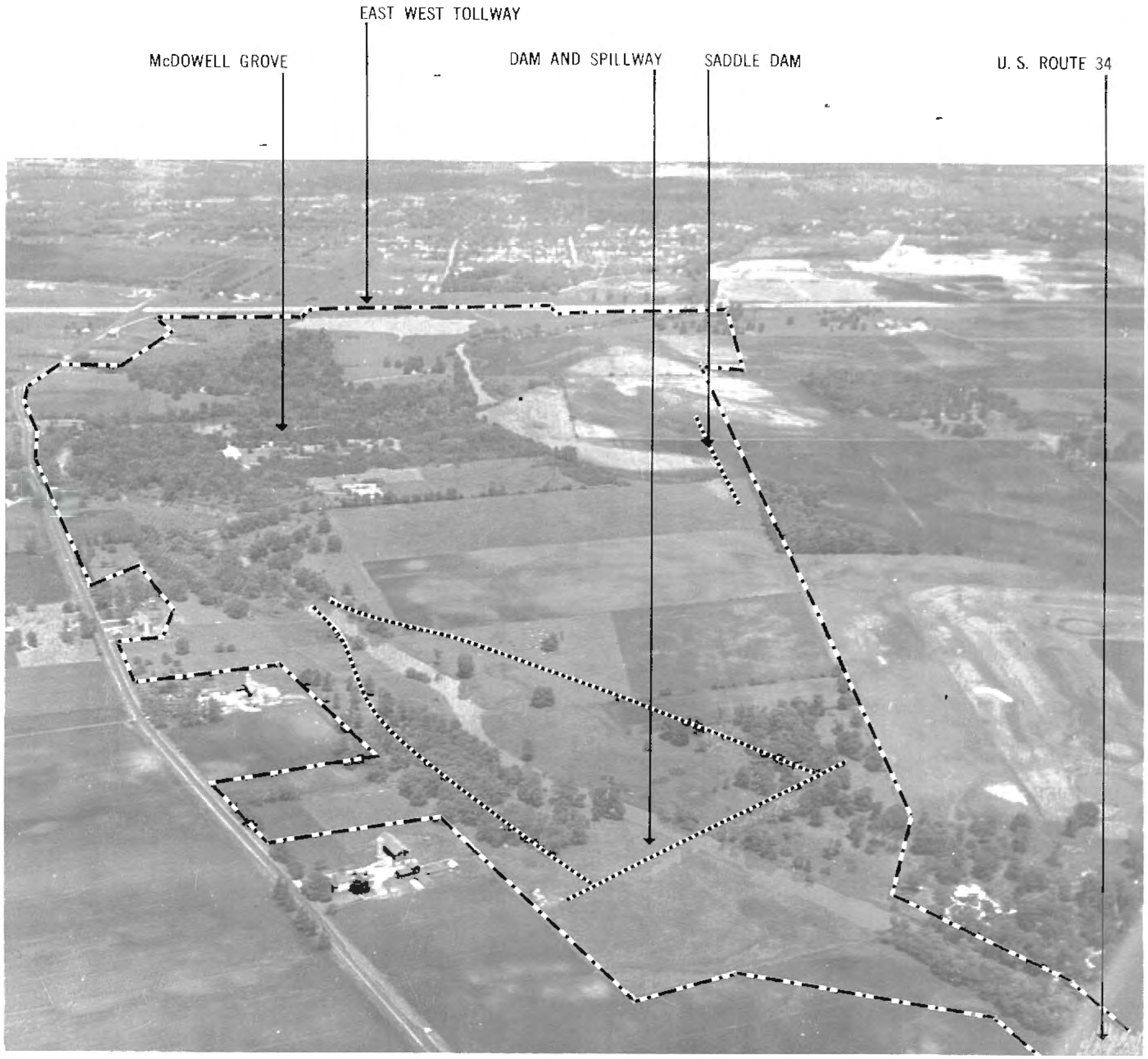
The reservoir will include a conservation or recreation pool of 24 surface acres, which will be available for canoeing and will also contain 120 acre-feet of storage for low-flow augmentation in the downstream river. When the pollution abatement pool is filled, probably during nine months of the year, the water surface for pleasure boating will be 38 acres and will include substantial relatively primitive woodland in the McDowell Forest Preserve.

The flood control storage in the reservoir will be 2900 acre-feet, which is sufficient to reduce the design inflow of 7400 cfs to 3800 cfs at outlet.

In this particular case the almost 50 percent reduction in design discharge will save sufficient expenditure in channel improvements to pay for the flood control aspects of the reservoirs and will also provide the recreation and low-flow augmentation benefits.

DuPage County is one of the few counties in the State to enact a flood plain regulation ordinance. As demonstrated above, this ordinance is not completely effective and must be strengthened by an amendment stipulating encroachment limits within which no fill or structure will be permitted. Nonetheless, without the flood-plain measure, it is most probable that both reservoir sites would have been developed for other uses. The projected population growth and increased density of occupancy point up the increasing demand for greater urban use of the flood-plain lands and also emphasize the need for more stringent laws and ordinances controlling flood-plain development.

Effective regulatory measures are essential to the establishment of any flood control program. In DuPage County, the application of such measures has already resulted in lower costs of right of way and construction for the recommended flood control improvements with resultant savings of the tax dollar. It is this kind of program that is required throughout the State.



The proposed Naperville Reservoir would be located on the West Branch of the DuPage River.

1943 Illinois River Flood at Meredosia

The State of Illinois must face its responsibility to provide a relatively flood-free environment for continued agricultural, industrial, and urban growth and development. To meet this obligation, it is essential that an aggressive and sustained program of planning, construction, and regulation be adopted and implemented. The following recommendations are presented as a means to accomplish these aims.

I. It is recommended that funds in the amount of $100 million be allocated from the Illinois Resource Development Fund for the period 1968 through 1980 for right-of-way acquisition and construction of flood control and water resources projects.

The amount of $30 million of this would be spent for high priority projects for which plans of improvement have been completed. This would allow immediate implementation of the following crucial flood control projects:

A. DesPlaines River near Gurnee $5,000,000
Project to be constructed on the DesPlaines River in Lake County near Gurnee, in cooperation with the Lake County Forest Preserve District, for purposes of flood control, low-flow augmentation and recreation.

B. Salt Creek $1,800,000
Project to be constructed on Salt Creek in DuPage County near Elmhurst, in cooperation with the DuPage Forest Preserve District and the city of Elmhurst, for purposes of flood control and drainage.

C. Addison Creek $5,000,000
Project to be constructed on Addison Creek in Cook County near Stone Park, in cooperation with the Addison Creek Conservancy District, for purposes of flood control and drainage.

D. Weller Creek $ 970,000
Project to be constructed on Weller Creek in Cook County near DesPlaines, in cooperation with the towns of DesPlaines and Mt. Prospect, for purposes of flood control and drainage.

E. DuPage River and Tributaries $9,000,000
Project to be constructed on DuPage River and St. Joseph Creek in Will and DuPage Counties, in cooperation with numerous county, municipal, and local agencies, for purposes of flood control, drainage, low-flow augmentation, and recreation.

F. Iroquois River $2,000,000
Project to be constructed on the Iroquois River in Iroquois County at Watseka, in cooperation with local authorities, for purpose of flood control.

G. Kinkaid Creek Dam and Reservoir $6,000,000
Project to be constructed on Kinkaid Creek in Jackson County near Murphysboro, in cooperation with the Kinkaid-Reeds Creek Conservancy District, the U. S. Forest Service, and the Illinois Department of Conservation, for purposes of water supply, recreation, and wildlife enhancement.

The remaining $70 million would be allocated for the period 1968 through 1980 to be used as follows:

A. For acquisition of rights of way, construction, maintenance, and operation of State facilities and works;

B. To enable the State to assist local governments in the development of feasible water resources projects; and

C. To permit the State to participate as local sponsor in proposed Federal flood control, navigation, and multi-purpose water resource projects.

II. To accomplish comprehensive water resource development planning for the major river basins of the State prior to 1980, it is recommended that $200,000 per biennium be provided in the regular budget for procurement of the requisite aerial photography, surveys, mapping, and economic data to develop such plans.

A. It is recommended that funds in the amount of $75,000 be provided to permit initiation of a matching fund program with the U. S. Geological Survey to secure Hydrologic Atlas coverage of the flood problems in the flood plains of the agricultural areas of the State.

III. To expedite the development of flood-plain regulation measures for all watersheds in the State, it is essential that a multi-faceted program be initiated involving the cooperative efforts of local, State, and Federal interests. It is recommended that the following steps be initiated to implement this program:

A. Provide funds in the amount of $100,000 per biennium to permit inauguration of a cooperative program with the U. S. Army, Corps of Engineers, and local governments to secure flood-plain information studies on streams in the urban centers of the State.

B. Provide funds in the amount of $75,000 per biennium to inaugurate a cooperative program, on a matching fund basis, to provide technical assistance and advice to local governmental units in formulating effective flood-plain regulation ordinances vital to halt encroachment of the flood-plain and prevent increase in flood damages.

C. Provide necessary funds in the amount of $50,000 per biennium to accelerate the 7.5 minute quadrangle mapping program of the entire State and to assist in the foregoing flood-plain determination studies.

IV. To protect the State's investment in its rivers, floodways, and flood control improvements, it is recommended that a program of regular maintenance be adopted, as initiated by the 74th General Assembly, through the provision of funds in the amount of $500,000 per biennium for such work. The funds would be used for snagging and cleaning streams and maintenance of engineering works.

ACKNOWLEDGMENTS

This chapter, prepared under the direction of Mr. John C. Guillou, Chief Waterway Engineer, was compiled by Mr. L. Murray Pipkin, Assistant Bureau Chief, and Mr. Albert L. Kellerstrass, Hydraulic Engineer, assisted by Mr. Ralph O. Fisher, Bureau Chief, and the personnel of the Hydraulic Design and Surveying and Mapping Section of the Bureau of Engineering.

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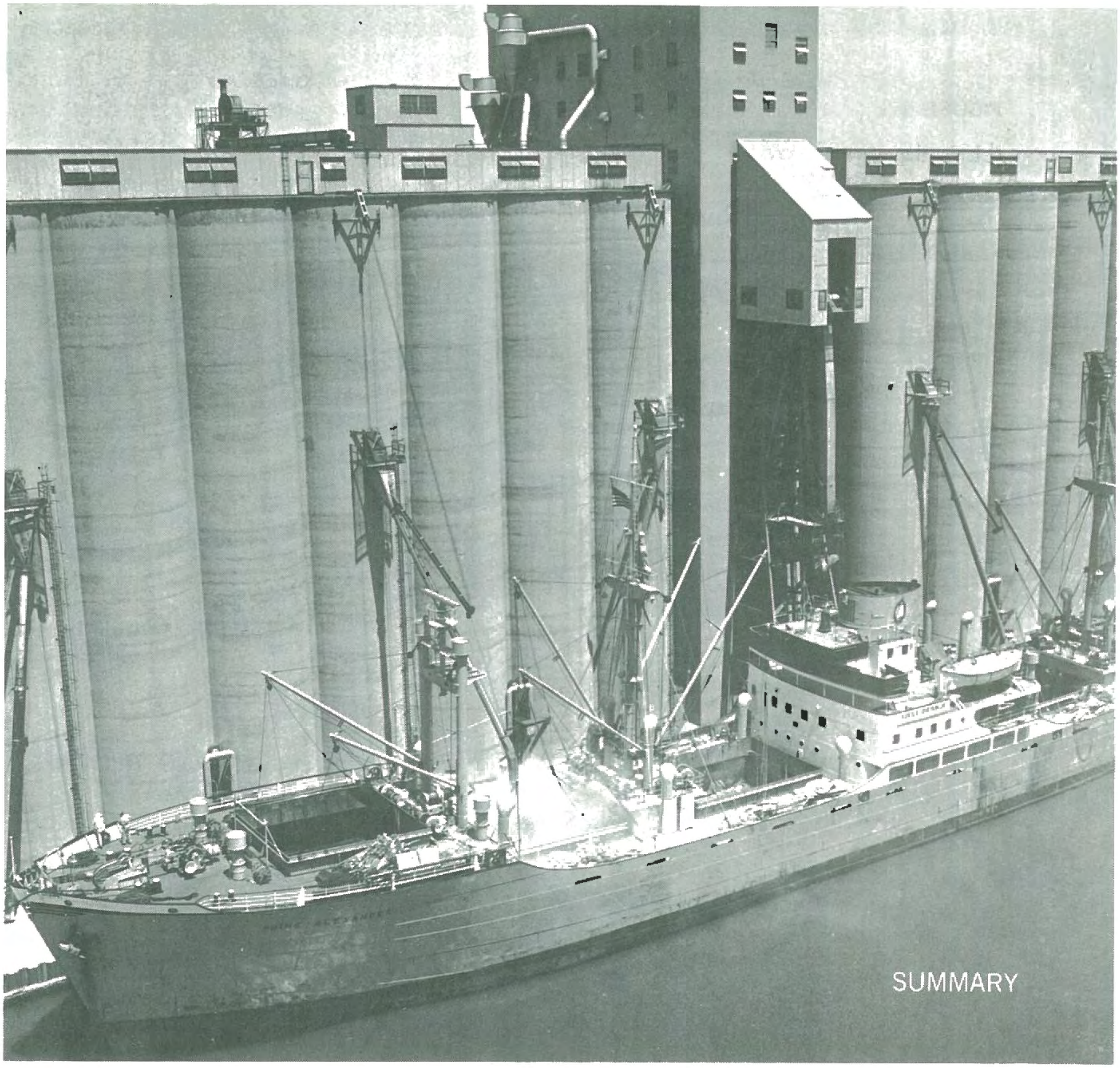
chapter seven / navigation

illinois technical advisory committee on water resources

"The decision to undertake any project should rest on actual need ascertained by investigation and judgment of experts and on its relation to great river systems and to the general plan, never on mere clamor."

Theodore Roosevelt



SUMMARY

The waterways and ports of Illinois have an important and permanent role in the State's transportation system. The Mississippi and Ohio Rivers, the Illinois Waterway, and the St. Lawrence Seaway form an extensive inland system for commercial navigation.

Since the Seaway was opened in 1959, the Port of Chicago has become an important world export center. Grain, processed animal and vegetable products, and manufactured goods enter the foreign market from Chicago. New iron ore deposits in Labrador were made accessible to the Chicago steel industry by the Seaway.

Coal travels the Mississippi and Illinois system to fuel Chicago power plants; grain is shipped by barge to New Orleans or Chicago; petroleum is shipped from refineries to Illinois distributing centers.

Waterway projects are being studied for the Illinois system, the Illinois-Mississippi Canal, the Big Muddy and Saline Rivers, and the Wabash. A navigation project on the Kaskaskia River is underway. Plans for these projects are described in case studies.

The increasing demand for water-related recreation has prompted proposals for recreational development of Illinois waterways. Most of the proposals are for development of Illinois' major rivers or conversion of abandoned commercial waterways for recreational use. The Fox River canalization project is probably the only new recreational waterway under construction in the United States.

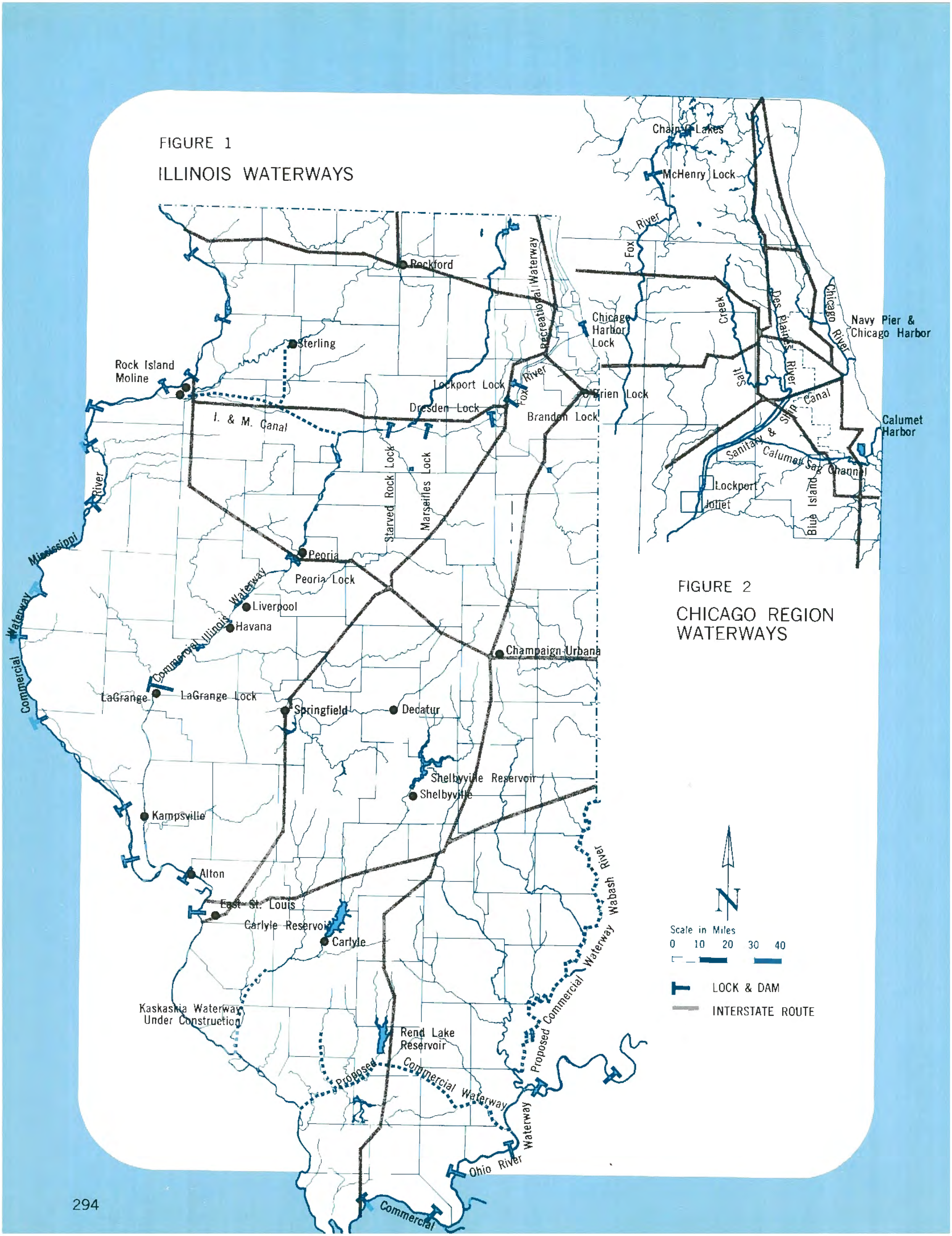


FIGURE 1

ILLINOIS WATERWAYS

FIGURE 2

CHICAGO REGION WATERWAYS

The map in Figure 1 reveals the excellent natural system of waterways in Illinois. The Mississippi River forms the west boundary, the Ohio and Wabash are the south and east boundaries, and Lake Michigan forms the northeast boundary. The headwaters of the Illinois River lie within a few miles of Lake Michigan near Chicago.

The possibility of connecting the Illinois River and Lake Michigan by a canal was noted as early as 1673 by Joliet and Marquette. This same portage from the Chicago River across Mud Lake into the DesPlaines River was used again by LaSalle in 1682 and by many others in the following years.

Holding the northwest frontier after the Revolutionary War became a problem. By the Treaty of Greenville in 1794, the Indians ceded 6 square miles of land near the mouth of the Chicago River, including the Chicago Portage. Fort Dearborn was erected near the river mouth in 1803 to protect the portage route. An ambitious scheme of roads and canals was proposed by Treasury Secretary Gallatin in 1807; his report mentioned the Chicago Portage. The War of 1812 emphasized the need for improved communications throughout the country.

In 1816 a large tract of land was ceded by the Indians along the possible canal route and a reconnaissance report was made by Major Stephen Long. During these years immigrants came to Illinois along the Ohio River and settled on the major tributaries of the Ohio, Wabash, and Mississippi Rivers.

Illinois became a state in 1818, and the First General Assembly discussed the problem of settling the undeveloped northern regions. Governor Bond urged the construction of an Illinois and Michigan Canal connecting Lake Michigan with the Illinois River in his inaugural message, and steps were taken to secure Federal assistance in Congress.

THE ILLINOIS WATERWAY

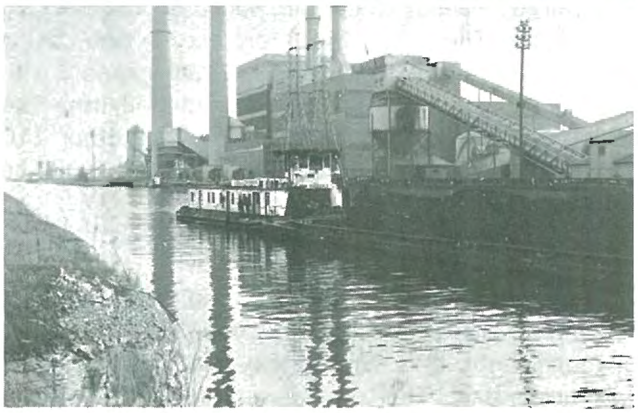
Activities of the Illinois delegation in Congress resulted in a land grant in 1827 to finance construction of the Illinois and Michigan Canal. Construction was started in 1836 but was hampered by the Depression of 1837 which slowed land sales. By 1842 construction halted because available funds and the State's credit were exhausted. Governor Ford arranged to turn the incomplete canal over to the bondholders by trust deed; the bondholders agreed to put up additional funds, complete the canal, and hold it until the debt had been paid.

The Canal was completed in 1848 by the trustees and immediately became an important route of settlement and commerce. The Erie Canal, which had been opened in 1825 along with the Great Lakes and the Illinois and Michigan Canal, formed a vastly improved route of immigration from the Atlantic seaboard to the Midwest. The tide of immigration swung from the Ohio valley to the north with settlers entering Illinois at Chicago.

Commerce increased steadily on the Illinois and Michigan Canal; the debt was discharged and the trust dissolved in 1871. However, it was soon apparent that the small size of the Canal and the shallow depths of the Illinois River were inadequate to meet the growing competition of the railroads.

Canalization of the lower Illinois River was begun with the construction of a lock and dam at Henry in 1872. This was followed by locks and dams at Copperas Creek in 1877, at LaGrange in 1883, and at Kampsville in 1893. This project partly financed from Canal funds and partly by the Federal Government provided a 7-foot channel from the Mississippi River to LaSalle. The locks, 75 feet by 350 feet, admitted the largest steamboats using the Illinois River.

In 1900 the Chicago Sanitary District opened the Sanitary and Ship Canal as a part of a project to divert sewage and storm drainage away from Lake Michigan. The minimum dimensions of the Canal were 24 feet in depth and 160 feet in width; current in the Canal was held down to favor navigation. In 1908 the power house and dam were completed at Lockport, and a lock connected the Sanitary and



Ship Canal with the upper basin of the Illinois and Michigan Canal in Joliet.

In the same year a $20 million bond issue was passed by state referendum for construction of the Illinois Waterway. This was the culmination of many years of agitation for an improved Waterway and was greatly encouraged by the construction of the Sanitary and Ship Canal. The Waterway plan provided for canalization of the DesPlaines and Illinois Rivers with four locks and dams; a new lock was to be built at Lockport. Each dam would have a hydroelectric power house, and the revenue from power leases would be used to retire the bonds.

Work began on the waterway in 1919 and was well advanced in 1930 when the bond issue funds were nearly depleted. The Federal Government agreed to complete the project if the State used the remaining bond issue funds to complete the highway bridges. Under this arrangement, the Waterway was completed and opened to traffic in 1933. The Federal Government replaced the old steamboat locks on the lower Illinois with the Peoria and New LaGrange locks and dams in 1939.

The present Illinois Waterway provides through navigation from the Mississippi River to Lake Michigan with a minimum channel depth of 9 feet. Minimum channel width is 300 feet, except in the Marseilles Canal and the Treats Island Cut-off. The Calumet-Sag Channel, completed in 1922, connects the Calumet River with the Sanitary and Ship Canal. It is now being widened to 225 feet.

OHIO AND MISSISSIPPI RIVERS

Early improvements on the Ohio and Mississippi consisted of removing snags and bypassing rapids with lateral canals. With the beginning of barge transportation near the end of the Nineteenth Century, it became necessary to canalize the rivers with locks and dams. Canalization of the Ohio River began with the construction of Davis Dam near Pittsburgh, Pennsylvania, in 1885 and was completed with 46 locks and dams in 1929. This project provided a 9-foot channel from Cairo, Illinois, to Pittsburgh, Pennsylvania, with locks of 110 feet by 600 feet. The Ohio River project is now being modernized and will provide a 12-foot channel with nineteen locks and dams. Each dam will have two locks: one 110 feet by 600 feet and the other 110 feet by 1200 feet. Two of the new dams will be located along the Illinois portion of the Ohio; one will be at Mound City and the other near Smithland, Kentucky.

The years of constructing dikes and wing dams on the upper Mississippi had only resulted in a 6-foot channel depth, and canalization by locks and dams was necessary. This project was completed in the early 1940s and consists of 26 locks and dams providing a 9-foot channel from Alton to St. Paul. In 1951 the Chain-of-Rocks Canal and Locks were completed, and the last major obstruction on the Mississippi River was bypassed.

The middle Mississippi between Cairo and St. Louis has been improved by open channel works, and a 9-foot channel is available except during extreme low water.

GREAT LAKES AND ST. LAWRENCE SEAWAY

Major navigation improvements on the Great Lakes started in 1829 with the first Welland Canal, which connected Lake Ontario with Lake Erie. The Canal was rebuilt in 1931 to accommodate large vessels. The locks have the same dimensions as those on the St. Lawrence Seaway—80 feet by 800 feet. The Canadians improved the St. Lawrence River by a system of lateral canals which provided a continuous 14-foot channel from Kingston to Montreal by 1901. This project has since been superceded by the St. Lawrence Seaway project, a joint venture of the United States and Canada. The Seaway includes seven locks, 80 feet by 800 feet, and provides a 27-foot channel from Lake Ontario to Montreal.

The second major improvement on the Great Lakes was the construction of the St. Mary's Falls Canal in 1855. This connection between Lake Superior and the other lakes opened water transportation to the vast iron ore deposits in Michigan, Minnesota, and Wisconsin. Traffic rapidly developed and required construction of additional locks on several occasions. There are presently four United States locks and one Canadian lock. The old Poe Lock is currently being replaced by a new lock which will be 110 feet by 1200 feet. These locks can accommodate the largest vessels on the Great Lakes. Traffic through the Soo has been as high as 128 million tons, but has recently fallen below 100 million tons, mainly because the iron ore reserves have been depleted.

PORT OF CHICAGO AND THE GREAT LAKES-ST. LAWRENCE SEAWAY

The Port of Chicago is strategically located at the junction of two great waterway systems (Figure 2). The Lake-to-Gulf waterway system is directly connected with deep draft navigation from the Great Lakes at Chicago Harbor through the Sanitary and Ship Canal and the Chicago River and at Calumet Harbor through the Calumet-Sag Channel and the Calumet Rivers. Traffic statistics do not tell us the magnitude of interchange between these waterway systems, but they do tell us that tremendous quantities of traffic move into and out of the port by both deep and shallow draft transportation. Since the opening of the St. Lawrence Seaway in 1959, Chicago has had an excellent deep draft ocean connection and has become an important world port.

The Port of Chicago includes three distinct port areas: Chicago Harbor, Calumet Harbor, and Lake Calumet Harbor. Chicago Harbor, which includes the Chicago River and its branches, was once the major shipping area in the port, but has been overgrown by the city. Today deep draft commerce consists mainly of overseas general cargo handled through Navy Pier and other terminals near the river mouth, newsprint received by newspaper plants along the river and a moderate traffic in salt and portland cement to various yards on the river branches. Calumet Harbor, which includes the Calumet River, now handles the largest volume of traffic. The cargo is mainly important bulk commodities such as inbound iron ore and limestone and outbound grain and coal, but the Harbor also handles substantial volumes of overseas general cargo. Lake Calumet Harbor is being developed by the Chicago Regional Port District and is the most important area for handling overseas general cargo.

The steel and cement industries are the large receivers of raw materials and have developed their own dock facilities. Grain is received by rail and barge and shipped through large public and private elevators on the Calumet River and Lake Calumet. Coal is shipped through the Rail-to-Water Transfer Terminal on the Calumet River, which is jointly owned by the large midwestern coal producers. The most important general cargo terminals have been developed by the city of Chicago at Navy Pier and by the port district at Lake Calumet and are operated by lessees. Several smaller general cargo terminals have been developed by private terminal operators.

Terminal facilities handling cargo for the public are as follows:

- Navy Pier—Berths, 6; transit sheds, 262,000 square feet; open storage, 117,000 square feet.
- Calumet Harbor and River—Berths, 15; transit sheds, 77,000 square feet; open storage,810,000 square feet; grain elevators, 32,210,000 bushels.
- Lake Calumet—Berths, 12; transit sheds, 322,000 square feet; grain elevators, 13,000,000 bushels.

All the terminals are served by rail, truck, and barge transportation. In addition, a 110-ton heavy lift crane is available at Lake Calumet.

The flow of traffic into and out of the Port of Chicago in 1964 is shown in Table 1. The leading overseas exports are raw and processed agricultural products in the following order: corn, animal feeds, edible oils and fats, soybeans, tallow, flour, hides, meat, inedible animal products, dried milk, and other vegetable products. Iron and steel, manufactured products, and chemicals are also important. The leading imports include motor vehicles, tools, and numerous other iron and steel products; liquors and wines; chemicals; vegetable products; and lumber products. Major exports to Canada are corn, soybeans, clay, wheat, and coal; major imports are iron ore, newsprint, salt, pig iron, barley and rye, and scrap iron. The origin and destination of foreign commerce in 1963 are given in Table 2.

TABLE 1

FREIGHT TRAFFIC: PORT OF CHICAGO, 1964

Type	Tonnage	Sub Totals
Overseas, imports	687,859	
exports	1,273,581	1,961,440
Canadian, imports	3,634,323	
exports	2,006,622	5,640,945
Great Lakes (domestic),		
receipts	10,438,410	
shipments	8,055,558	18,493,968
Inland Waterways,		
receipts	13,420,862	
shipments	2,196,199	15,617,061

TABLE 2

FOREIGN WATERBORNE COMMERCE: PORT OF CHICAGO, 1963

Numbers are in Short Tons		
Trade Area	Exports	Imports
Great Lakes Canada	559,066	343,598
Atlantic Canada	1,209,051	1,095,340
Caribbean	8,570	185
United Kingdom and Eire	241,887	81,451
Baltic, Scandinavia, Iceland, and Greenland	54,060	27,560
Bayonne-Hamburg Range	485,666	216,407
Azores, Mediterranean, and Black Sea	134,098	23,654
West Coast Africa	18,974	1,807
India, Persian Gulf, and Red Sea	34,731	1,388
Far East- Southern Area, Taiwan, and Philippines	20,951	8,739
Far East-Northern Area, Japan	41,615	66,058
Other Trade Areas	30,696	27,014
Totals	2,839,365	1,893,201

The most important receipts from United States lake ports are iron ore, pig iron, scrap, petroleum products, grains, cement, salt, and limestone. The major shipments are grain, coal, petroleum products, and iron and steel products. The origin and destination of lakewise commerce in 1963 is given in Table 3.

TABLE 3

LAKEWISE DOMESTIC COMMERCE: PORT OF CHICAGO, 1963

Area	Shipments, Tons	Receipts, Tons
Lake Michigan	4,985,985	811,092
Lake Superior	470,470	4,769,326
Lake Huron	171,489	1,636,861
St. Clair-Detroit	52,927	143,626
Lake Erie	345,385	370,793
Totals	6,026,255	7,731,698

Inland waterway traffic consists mainly of coal, petroleum products, sand and gravel, grain, iron and steel products, industrial and agricultural chemicals. Table 4 shows the origin and destination of five leading commodities in 1963. Sand and gravel, a local traffic from the upper Illinois River valley, amounted to 1,314,205 tons in 1963.

TABLE 4

INLAND WATERWAYS TRAFFIC: PORT OF CHICAGO, 1963

(Coal, Grain, Petroleum, Steel, Chemicals)		
Area	Shipments, Tons	Receipts, Tons
Ohio Valley	108,601	506,358
Tennessee Valley	125,216	140,289
Upper Mississippi Valley	341,422	984,206
Middle Mississippi Valley	208,281	392,392
Lower Mississippi Valley	300,124	467,147
New Orleans	118,386	340,409
East Gulf Coast	17,922	12,908
West Gulf Coast	327,488	1,192,173
Illinois Valley	377,815	5,766,474

The data above clearly illustrate the nation-wide and world-wide nature of commerce through the Port of Chicago. Essentially, the inbound commodities are fuels and raw materials consumed or processed in the metropolitan area, while the outbound commodities are raw and processed farm products and semi-finished and finished industrial products. Low cost water transportation brings the needed raw materials for industry, and at the same time opens world-wide markets for the industrial and agricultural products of Illinois.

Although foreign commerce tonnages appear small in comparison to lake and inland waterway commerce, the commodities handled are valued at several million dollars. It has been estimated that each ton of overseas cargo handled in the Port of Chicago adds $22 to the local economy. The excellent growth of overseas commerce has been made possible by the St. Lawrence Seaway. The completion of the Seaway has also opened the Labrador iron ore deposits to Chicago and a large grain market in tidewater Canada. In 1964 the Port of Chicago traffic through the Seaway was 4,563,105 tons, distributed as shown in Table 5.

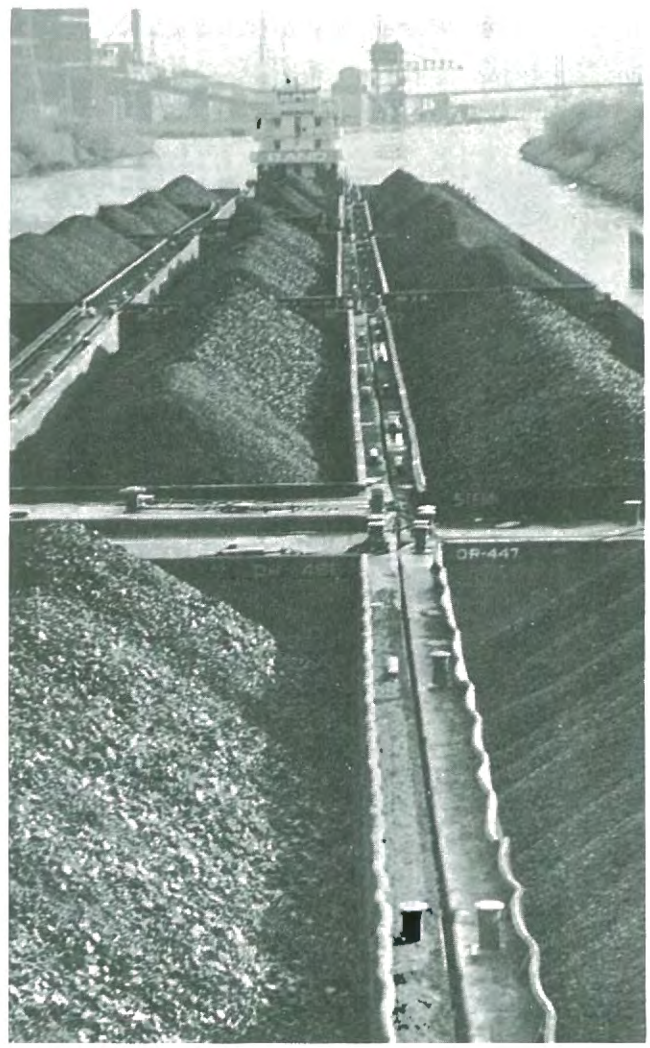


TABLE 5

PORT OF CHICAGO SEAWAY TRAFFIC, 1964

Inbound:		Outbound:	
General Cargo	860,721	General Cargo	242,269
Bulk Cargo	255,176	Bulk Cargo	2,089,042
Total	1,115,897	Total	2,331,311

Expanding facilities in the Port of Chicago to handle future traffic increases will be a problem. The metropolitan area has overgrown all the better sites for port development. Most of the lakefront lands have been appropriated for parks. An additional general cargo pier, similar to Navy Pier, is the last major addition which can be made at Chicago Harbor and will be required in the near future. Lake Calumet can meet general and bulk cargo needs for perhaps 25 years, depending on the growth of traffic. After 1980 the problem will be finding new areas for port expansion. This problem is not new; it was anticipated at least 50 years ago. The conclusion reached by every group that has studied the problem is that the best area for future port development is on the submerged lands and along the shoreline in the vicinity of the Illinois-Indiana state line. Positive steps by the State will be necessary to form an interstate port authority with Indiana in order to develop this area.

PROBLEMS AND PROGRESS

The use of barges and towboats in a unit called a tow was pioneered in the Pittsburgh pools near the end of the Nineteenth Century. A tow consists of barges assembled in a compact fleet and tightly locked together with steel cables and ratchets. The towboat, which literally pushes the tow, is secured at the rear of the barge fleet. The entire tow, towboat and barges, acts as a single vessel with all forward, reverse, and turning power supplied by the towboat. The towboat has complete control over the barges and is able to maneuver them through narrow bridge openings, around sharp bends, and through locks.

The industry has conducted a considerable amount of research to improve the performance of barge tows. The object is to improve the structural design of barges for cargo capacity at the lowest possible cost and for minimum towing resistance, and to develop a towboat which will efficiently convert engine horsepower into thrust and a rudder system capable of maneuvering large tows at very low speeds. The modern towboat is a victory of naval architecture and marine engineering over the difficult design problems peculiar to inland waterway operations.

NAVIGATION IMPROVEMENTS

Improved channels, locks, and bridges are the most important physical features of an inland waterway. Each imposes definite and sometimes critical limitations on the navigability of a waterway.

The Channel

The basic artery of travel is the channel; its practical traffic capacity is limited by width, depth, alignment, and current velocity. Width must generally be sufficient to allow two tows to pass. On the Illinois River, Ohio River, and the Mississippi between St. Louis and Baton Rouge, the channel width is 300 feet. The width of the channel on the Mississippi above St. Louis varies from 200 to 400 feet. Artificial canals generally have narrower widths: Chicago Sanitary and Ship Canal, 160 feet; improved Calumet-Sag Channel, 225 feet; Treats Island Channel (DesPlaines River), 250 feet; and Marseilles Canal, 200 feet.

Channel depth determines the draft to which barges can be loaded and profoundly influences towing resistance. Table 6 gives the relation between barge draft and cargo capacity for the most common size of barge. Generally, the barge draft must be at least 1.5 feet less than the controlling channel depth. Table 7 shows the relation between depth and towing resistance and its affect on line-haul costs for a tow commonly used on the Illinois Waterway. Fortunately, the controlling depth in most channels exists only at certain locations, such as at the head of a navigation pool or on a crossing bar. For instance, on the Ohio River it is estimated that 95 percent of the channel length has depths greater than the controlling depth of 9 feet.

TABLE 6

CARGO CAPACITY vs. DRAFT: OPEN JUMBO BARGE

Draft Feet	Capacity Tons	Draft Feet	Capacity Tons
2	100	6	900
3	300	7	1,100
4	500	8	1,300
5	700	9	1,500

TABLE 7

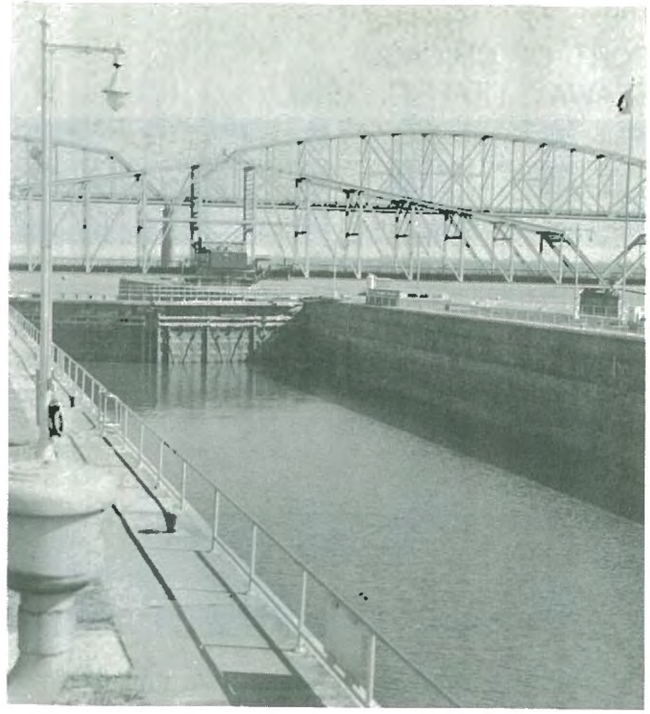
EFFECT OF CHANNEL DEPTH AND WIDTH ON TOWING COST

Cost in mills per ton-mile
Tow, 15 Barges, 3 x 5; Capacity, 22,500 Tons, Towboat, 3000 hp.
Barge Draft, 9 feet

Channel	Channel Width			
Depth	160	225	325	700
10	1.4	1.2	1.2	1.1
12	0.9	0.8	0.8	0.7
16	0.8	0.7	0.7	0.6
20	0.8	0.7	0.6	0.6

In alignment, the width and curvature of bends are the critical factors. In wide bends with long radii, a tow can be maneuvered by the steering rudders with only a small loss in efficiency. In moderately narrow or sharp bends, the tow must be maneuvered by a combination of turning and flanking which results in a significant loss in time and efficiency. Extremely narrow and sharp bends require "double tripping" whereby the tow is broken into smaller parts which are taken through the bend and then reassembled. On canalized rivers the lock size, rather than the bends, generally limits the length of tows. For instance, on the Illinois Waterway a 1200-foot tow is the longest practical length; improvements at the worst bends have eliminated double tripping for these tows, although flanking is still required at many others.

Generally, on canalized rivers such as the Illinois, Ohio, and upper Mississippi, channel widths and alignment limit tonnage capacity less than depth and lock size. However, in artificial canals such as the Calumet-Sag Channel and the Sanitary and Ship Canal, where the controlling dimensions prevail throughout, depth, width, and alignment are all important.



Locks

Locks have a decided effect on the practical tonnage capacity of all canalized waterways. The tonnage capacity of a lock is limited by: 1) the length and width of the lock chamber, 2) the time required for a lockage cycle, 3) the controlling depth of the waterway, 4) the distribution of tow sizes, 5) the time pattern of tow arrivals, and 6) the balance between upbound and downbound traffic.

The length and width of a tow which can be accommodated in a single lockage is obviously limited by the length and width of a lock chamber. Thus, a lock 600 feet by 110 feet will admit eight jumbo barges and a towboat. A lock 1200 feet by 110 feet will admit seventeen jumbo barges and a towboat. If the barges are loaded to 7.5 feet suitable for a 9-foot controlling depth, the first tow would carry 9600 tons and the second tow would carry 20,400 tons. If the channel had a 12-foot controlling depth, the barges could be loaded to 10.5 feet. The first tow would carry 14,400 tons; and the second tow would carry 30,600 tons. When a tow is larger than the lock, it is broken into halves, each of which is locked through. This procedure is called double locking, and is very common throughout the waterways.

Locking time at the absolute minimum consists of time for the tow to enter the lock, time for the gates to close, time to fill or empty the chamber, time to open the gates, and time for the tow to leave the lock. This minimum lock cycle time depends on the lock lift and on the design of lock approaches, gate machinery, and the filling-emptying system.

The minimum lock cycle time determines the maximum number of lockages which can be made in one year. For instance, a lock with a 60-minute cycle time can perform a maximum of 8760 lockages per year. Assuming that a lock 600 feet by 110 feet has a cycle time of 60 minutes and the maximum tow tonnage (9-foot controlling depth) is 9600 tons and that the traffic consists entirely of maximum size tows, perfectly disciplined, with a tow always waiting at either end of the lock, the lock would handle 8760 times 9600, or 84,096,000 tons in one year. This quantity is called the Maximum Tonnage Capacity (MTC) of the lock.

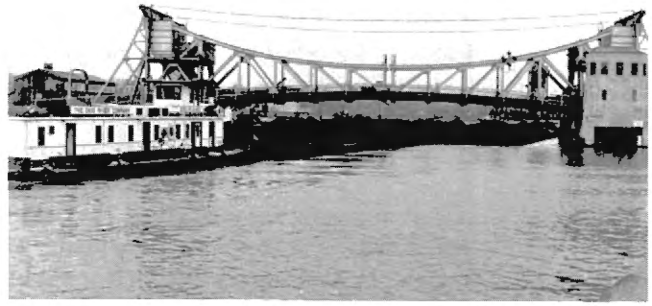
The MTC of a lock is theoretical and cannot be obtained in reality. Every deviation from the theoretical assumptions decreases the tonnage capacity of the lock. Some of the common deviations are listed below:

- — Tow sizes vary from a single barge to tows of twice the lock capacity.
- — Barge loadings vary from empty to fully loaded.
- — On the Illinois River, about one-half of the barges moved are empty.
- — Speeds of individual tows vary, and they arrive at locks at different times.
- — Double locking requires more time than two single lockages, and is a less efficient use of the lock but a more efficient use of towing equipment and personnel.
- — Locks are never available for service all of the time because of shutdowns for inspection, maintenance, and repair.

A realistic estimate of lock capacity reflects the combined effects of lock design and traffic patterns. These estimates are obtained by studies of actual operations and are called the Practical Tonnage Capacity (PTC). With certain modifications dictated by reason, the PTC represents the maximum annual tonnage which can be handled by a lock consistently and economically. Studies conducted by the Corps of Engineers on several waterways indicate that the PTC is about 25 percent of the MTC.

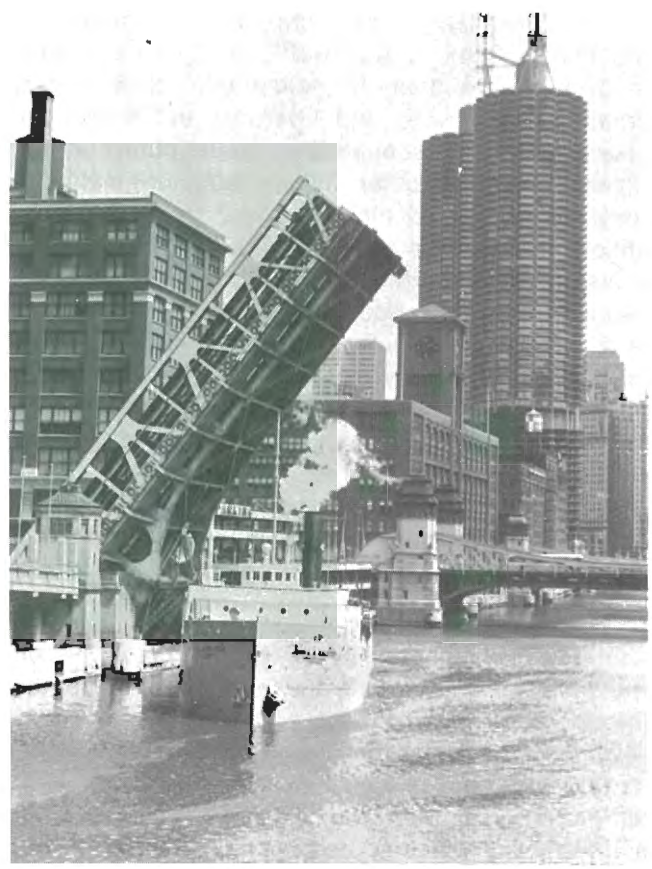
Bridges

Bridges invariably obstruct navigation to some degree. Horizontal clearance, vertical clearance, and alignment are the most important factors in designing bridges over navigable waterways. The Corps of Engineers establishes the minimum clearances for new bridges over all the navigable waterways of the United States. These standards are often a compromise between the needs of navigation and the costs of building more adequate bridges.



Bridges with horizontal clearances only slightly greater than the width of a tow are extremely difficult to pass. The tow must be very carefully aligned with the opening, and there is no margin for error, crosswinds, cross-currents, or the residual flanking motion which is often imperceptible to the pilot. A series of bridges in close succession compounds the problem. The waterways still have many swing bridges with center piers which cut the available clearance in half. Several bridges on the Illinois Waterway have horizontal clearances only slightly greater or less than the clear width of locks—110 feet.

Vertical clearances are usually measured from the ordinary water level to the lowest point on the bridge over the navigation channel. Vertical clearances are seldom important for barges, which have a low silhouette. However, the controlling vertical clearance imposes a direct limitation on the height of



towboats. The highest point on a towboat is ordinarily the pilot house. There is a direct relation between the height of the pilothouse and the pilot's visibility of the head of the tow. Reasonable safety requires that the pilot have as clear a view as possible of the head of the tow. In practice, however, the pilot's view of the area immediately ahead of the tow is always masked somewhat by the lead barges. This deficiency is corrected by placing a lookout forward who can communicate with the pilot.

The deficiencies in bridge clearances and alignment are being gradually corrected as older structures become obsolete and are replaced with new ones, but the problem created by the bridges in downtown Chicago has no reasonable solution. In the city it is impossible to build high-level fixed bridges on every major street and railroad; the continued opening of movable bridges during the day creates an unreasonable obstruction to land transportation. As a result, most movable bridges are not operated during the rush hours, and the controlling vertical clearance is about 17 feet.

In summary, channels, locks, and bridges all offer considerable constraint on free and easy navigation. Since navigation improvements are very expensive, waterways are generally improved one step at a time by concentrating first on the most critical deficiencies.

INLAND WATERWAYS COMMODITIES

A relatively small group of commodities make up about 90 percent of the traffic carried on the waterways of Illinois. These are coal, petroleum, sand and gravel, iron and steel, grain, sulphur, sugar, and chemicals.

COAL

Coal is currently the most important commodity on the Illinois River with a traffic of 7,874,918 tons in 1964. More than 5 million tons of this total originates at Havana and Liverpool and moves upbound to large steam-electric power plants in the Chicago area. Another million tons originates in the Ohio valley and moves upbond to ports on the Illinois River and to Chicago. The remaining traffic is also predominantly upbound, moving from Havana and Liverpool to various coal docks on the Illinois River. More than 5 million tons of coal moves up the Mississippi to coal docks as far north as Minneapolis. Almost half of this coal originates in the southern Illinois coal fields and is shipped through the coal dock at Ford. Most of the remaining traffic originates in the Ohio valley. The Springfield and Fulton district coal is not competitive with the southern Illinois and west Kentucky coal in the upper Mississippi market.

Coal tows are generally the largest employed on the waterways. Below Brandon Road Lock on the Illinois Waterway, coal tows consist of fifteen to seventeen barges with a capacity of 18,500 to 21,000 tons and are pushed by towboats of 3000 to 4000 horsepower. Since the present locks on the Waterway will only accommodate eight barges, these tows must double-lock at Peoria, Starved Rock, Marseilles, Dresden, and Brandon Road. In Brandon Road Pool the coal tows are broken into smaller tows of two to four barges and are moved to the coal docks by smaller towboats equipped with elevating pilothouses.

Plans for future electric power plants in Illinois do not include any new plants that will receive coal by barge. Power plants at the mouths of the mines or unit-train coal haulage to load center generating plants are being considered in planning for regions close to the coal fields. In regions distant from the coal fields, nuclear power plants are being considered for the future. Therefore, it appears that the upbound coal traffic on the Illinois and upper Mississippi will not expand far beyond the current tonnage. These tonnages will probably peak near 9 million tons on both waterways. However, the power plant coal market is continuing to expand in the Ohio valley and the Gulf Coast of Florida. Southern Illinois coal may be able to compete in the Florida and deep south market which is presently dominated by west Kentucky coal.

SAND AND GRAVEL

Traffic in sand and gravel on the Illinois River was 1,929,340 tons in 1964. This is predominantly an upbound traffic originating at gravel pits in the upper Illinois valley and moving to materials yards in the Chicago area. The traffic fluctuates according to the demands of heavy construction. It is probable that the future trend in this traffic will be upward.

IRON AND STEEL

Iron and steel traffic on the Illinois River was 1,650,000 tons in 1964. This group includes iron ore, pig iron, scrap, semi-finished steel products, castings, forgings, pipe, and finished mill products. Generally, the raw materials such as ore, scrap, and pig iron move upstream; the finished products move downstream. The traffic is predominantly downbound from Chicago and destined for ports throughout the Mississippi system and Gulf Coast.

The movement of iron and steel products increases or decreases inversely with demand for these products. That is, when the demand for iron and steel is high, shipping time is more important than cost, and the traffic tends to move by faster modes of transportation. Future traffic may reach 2.5 million tons during periods of low demand.

GRAIN

The fastest growing traffic on the Illinois River is in grain shipments. The movement is predominantly downbound and totaled 6,315,581 tons in 1964. The grain traffic consists mainly of corn and soybeans, with moderate tonnages of wheat, oats, barley, and rye. Outbound grain trans-shipped to lake vessels at Chicago totaled 77,775 tons in 1963. Most of the grain shipments from the Illinois River are destined for the deep south, where a large portion enters the foreign export trade through Baton Rouge and New Orleans. Table 8 indicates the increasing importance of grain shipments via barge.

Future shipments of grain are limited by the grain production and sales within the area tributary to the river elevators. Traffic will probably reach 10 million tons between 1970 and 1980. Upbound grain traffic to Chicago probably will not increase until waterway improvements on the Cal-Sag, Sanitary and Ship Canal, and the duplicate locks are completed.

TABLE 8

BARGE SHIPMENTS OF GRAIN VIA ILLINOIS RIVER

Year	Total Farm Grain (Sales, 1000 tons)	Barge Shipments (Sales, 1000 tons)	Percent of Sales Shipped by Barge
1958	15,800	2,400	15.2
1959	16,100	2,460	15.3
1960	17,600	2,720	15.5
1961	17,300	3,260	18.9
1962	18,400	4,540	24.6
1963	20,650	4,550	22.0
1964	19,100	5,650	29.8

PETROLEUM PRODUCTS

Petroleum products rank third among the commodity groups shipped on the Illinois River. The 1964 traffic was 4,867,205 tons. This group includes gasoline, distillate fuel oils, jet fuel, kerosene, residual fuel oil, asphalt, aliphatic naptha, lubricating oils, and greases. The traffic is predominantly upbound to terminals on the Illinois River and in the Chicago area. The traffic originates at important pipeline terminals such as Alton-Wood River and Helena, Arkansas, and also at producing areas in Louisiana and Texas.

Barge movement of petroleum products fulfills two major functions: to supplement pipelines during periods of peak demand, and to distribute petroleum products to marketing centers which are too small to justify pipeline service. In most cases, barge haulage is not competitive with pipelines; hence, no major expansion of the traffic is projected. However, it is reasonable to expect that barge transportation will continue to serve the two functions above. Future traffic is expected to average 5 million tons on the Illinois River and 3 million tons on the Mississippi above the mouth of the Illinois.

CHEMICALS

Chemicals are an important commodity group on the Waterway. The fastest growing commodity in this group is fertilizers which exceeded 900,000 tons in 1964. The fertilizer traffic is growing proportionately to the grain traffic and will probably reach 2.5 million tons between 1970 and 1980. Although the movement of fertilizers is predominantly upbound, about one-fourth of the tonnage is transferred from ship to barge at Chicago and moves downbound. Other important chemical tonnages in 1964 were: sulphur, 470,000 tons; alcohols, 195,000 tons; and coal tar products, 237,000 tons.

COMMODITY SUMMARY

The commodity groups discussed above represent about nine-tenths of the total tonnage being carried on the Illinois River. From the discussion of each group, it appears that some commodities have reached a stage of equilibrium and are expected to show neither marked growth nor decline in the foreseeable future. These groups include coal, petroleum, sand and gravel, iron and steel, sulphur, and sugar and have been the leading commodities in the past; they represent about two-thirds of the current traffic. The other third includes grain, agricultural chemicals, industrial chemicals other than sulphur, and a number of minor commodities.

FIGURE 3

ILLINOIS RIVER THROUGH TRAFFIC, RECEIPTS AND SHIPMENTS, 1933-1964

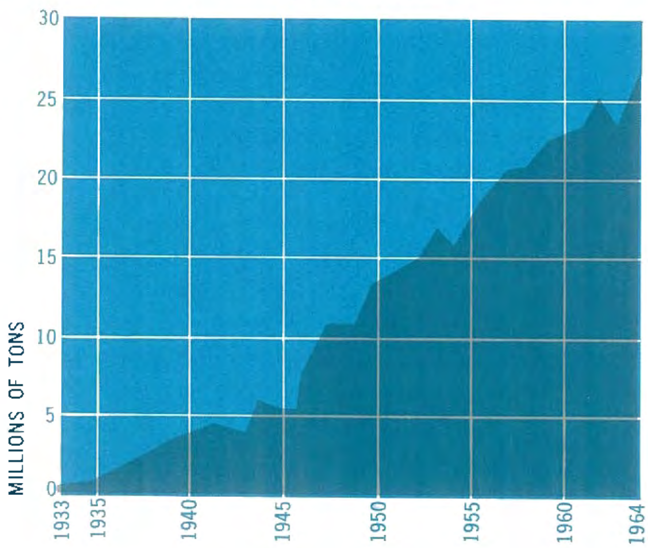


FIGURE 4

CHICAGO SANITARY AND SHIP CANAL, THROUGH TRAFFIC, RECEIPTS AND SHIPMENTS, 1933-1964

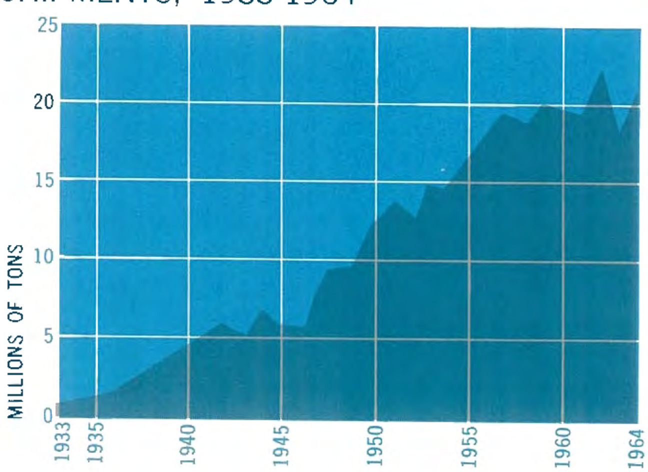
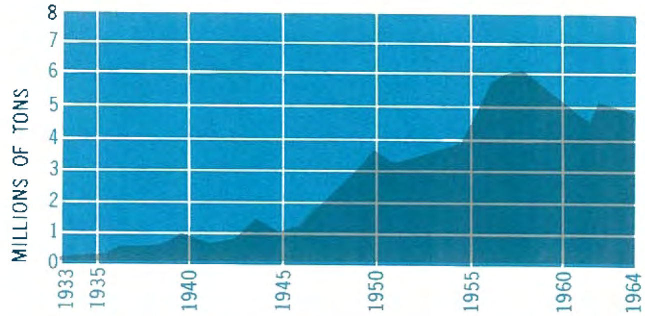


FIGURE 5

CALUMET—SAG CHANNEL THROUGH TRAFFIC, RECEIPTS AND SHIPMENTS, 1933-1964



Figures 3, 4, and 5 show the historical trend of total tonnage. The six commodities—coal, sand and gravel, iron and steel, grain, petroleum products, and chemicals represent two-thirds of the traffic, and the remaining commodities represent one-third of the traffic. The larger group is called the Big Six because of their historical significance. This group has shown neither marked growth nor decline since 1956. The other group has shown consistent growth and has been responsible for all of the waterway tonnage growth in the last ten years.

WATERWAYS COMPETITION

The volume of traffic hauled by water carriers depends on the demand for transportation services and on the competitive position of water carriage relative to other modes of transportation. The first factor determines the total traffic of all commodities transported, while the second factor determines what portion of the total will be carried by water.

The competitive position of water transportation relative to land transportation depends on a comparison of cost and quality of service. In order for water transportation to have an edge over its competitors, it must deliver a shipper's cargo in the proper quantity, in the proper condition, at the proper time, and at the lowest total delivered cost.

The total cost of transportation consists of some or all of the following elements:

— Short line transportation of a commodity from source to river dock by railroad, truckline, conveyor, or other mode;

— Transfer of cargo at the river dock from land carriage to barges;

— Line-haul cost of barge transportation from origin to destination; and

— Unloading costs at destination, including any special rehandling or storage costs for water transportation.

If the total cost is as low as any alternative method of transportation and if the deliveries meet the consignee's schedule, water transportation is competitive.

The succeeding discussion covers the various costs in water carriage of bulk commodities, with particular emphasis on coal as an example. The comparable costs of other competitors are included where applicable in order to give a complete picture.

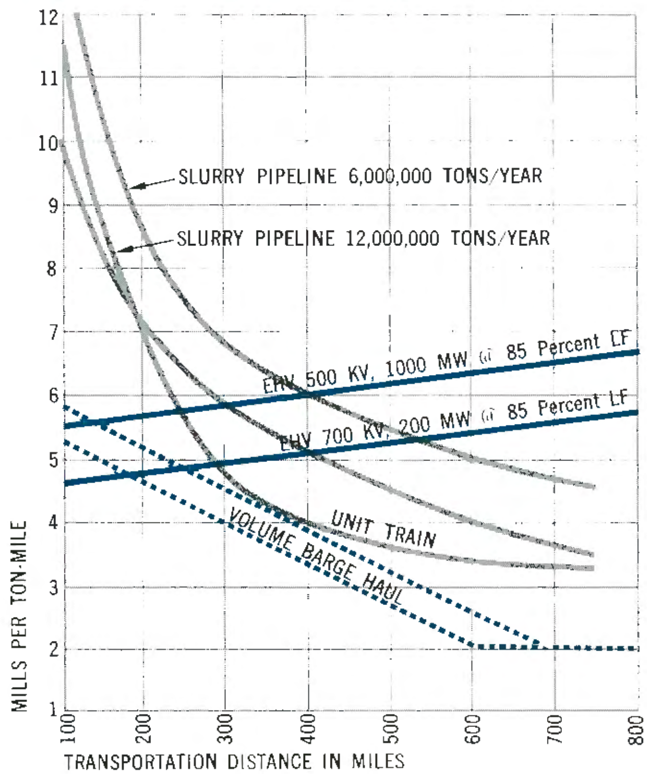
LINE-HAUL COSTS

Line-haul costs depend on the amount of equipment required, the time-length of haul, and the tonnage carried. The amount of equipment depends on the tonnage volume and the cargo capacity of the haulage units (barges) and on the round trip time. Haul-time depends on the speed of the tow and includes delays such as turn-around time, and lockage time. For comparison, line-haul costs are generally reported as cost per ton-mile.

Figure 6 shows generalized relations of line-haul costs for four competitors in the coal trade: barge lines, unit trains, slurry pipelines, and extra high voltage transmission lines. The EHV lines are a special alternative whereby electrical energy is transported rather than the coal. Pipelines, EHV lines, and railroads generally connect origin and destination by a nearly straight line much shorter than travel by river. For instance, on one coal haul in Illinois the river distance is 400 miles, while the rail distance is 300 miles; the total line-haul costs per ton would be $1.56 by water and $1.62 by unit train. The six-cent per ton difference actually favors the unit train because of differences in terminal costs which are added to the line-haul costs for water transportation.

FIGURE 6

LINE-HAUL TRANSPORTATION COSTS



TERMINAL COSTS

Terminal costs for waterway commodities depend on the quantity and type of cargo being handled and tend to be higher than such costs for other transportation systems. Barge loading docks for dry bulk commodities generally consist of a gravity process from storage, such as a grain elevator or riverside tipple, or a conveyor which moves cargo directly from a car dump or truck dump pit. Costs usually vary from 10 to 20 cents per ton.

Unloading terminals for dry bulk commodities are usually integrated with plant processes and tend to be quite elaborate. At power plant coal docks, the unloading device is either a clam-shell bucket or a bucket ladder which transfers coal from the barges to the main conveyor. Belt trippers and secondary conveyors transfer coal from the main conveyor, either directly to the plant or to storage. Coal handling costs generally vary from 15 to 30 cents per ton.

River terminals must have adequate mooring areas for empty and loaded barges. These usually consist of a series of pile clusters which are strong enough to withstand impact and hawser loads and are high enough to accommodate the expected stage fluctuations. Provisions are made for moving barges from the mooring areas by dock winch or workboat to the loading or unloading area.

OTHER COSTS

In most cases, a commodity must be hauled to a river loading dock by rail or truck, and this rate must be added to the terminal and line-haul costs. A sample of rail rates for moving coal to river docks is given in Table 9.

TABLE 9

RAIL RATES FOR MOVING COAL FROM MINE TO RIVER DOCK

Coal Freight District	River Dock	Ultimate Destination of Coal	
		Mississippi & Minnesota Rivers (per ton)	Illinois Waterway & Missouri River (per ton)
Belleville	Alton	$1.09	$1.32
	E. St. Louis	.99	1.22
	Ford	.79	1.02
	Havana	1.62	1.62
Southern Illinois	Ford	1.06	1.24
	Joppa	.90	.90
Springfield	Havana	1.16	1.16
Fulton	S. Liverpool	.42	.42

The combination of transportation charges, plus the mine price of coal adjusted for quality, determines which coal will enter what market and by what means it will be transported. Although coal prices and freight charges can and do change, the patterns of coal movement from mine to market adjust slowly. This slow adjustment is because coal is generally purchased by utilities on long term contracts of up to twenty years, and a changeover from rail coal to barge coal or vice versa, with the consequent new investment in unloading equipment, can almost never be justified.

Most of the elements of transportation competition

illustrated in the discussion on coal apply equally to all bulk commodities. The net effect of competitive forces is to limit the market area tributary to navigable waterways and to further restrict the type and quantities of commodities moved by water, even where water transportation is readily available. A shipper benefits directly from the competition. If the origin and destination of his shipment lies on or near navigable waterways, he should never have to pay more than the cost of water transportation and often pays less.

It is a fortunate geographic fact that most of the large centers of population and industry in Illinois lie on navigable waters. Whenever these centers trade with other areas located on waterways, the shippers receive benefits from water transportation rates. This is true even when the shippers use land transportation. Thus, the benefits of navigable waterways are not entirely measured by the freight savings on the tonnage carried, but also bring freight savings on all transportation for which rates have been lowered to meet water competition.

As a practical matter, rate reduction is not considered a direct benefit of the waterways, because these benefits may be a cost borne by a transportation competitor. Also, the costs of lost traffic or rate reductions are not charged against the waterway. One reason is that reductions in transportation rates tend to increase traffic, and the increase in total traffic is assumed to compensate tonnage diversions. Another reason is that rate reductions made to meet water competition are often offset by rate increases in noncompetitive areas.

FUTURE OF WATER TRANSPORTATION

Future developments in water transportation depend on the demand for this service and in particular on whether that demand will increase or decrease. The problems seem to fall into three categories: 1) What must be done to existing waterways in order to accommodate increasing traffic? 2) What must be done to existing waterways if traffic declines? and 3) Should new waterways be provided?

INCREASING TRAFFIC

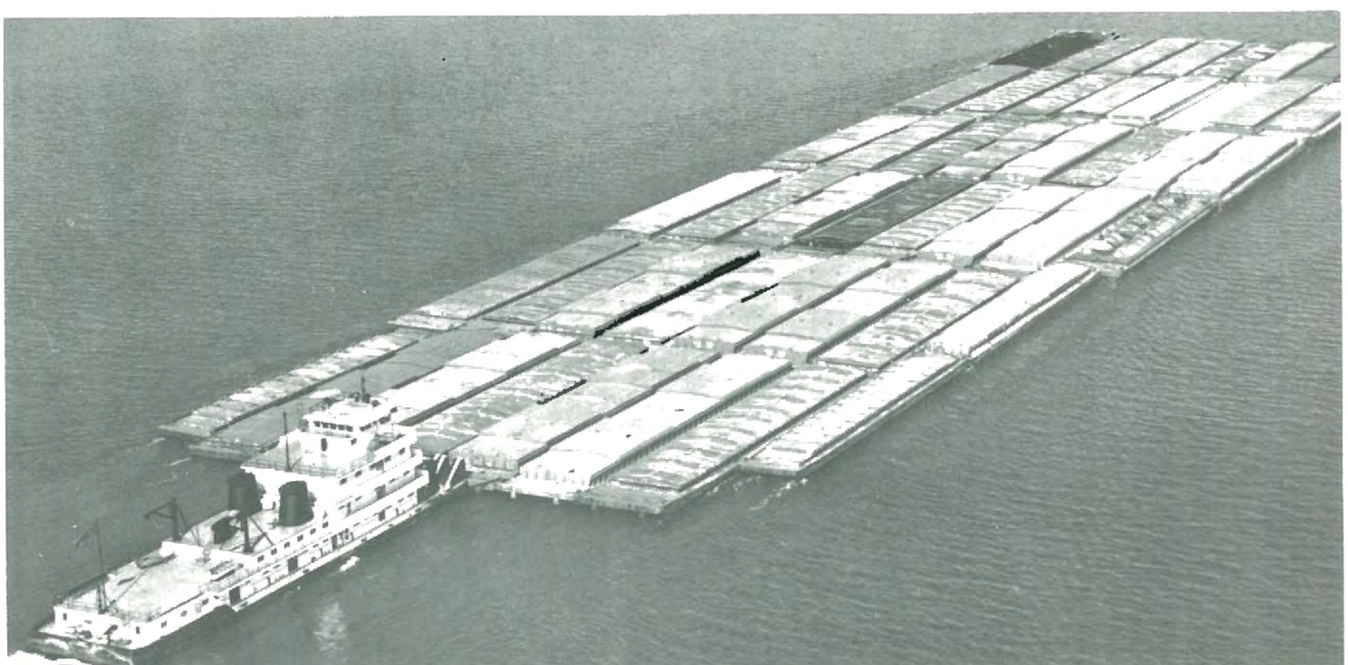
Increasing traffic requires more equipment and results in more and larger tows moving up and down the waterway at closer headings. As traffic increases, it approaches a density limit at which congestion begins to raise costs. Conceivably, the costs would rise only to a point at which no further traffic would be added to the waterway. This traffic density has been defined as the practical tonnage capacity of a waterway. Several attempts have been made at estimating the PTC of a waterway. One of the best known of these studies is the Corps of Engineers' report, **Duplicate Locks on the Illinois Waterway.** The Corps based their estimate of PTC on the number of lockages in a peak month and on the average tonnage per lockage, which was 2900 tons at that time. Unfortunately, neither the number of lockages in a peak month nor the average tonnage per lockage are historical constants. A comparison of lockages and tonnage per lockage for 1950 and 1965 is given in Table 10.

TABLE 10

COMPARISON OF LOCKAGES AND TONNAGE, 1950 AND 1965

	Lockport	Brandon Road	Dresden Island	Marseilles	Starved Rock
Number of Lockages					
1950	4,723	4,071	4,065	3,860	3,835
1965	6,000	4,675	4,395	4,310	3,990
Percent Increase	27.0	37.9	8.1	11.6	4.0
Average Tonnage per Lockage					
1950	2,160	2,640	2,740	2,660	2,690
1965	3,580	4,860	5,210	5,220	5,940
Percent Increase	65.7	84.0	90.1	96.2	120.8

It appears from Table 10 that the increase in waterway traffic has been handled mainly by an increase in tow size, while the number of tow-lockages has shown only a slight to moderate increase. The higher number of lockages and smaller tow size at the Brandon Road and Lockport Locks are caused by the breakup of tows in Brandon Pool into smaller units in order that they may pass through the waterway of restricted dimensions between Joliet and Chicago. At Lockport, most of the tows are small enough for a single lockage, i.e., eight barges or less; below Brandon Road most of the tows require double lockages. A double lockage takes two and one-half times as long as a single lockage. Thus, it is obvious that, as the number of tows requiring



double lockage increases, the number of lockages which can be made in a year decreases.

It can be reasoned here that, as the proportion of tows requiring double lockage increases, the average heading between all tows approaches the time of double lockage. Or, the total number of lockages approaches the total possible number of double lockages. A study of lockages and lockage time indicates that the limiting number of double lockages is being closely approached at Brandon Road, Dresden Island, Marseilles, and Starved Rock Locks.

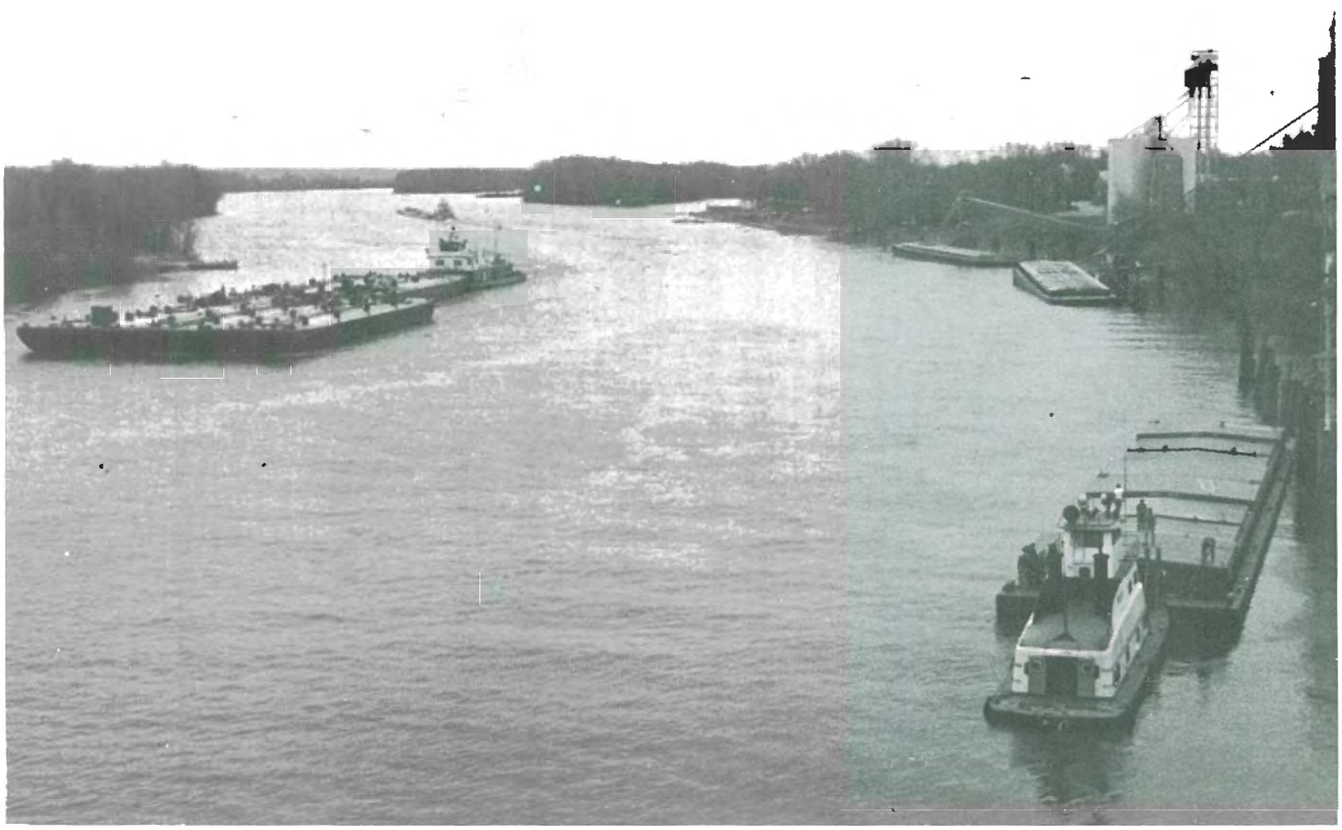
Thus, it appears that the existing locks on the Illinois Waterway are at a point of equipment saturation. Almost no additional tows can be added to the stream of traffic. Therefore, almost no new shipments can be handled, if they would require an additional tow. The only remaining way to accommodate additional traffic is to increase the size of tows or attract additional backhaul shipments to use empty barges.

Two alternatives are available for increasing the traffic capacity of the Waterway—duplicate locks and larger channels. Duplicate locks of 110 feet by 1200 feet would more than triple the lockage capacity of the Waterway. Channel deepening to at least 12 feet would increase possible barge loadings from the current 1250 tons to handle the barge's rated capacity of 1500 tons, a 20 percent increase. Increasing channel widths and bridge clearances above Lockport would allow the use of large, efficient tows and probably eliminate the need for breaking tows in Brandon Pool. Preliminary studies indicate that all these improvements might decrease line-haul costs by as much as 0.5 to 1.0 mill per ton-mile. These adjustments, both in cost and capacity, would put the Illinois Waterway on a par with the Mississippi and Ohio Rivers.

DECREASING TRAFFIC

Decreasing traffic is a much different problem to plan for than is increasing traffic. Many waterways built in the past have ceased to carry traffic and have been abandoned. In most cases, the decline of traffic has been caused by competition from railroad and highway carriers. In other cases, the loss of traffic has been caused by exhaustion of mineral reserves or changing market patterns.

These forces of change continue to affect modern waterways, but only for individual commodities. Thus, commodities come and go from the waterways or are carried in greater or lesser quantities, depending on markets and relative transportation costs. An examination of historical tonnage records by commodity groups indicates many changes of this type, but the net change in total traffic has been consistently upward for the larger waterways.



Apparently, waterways which connect large, diversified market areas such as the Illinois, Ohio, and Mississippi Rivers are little affected by the loss of individual commodities.

Tributary waterways cannot be expected to show the same traffic stability as the large, trunk waterways. This is because they are usually built to serve a limited group of commodities. In cases like the Green River in Kentucky, where coal is more than 90 percent of the cargo, the loss of a single commodity could eliminate traffic.

Traffic declines should be investigated to see if they are permanent or temporary. If traffic continues to decline and the estimated benefits approach the operation and maintenance costs, steps should be taken to reduce these costs. Cost reductions are usually accomplished by restricting lock operations and reducing maintenance to a minimum. Commercial operation should be terminated, if the traffic benefits fall below the annual costs for sustained periods of time. Before a waterway is abandoned, all the benefits attributable to the waterway, such as water supply, recreation, and water-level control, should be considered. The possibility of continuing operations as a recreational waterway is discussed later in this chapter.

PLANNING WATERWAYS PROJECTS

Waterway proposals can be properly evaluated only when the relevant facts are adjusted to be comparable with other systems of transportation. This requires an estimate of commodity movements based on market and rate studies, an estimate of the cost of providing facilities adequate for the design traffic, an estimate of transportation savings based on the most likely alternative, and an estimate of secondary or intangible costs and benefits. Decisions traditionally have been based on a comparison of benefits and costs, an evaluation of the quality of the estimates, and an estimate of the urgency of the project. A proposal is economically justifiable only if the benefits exceed the costs. Because of possible errors in cost and benefit estimates, some investigators have suggested that, for commercial navigation projects, the benefits be at least twice the costs before a project should be considered justifiable.

Project planning for new waterways begins with a series of studies of the magnitude and patterns of traffic expected to move over different reaches of the river system from the surrounding economic region. From this data engineers prepare design criteria for proportioning channels and locks. Lock and channel dimensions depend on the size of tows, lockage time, tow headings, position of major terminals, location of barge fleeting areas, and many other factors. A tentative design is then completed, using the design criteria and design traffic loading evolved earlier. Tentative design also considers such factors as route location, lock and dam locations, terminal locations, water supply, topographic features, soil and foundation conditions, bridge modifications, right-of-way acquisition, and other damages. The tentative design is adjusted to minimize the cost without sacrificing the waterway's capabilities.

Preliminary cost estimates are prepared for the adjusted design and include construction, right-of-way acquisition, damages, operation and maintenance costs, and interest. Operation studies are made to check earlier assumptions on waterway transportation rates. An estimate of traffic volume and transportation savings based on the operation studies and other data is prepared. The transportation savings are then compared with the project costs. Benefits from the use of a waterway improvement accrue if:

- The project results in lower transportation costs as compared with existing or potential costs by alternative means, such as existing or potential waterways, railroads, highways, or pipelines.
- The project attracts new traffic which, in the absence of the project, would not be expected because of prohibitive cost or lack of available transportation.

The benefits are generally measured as the difference in transportation costs with and without the waterway. Along with the difference in costs between water transportation and alternate modes, these benefits may include reduced operation and maintenance costs of the waterway and of the water carriers. The transportation cost savings are the primary benefits of a waterway project, but secondary benefits may include low-flow regulation, recreation, and appreciation of land values.

In order to make a direct comparison between benefits and costs, all tangible benefits must be evaluated in terms of dollar value. This is the most difficult problem in waterway economics, since adequate data for making benefit evaluations is seldom available. Primary benefits have usually been evaluated on the basis of published rates of railroads, truck lines, and barge lines, since actual costs are seldom available. Rates are usually poor indexes of costs for any form of transportation. Barge lines are not required to publish rates on bulk commodities. A great deal of estimating based on incomplete data is required to obtain comparable charges for various means of transportation.

Much controversy has centered on the selection of the most economical alternate mode of transportation. As an example, to move petroleum products, which is the most economical alternative—railroad tank cars, tank trucks, or pipelines? Available data are seldom adequate to answer this beyond a reasonable doubt. In the case of energy transportation, the alternatives must include all the energy sources—coal, oil, gas, nuclear power, and hydropower. All the means by which the energy may be transported—rail, barge truck, conveyer, pipeline, and electrical transmission line—must also be included. Thus, benefit estimates for waterways require the evaluation of an almost staggering number of alternatives.

Benefit estimates are also based on many assumptions required by the lack of factual data. The assumptions cause an unpredictable error to be built into the estimates. For this reason, some economists have recommended the use of higher interest rates or a minimum benefit-cost ratio of 2:1 to allow a margin for error.

Risk is built into the economic evaluation of any waterway project because of possible large errors in the estimates of benefits or costs. Generally, the cost estimates are more accurate than the benefit estimates. Every possible means should be taken to minimize risk in the final decision as to whether or not a project shall be undertaken.

Changing conditions may profoundly influence the economic evaluation of a project. Two studies made by the Corps of Engineers on the Kaskaskia River are an example. In the first report in 1961, the Corps study indicated that coal would move via the waterway to markets on the Illinois River and Lake Michigan, and to markets in the Chicago Switching District, on the upper Mississippi River, the Missouri River, and to Memphis. The annual benefits were estimated to be $5,120,000, and the annual costs were estimated at $2,649,000; the net benefits were $2,471,000 per year, and the benefit-cost ratio was 1.9 to 1.

Between 1961 and 1965 the railroads serving the Belleville coal district published trainload and unit-train coal rates which represented very substantial reductions in charges. A re-evaluation study made by the Corps in 1965 indicated that coal could move to market on the Illinois River, at Chicago, and on Lake Michigan at a lower cost by rail than by barge. The study uncovered a new market in Florida, which had developed in the period between 1961 and 1965. However, the net effect of these rate changes and market changes was to reduce the annual benefits to $4,680,000. At the same time, problems of water supply, rising construction costs, and rising interest rates increased the annual costs to $3,571,000. As a result, the net benefit fell to $1,109,000, per year and the benefit-cost ratio became 1.3 to 1.

FINANCING WATERWAYS

The waterways of the United States, except for the St. Lawrence Seaway which is international, are toll free and were built with tax funds as non-reimbursable projects. Most of the waterways were built entirely by the Federal Government or with considerable Federal assistance. All public navigable waterways are under the control and jurisdiction of Congress, a power which stems from the commerce clause of the Consititution.

Federal participation in a waterway project requires prior authorization by Congress. The Corps of Engineers is the Federal operating agency in charge of waterways, and the Corps' powers and responsibilities for each project are derived from general as well as specific authorizing legislation.

There is a great deal of controversy over the financing of waterway projects. Some groups contend that waterways should not be non-reimbursable, toll-free projects, but should instead be paid for by the users through a system of tolls, user charges, or special taxes. These groups argue that general tax financing of waterways amounts to a subsidy to the operators of the waterways, which distorts the true position of waterways transportation with respect to its competitors. The opponents of user charges argue that the waterways have been historically free, that user charges would destroy the waterways industry, and that all beneficiaries of waterways improvements would not be charged a fair share.

Determining an equitable user charge which would recover the costs associated with navigable waterways is difficult. No satisfactory solution has been proposed. The imposition of inequitable user charges would disrupt the national transportation system. If all the beneficiaries could be charged a fair share, there would be little effect on the overall pattern of transportation.

The argument on transportation financing masks the basic issue. The United States does not have, at present, an objective, definitive, national transportation policy based on the transportation needs of the people. Sound decisions affecting transportation competition cannot be made without such an overall policy. Each transportation interest seeks changes in government policy, subsidy, and regulation to improve its own competitive position. The decision on changing the financing of waterways should be withheld until Congress has established a comprehensive, national transportation policy.

NAVIGATION PROJECTS

New commercial waterways have been proposed from time to time for almost every major stream in Illinois. In some cases work was actually begun, only to be abandoned. One or more locks and dams have been built and abandoned on the Galena, Rock, Kankakee, Wabash, and Little Wabash Rivers. Proposals in the last few years have included a Wabash-Maumee Canal, a Wabash-Illinois Canal, a Wabash-Michigan Canal, a canalized Wabash River, a canalized Big Muddy River and Beaucoup Creek, an improved Saline River, a Saline-Big Muddy Canal, and a new Illinois-Mississippi Canal. This list does not include proposed recreational waterways. A discussion of some of the more important new and proposed waterways should begin with the Kaskaskia River Navigation Project which is now under construction.

KASKASKIA RIVER NAVIGATION PROJECT

The Kaskaskia River rises just west of Champaign and flows about 330 miles southwesterly to the Mississippi River. The river drains approximately 5840 square miles. The Basin is about 180 miles long and 55 miles at its widest point. Elevations in the Basin vary more than 500 feet—from about 850 feet above mean sea level (msl) in the headwater to about 340 msl near the mouth.

History of Kaskaskia Navigation

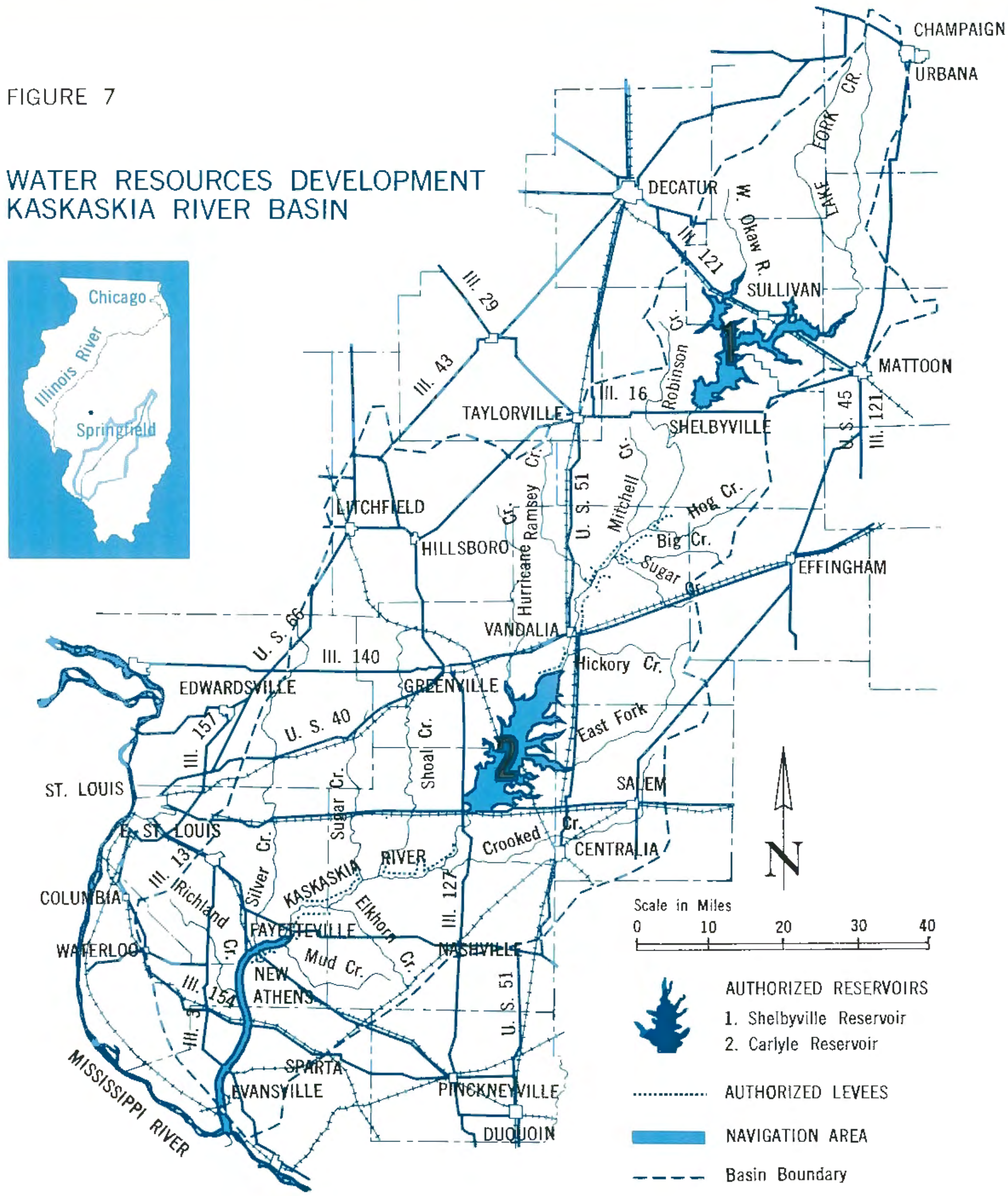
The use of the Kaskaskia for transportation began very early. Flatboats were used in the early 1800s, and steamboats plied the Kaskaskia before 1840. The Federal Government investigated the possibility of improving the Kaskaskia in 1887. On the basis of this study, $10,500 was appropriated during the period 1890 to 1892 and was used by the Corps of Engineers for deepening the channel to 3 feet, from the mouth to Evansville, and for clearing and snagging to Baldwin Shoals.

The Corps made another study of the navigability of the Kaskaskia River. In a report submitted in 1931 by the St. Louis District Engineer, it was reported that no navigation existed on the River, and that the benefits would be insufficient to warrant expenditure of funds for improving it for navigation.

The Federal Government presently has several projects planned or under construction in the Kaskaskia Basin (Figures 7 and 8). The local sponsors of the Shoal Creek Watershed, under the P. L. 566 Watershed Protection and Flood Prevention Act of 1954,

FIGURE 7

WATER RESOURCES DEVELOPMENT KASKASKIA RIVER BASIN



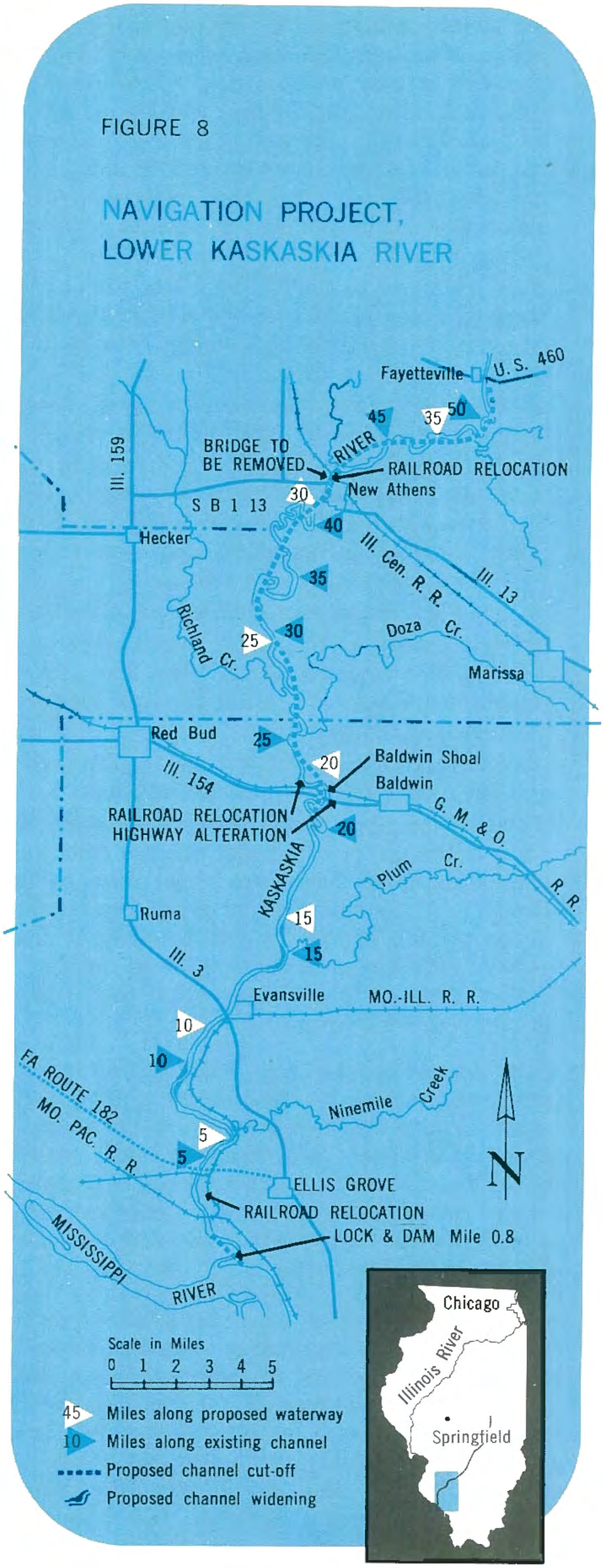


FIGURE 8

NAVIGATION PROJECT, LOWER KASKASKIA RIVER

......Construction of F A Route 182 and rerouting of S B 1 13 proposed by state are not a part of the navigation improvement. River mileage originates at Mouth of Kaskaskia River.

have completed two structures on the West Branch of Shoal Creek above Litchfield. In the future, several more structures will be constructed below Litchfield and Hillsboro to just above Panama.

The Corps of Engineers has plans for levees to protect about 55,000 acres of agricultural land in the Kaskaskia valley—30,000 acres between New Athens and Carlyle and 25,000 acres between Carlyle Reservoir and Cowden. These projects are presently inactive because local interest is lacking. A levee to protect New Athens and two large flood control reservoirs are now under construction. One is at Carlyle and is substantially complete; the other is at Shelbyville and is about 20 percent complete. The State is acting as local sponsor for the New Athens, Carlyle, and Shelbyville projects. It is expected that total State expenditure will be more than $13 million on these three projects.

River and Harbor Projects

The St. Louis District Office of the United States Corps of Engineers is presently proceeding with a project to make the Kaskaskia River navigable from Fayetteville to the mouth (Figure 8). The first construction contract, which calls for dredging 4.8 miles of channel from canal mile 19.0 near Baldwin Shoals north to canal mile 23.8, was let June 16, 1966. The project should be completed and in operation by June 1971.

The navigation project consists of a lock and dam at mile 0.8, channel widening, deepening, and straightening. The lock and dam will consist of a reinforced concrete lock chamber 84 feet by 600 feet and a reinforced concrete spillway controlled by two 60-foot by 30-foot tainter gates. There will also be an earth fill across the old channel to complete the dam. The maximum lock lift will be 29.2 feet. Normal navigation pool elevation will be 368 msl. The channel will be realigned to eliminate sharp bends and ox-bows common to the lower Kaskaskia.

The navigation pool will have a minimum depth of 9 feet and a minimum width of 225 feet. The present river mileage from Fayetteville to the mouth will be decreased from 50 miles to 36.2 miles by eliminating meanders. Four railroad bridges will be removed and replaced by three high-level spans with a minimum 100-foot horizontal clearance and 25-foot vertical clearance. Two highway bridges will be replaced by high-level spans to provide the same clearance. Numerous utility lines will be altered during the construction of the waterway.

The quantity of water available in the Kaskaskia River during droughts and periods of low flow is insufficient to maintain the 9-foot navigation depth because of water losses from evaporation and lockages. In order to provide sufficient water, storage in the two large reservoirs now under construction has been allocated to navigation. The two reservoirs, Carlyle and Shelbyville, were designed primarily to reduce flood flow on the middle Mississippi valley. Storage for water supply for domestic and industrial use and low-flow augmentation has been incorporated into the design of the reservoirs. About 200,000 acre-feet of storage in Carlyle Reservoir and 155,000 acre-feet of storage in Shelbyville Reservoir has been allocated to supply the anticipated 200 cfs flow required when the navigation waterway is operating at its capacity of 20 million tons per year.

Local Action

The area to be served by the Kaskaskia River Navigation Project is predominantly rural and is economically oriented to agriculture. The area through which the Kaskaskia flows is underlain by coal. There is estimated to be a recoverable coal reserve (predominantly Herrin Number 6 coal) in excess of 2.6 billion tons within 15 miles of the navigation project. The coal interests were largely responsible for organizing local support for the project. Local groups were organized to publicize the project and to seek support from elected representatives.

Local supporters believe the project will reverse the economic decline of the region, increase coal production, attract industry, and not only stop the population decline but bring an increase.

The result of the local efforts on behalf of the project was a directive by the Chief of Engineers to the St. Louis District Engineer in August 1954 to make a preliminary study of the navigability of the Kaskaskia River. The preliminary report by the District Engineer, submitted in September 1956, recommended a detailed study of the lower 50 miles of the Kaskaskia. In March 1957 the Chief of Engineers authorized a report of survey, which was submitted in November 1959 and revised and resubmitted in November 1960. The railroad interests objected strongly to the project. A re-evaluation of the economic aspects of the project was ordered to be completed before construction funds were requested and was submitted in March 1965.

The November 1960 survey report shows a benefit-cost ratio of 1.9 to 1.0. Federal costs were estimated to be $58,445,000; non-Federal, $2,300,000. Annual costs were estimated to be $2,649,000 and annual benefits $5,120,000. The report also recommended that prior to construction local interests agree to:

— Provide without cost to the United States and upon request of the Chief of Engineers all lands, easements, and rights of way required for construction and subsequent maintenance of the project and of aids to navigation. These were to include suitable areas, determined by the Chief of Engineers to be required in the public interest for initial and subsequent disposal of spoil, and the necessary retaining dikes, bulkheads, and embankments therefor or the costs of such retaining works;
— Hold and save the United States free from damages that may result from the construction and subsequent operation and maintenance of the project;
— Make all necessary alterations to sewer, water supply, drainage, and other utility facilities;
— Bear a proportionate share of the costs of relocations of railroad and highway bridges in accordance with the principles of Public Law 647, 76th Congress, as amended, and remove one highway bridge at their own expense;
— Maintain all bridges over the improved waterway;
— Provide private loading docks on the waterway and mooring dolphins on the Mississippi at the mouth of the Kaskaskia River adequate to meet the needs of commerce;
— Provide adequate public terminal and transfer facilities, open to all on equal terms; and
— Establish an appropriate agency empowered to restrict the use or withdrawal of water from the Kaskaskia River below the Carlyle Dam or to provide for the replenishment of withdrawn water when, in the opinion of the Secretary of the Army, such use or withdrawal would adversely affect the construction, operation, and maintenance of the project.

The local organizations were financially and legally incapable of acting as local sponsor. They did, however, induce the State of Illinois to act as local sponsor. The Illinois Department of Public Works and Buildings was designated to act as the representative of the State. The Division of Waterways, an agency of the Department, is handling the technical details of sponsorship.

The Division has worked closely with the Corps of Engineers during all stages of pre-construction planning. As an example of the spirit of cooperation between the two agencies, the Division of Waterways was able to effect a change in the alignment of the New Athens Levee and the navigation channel near New Athens. This realignment resulted in a less costly and more desirable project in that area. A better interior drainage system was provided within the protected area, and an additional 23 acres of protected land will become available for recreational, commercial, and industrial use.

In order to comply with the sponsorship agreement, it is necessary for the State to purchase the bed and banks of the Kaskaskia River from Carlyle Dam to the head of navigation. This is the only way, under existing law, in which the State can control the withdrawal of water from the River. This cost was not included in the Corps' estimate. The present project is estimated to cost $72,840,000, of which $65,660,000 is Federal and $7,180,000 is State cost. Annual charges are estimated to be $3,571,000 and annual benefits are estimated to be $4,818,000 for a benefit-cost ratio of 1.3 to 1.0. To date the State has spent more than $1.2 million on the navigation project.

Future of the Kaskaskia Waterway

Study of the economic re-evaluation of the project leads to the conclusion that the future success of the Kaskaskia Navigation Project is problematical. The re-evaluation has allegedly taken into account the effect of mine-mouth power generation, unit-train coal haulage, and power generation with nuclear energy. The Waterway may have ability to handle as much as 30 million tons of cargo per year, but the economic study shows a maximum tonnage projection of 20 million in 1991, twenty years after completion of the Waterway. The 50-year average annual shipments are estimated at slightly more than 14 million tons, and it is estimated that the Waterway will be carrying only 8.3 million tons in 2021. It is estimated that the bulk of the coal originating on the Kaskaskia will move north to steam-electric plants on the upper Mississippi or down the Mississippi for ultimate use in Florida. No shipments are projected to move up the Illinois Waterway.

One item which makes a waterway such as the Kaskaskia, which is dependent upon the shipment of coal, appear to have a doubtful future is the rapid growth of nuclear-powered electric generating stations. Numerous stations have been constructed and many more are planned. A second consideration, which is of interim importance, is the continuing trend toward mine-mouth power generation. One such major project which will be located on the Kaskaskia River is now in the final design stage.

BIG MUDDY-BEAUCOUP CREEK NAVIGATION CHANNEL

The St. Louis District Office of the Corps of Engineers has studied the engineering and economic feasibility of canalizing the Big Muddy River and Beaucoup Creek (Figure 9). The principal commodity to be moved over the proposed waterway is coal. Recoverable coal reserves within 15 miles of the waterway are estimated at about 2 billion tons in the upper Big Muddy area and about 1.5 billion tons in the Beaucoup Creek area.

Several schemes of improvement were investigated, and three were studied in detail. Plan I consisted of a slack-water system from the Mississippi River extending up the main stem of the Big Muddy River to Rend Lake; installation of a lock in the Rend Lake Dam to allow access to the reservoir area; and improvement of Beaucoup Creek from its mouth to Pinckneyville. Plan II would provide a waterway only on the main stem, as outlined in Plan I, with development of the Beaucoup Creek reach omitted. Plan III consisted of a waterway from the Mississippi River to the mouth of Beaucoup Creek, and thence along Beaucoup Creek to Pinck-

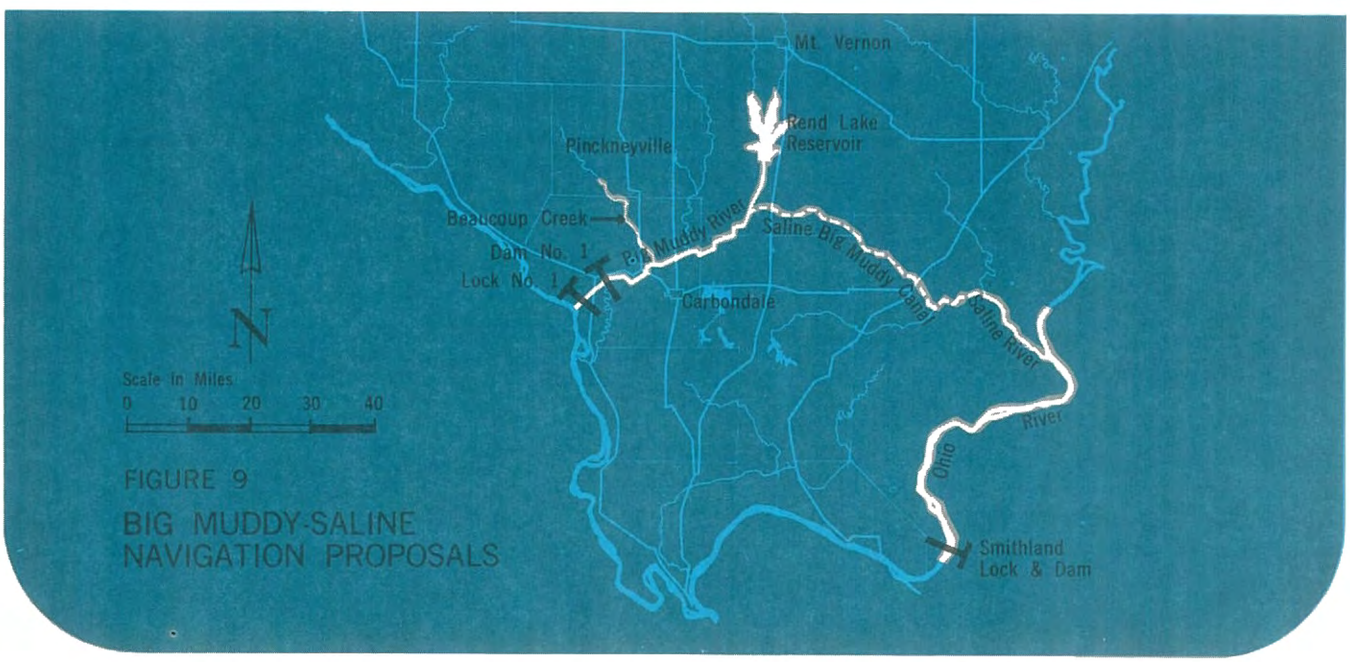


FIGURE 9
BIG MUDDY-SALINE NAVIGATION PROPOSALS

neyville; the upper arm of Big Muddy River would be omitted under this plan.

Certain features are common to all three plans. A new entrance channel would be provided to the Mississippi River near Gorham from about Grimsby, a distance of 6.5 miles; confining levees would be constructed on each side of this channel to prevent overflow into the adjacent drainage district; a lock would be constructed at the mouth of the new channel and a control dam placed in the existing channel of the Big Muddy River near Grimsby; the channel would have a bottom width of 225 feet, with additional width in bends; lock sizes adopted for the waterway would be 84 feet by 600 feet; existing railroad and highway bridges would be replaced with high-level structures; and supplementary sources of water would be provided by recirculating pumps at each lock site. The cost of these plans varies from about $150 million to more than $225 million.

In the latest analysis, even with the vast increases which are projected for national energy requirements, consideration had to be given to such influencing factors as the use of integral trains, the increasing use of nuclear energy, and the growth of mine-mouth power generation. Through a thorough and painstaking market analysis, the competitive position of the Big Muddy River region was compared with other coal-producing areas in the various market areas, and the estimated volume of canal shipments determined. In the overall plan for Big Muddy River-Beaucoup Creek development, as well as in Plans II and III, the benefit-cost ratios were determined to be substantially less than unity.

SALINE RIVER CANAL AND SALINE-BIG MUDDY CANAL

Over the years, there has been considerable local interest in the improvement of the Saline River for navigation. The primary local interest is to improve the competitive position of Saline valley coal. It has also been suggested that a navigable Saline would promote industrial growth in the region. A study of the Green River in Kentucky shows that a navigation improvement did increase the coal production, but did not attract industry or bring any measurable improvement in the economy of the region near the River.

When the Corps of Engineers completes the proposed Smithland Locks and Dam on the Ohio River, the water level at the mouth of the Saline River will be raised 7 feet, from 320 msl to 327 msl. Canalization of a portion of the Saline River will then be fairly simple. Some straightening, widening, and very little deepening of the Saline will be required to permit commercial navigation from the mouth to Equality, about 18 miles. It is estimated that the construction costs, exclusive of right-of-way and mooring facilities which should be provided by the coal interests, would be approximately $4 million.

Another scheme, which has received some press coverage but has not been studied by any State or Federal agency, is a canal connecting the Saline River with the Big Muddy River. This proposal would require numerous locks or deep channel cuts, because there is more than 200 feet difference in elevation between the mouth and headwater.

PROPOSED WATERWAY DEVELOPMENT, CHICAGO REGION

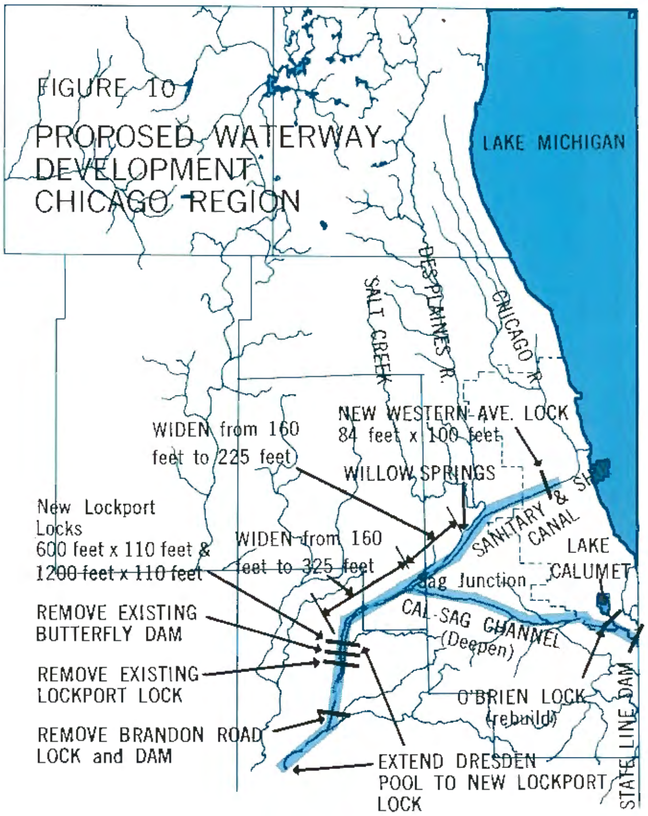
The Division of Waterways presently has under study a multiple-purpose project which would improve navigation on the Illinois Waterway above Joliet (Figure 10). A study of the area revealed the need for solutions to various water resources problems. Briefly, these problems are:

— Stabilization and protection of the Lake Michigan Shore;
— Development of the submerged lands of Lake Michigan for optimum use;
— Protection of the quality of the region's major water supply—Lake Michigan;
— Protection and improvement of the region's harbors and navigable waterways; and
— Improvement of drainage and storm-water outlets.

A comprehensive planning approach to the various problems developed the multiple-purpose plan, which is now being studied in greater detail. The main provisions of the Chicago Plan are for the construction of offshore breakwaters in Lake Michigan to protect the Illinois shore and to provide protected waters for pleasure boating and other recreational facilities. Flood control and improvement of drainage and navigation facilities will be provided by modification of the Chicago Sanitary and Ship Canal and the Cal-Sag Channel.

The total Canal improvement includes the removal of Brandon Road Lock and Dam; Lockport Locks, Dam, and Powerhouse; and the Butterfly Dam. Dresden Pool will be extended to the vicinity of Lockport, where new dual locks and a control works will be built. The locks will be 110 feet by 600 feet and 110 feet by 1200 feet. The water surface above the New Lockport Locks will be lowered 10 feet. The Sanitary and Ship Canal will have to be deepened only through the earth section, since the rock section is presently 25 feet deep.

The Cal-Sag Channel will be deepened 10 feet from Sag Junction to O'Brien Lock. A lock 84 feet by



600 feet and a control works will be installed at Western Avenue, the head of deep-draft navigation. O'Brien Lock will be rebuilt to accommodate the 10-foot lower canal. A control works will be built on the Grand Calumet River near the Illinois-Indiana state line in order to prevent discharge through Indiana Harbor into the Illinois Waterway. The Sanitary and Ship Canal will also be widened from 160 feet to 225 feet from Willow Springs to Sag Junction and to 325 feet from Sag Junction to Lockport.

The lowered Canal surface will provide an improved outlet for existing and future storm drains and will permit the drainage of low lands in the Calumet area. Operation of the Western Avenue and Lockport Control Works will permit the early establishment of the necessary hydraulic gradient for the discharge of floodwaters. The widened Canal will provide increased storm water discharge capacity and the lowered Canal surface will provide an additional 15,000 acre-feet of surcharge storage. Discharge of polluted storm water into Lake Michigan will be eliminated.

The elimination of Brandon Road Lock, the installation of dual locks at Lockport, and the widened Canal will provide increased capacity for the future increase in barge traffic. The lowered water surface will eliminate the necessity for high-level bridges or movable bridges, which are obstructive to both land and water traffic and expensive to operate and maintain. Material excavated during the improvement of the Canal will be used in the construction of the offshore breakwaters in Lake Michigan. Preliminary estimates of project costs and savings by the multiple-purpose project over single-purpose projects are give in Table 11.

TABLE 11

CHICAGO PLAN MULTI-PURPOSE PROJECT

Project Costs in $1,000		Project Savings* in $1,000	
Channel Earthworks	$ 68,000	Navigation	$ 62,000
Hydraulic and Navigation Structures	45,000	Storm Sewer Improvements	100,000
Bridges	4,600	Flood Control	41,000
Dock Modifications and Restorations	2,800	Land Drainage	500
Utility Modifications and Restorations	1,200	Bridges	5,200
Land Fills	204,000	Shore Protection	22,000
Transportation Development	60,000	Recreation	608,000
Recreation Development	110,400	Land Development	140,000
Land Acquisition	29,300		
Transportation Damages	11,000		
Totals	$536,300		$978,700

* Over most economical alternate, single-purpose project.

The multiple-purpose approach used in the development of this plan attempts to arrive at the most economical solution to the many water resource problems. Increasing waterway traffic is one of the problems for which the plan presents a solution.

ILLINOIS AND MISSISSIPPI CANAL

A new Illinois and Mississippi Canal was proposed in a 1951 survey report by the Corps of Engineers (Rock Island). The proposed Canal (Figure 11) would begin on the Mississippi River near Hampton and follow a southeasterly alignment for 17.9 miles to the old Canal near Geneseo. From Geneseo the Canal would generally follow the old alignment for 40 miles, then it would follow a new alignment for the last 6.4 miles to the Illinois River. The Canal would have a depth of 15 feet and a bottom width of 200 feet. Seven locks 80 feet by 600 feet would be used with two locks ascending to the summit level from the Mississippi River and five locks descending to the Illinois River.

The plan required enlarging the present I and M Feeder Canal to an 11-foot depth and 68-foot bottom width. The feeder would have two locks each 40 feet by 200 feet. Water supply for the Canal would come mainly from the Rock River through the Feeder Canal, but would also be supplemented by pumping at the two western locks. Seven aqueducts 80 feet wide would be required to cross large streams. The plan requires 47 new highway bridges and 7 new railroad bridges with a minimum vertical clearance of 25 feet on the main Canal and 12 feet on the Feeder Canal.

Prospective commercial traffic was estimated at 4.5 million tons annually. About one-half of the tonnage would be westbound coal and petroleum products. About one-third of the tonnage would be eastbound grain and grain products. The remaining tonnage would consist of iron and steel products, cement, fertilizers, and other commodities.

Traffic would be handled by four-barge tows consisting of four jumbo barges (35 feet by 195 feet) and a 1000-horsepower towboat. Capacity of loaded tows would be 5000 to 6000 tons.

The District Engineer estimated the costs as $99.8 million and a benefit-cost ratio of 1.15 to 1.0. Upon review of the report, the Board of Engineers for Rivers and Harbors increased the cost-estimate to $162 million and decreased the tonnage estimate, resulting in a benefit-cost ratio of 0.47 to 1.0. Both the Board and the Chief of Engineers concluded that the project was not advisable at that time. No attempts have been made to restudy the proposal, and the project is presently inactive.

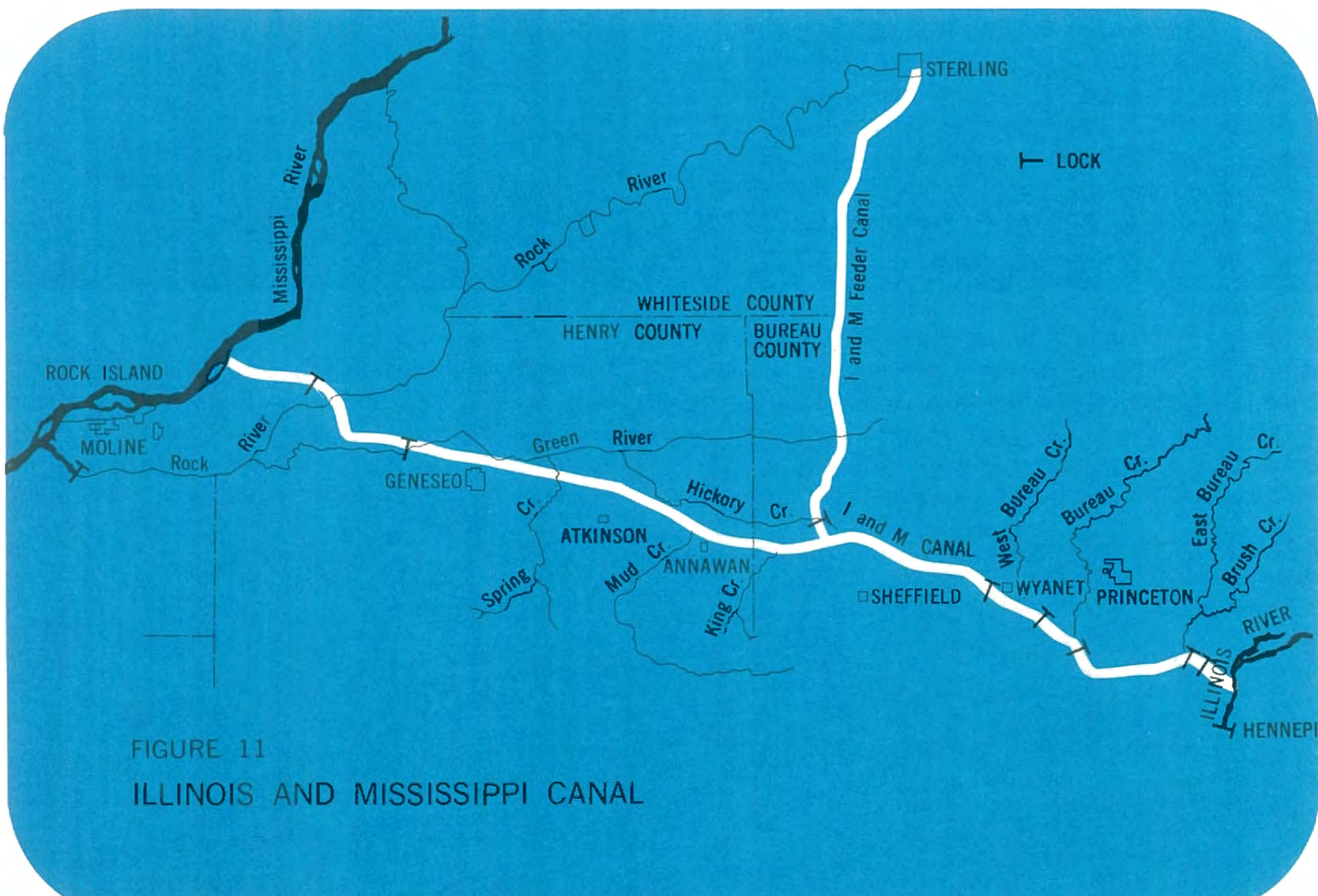
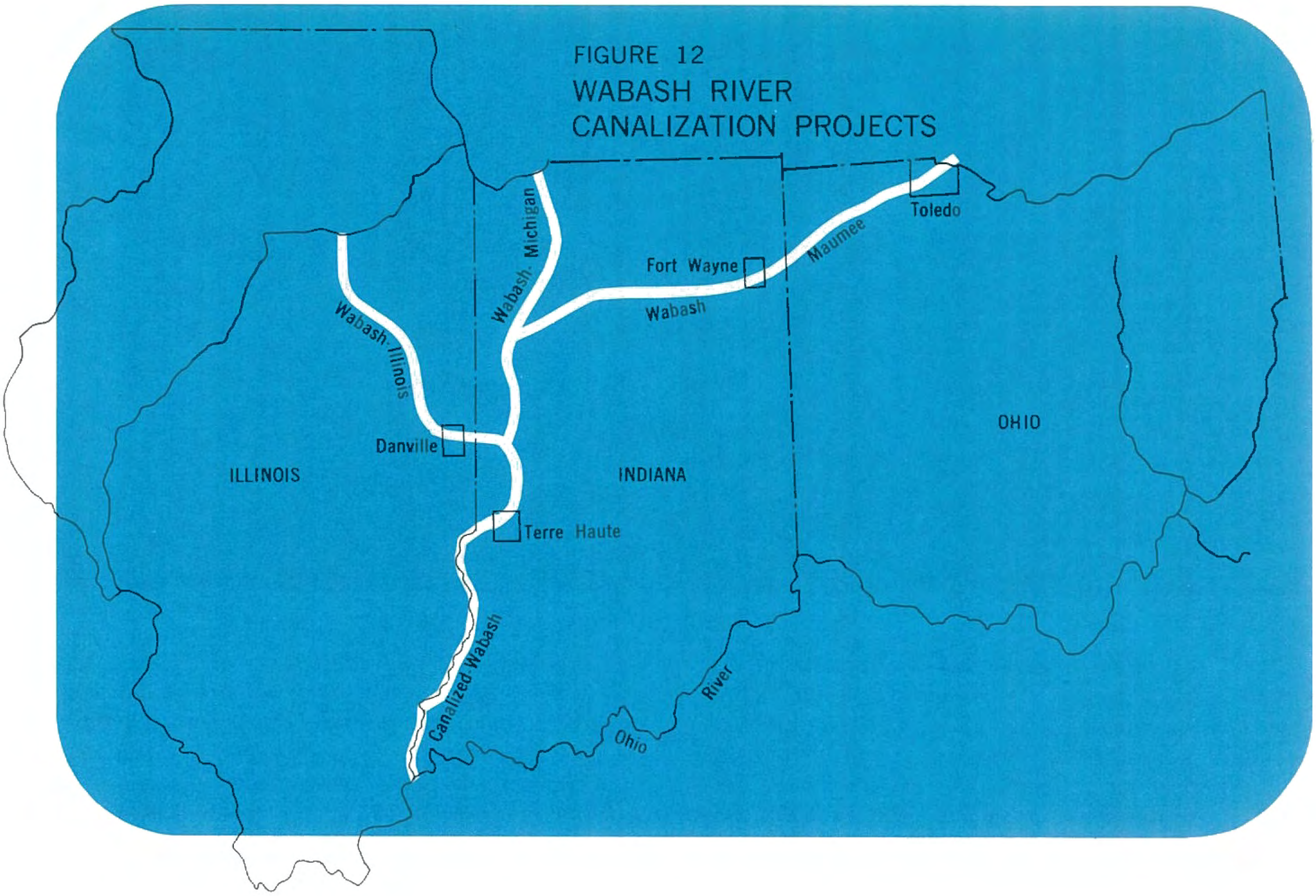


FIGURE 11

ILLINOIS AND MISSISSIPPI CANAL



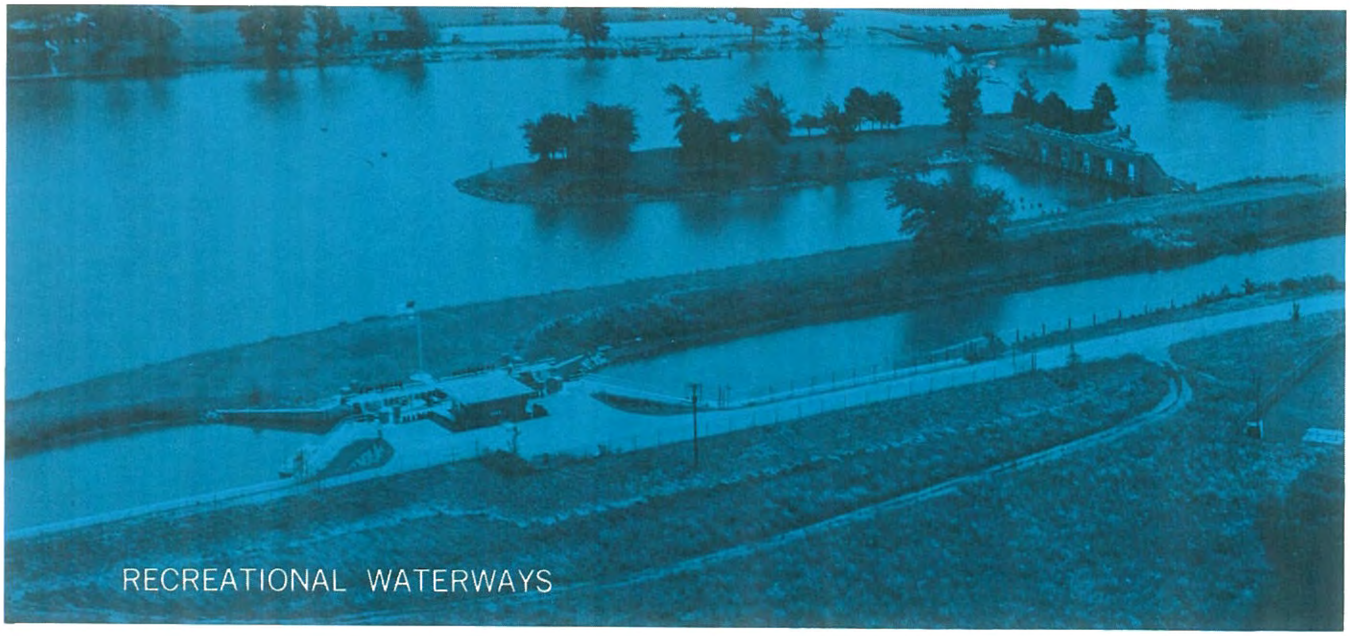
WABASH RIVER NAVIGATION

The Corps of Engineers is presently restudying the feasibility of canalizing the Wabash River from its mouth to Terre Haute, Indiana, (Figure 12). The first major study of navigation improvements on the Wabash was completed in 1933. This report considered the construction of 31 locks and dams on the River between the mouth and Americus, Indiana, and a lateral canal with five locks between Americus and Huntington, Indiana. The Wabash at Huntington was to be connected to Toledo, Ohio, via a canal along the Maumee River. The estimated cost of the project in 1933 was $161.4 million, but the report concluded that future commercial use of the Canal would not be great enough to justify the cost.

The second major study of the Wabash navigation project was completed in 1959 as a doctoral thesis. The plan of improvement was similar to the 1933 report, but required only 29 locks on the Wabash and Maumee between the Ohio River and Toledo, Ohio. The estimated cost of the project in 1959 was $800 million, and benefits were estimated to average $158 million per year. The study concluded that the project was economically justified.

In the current restudy of the project, the Corps of Engineers is considering a new plan of improvements between the mouth of the Wabash and Terre Haute. Cut-offs at large bends would reduce the channel length from 180 miles to 130 miles. However, since most of these cut-offs are in Indiana, about 50 miles of the river bank in Illinois would not have frontage on the waterway. Channel dimensions of the waterway would be 200 feet by 9 feet, and locks would be 84 feet by 600 feet. The tentative cost estimate for the project is $200 million. Economic studies are not completed, but there is indication that coal and grain will be the major items of traffic. It is impossible to say at this time if the project is economically justified or not.

The Wabash Valley Interstate Commission is also studying several proposals for improving the Wabash River for navigation. The Commission has also considered the previously mentioned schemes for connecting the Wabash with the Illinois River, Lake Michigan, or Lake Erie. These schemes do not yet have any official status. The Commission is also sponsoring a study at Indiana University to determine the economic impact of the different waterway proposals on the Wabash Basin.



RECREATIONAL WATERWAYS

McHenry Lock and Dam

A true recreational waterway is a system of improved rivers, canals, or channels through natural lakes with space and facilities for extensive pleasure boating. Large natural lakes, reservoirs, or streams suitable only for canoeing are not considered recreational waterways. Almost every commercial waterway can be used for pleasure boating, and thus is a recreational waterway. The increasing demand for water-related recreation and proposals for new facilities are discussed in Chapter VIII.

The most important recreational waterways in North America were not planned as such. Pleasure boating increased concurrently with the decrease in traffic on old commercial waterways, and they became recreational waterways. The best of these waterways are located in New York and Ontario. In Canada they include the Trent-Severn Waterway, the Rideau Waterway, the Ottawa River, the Richelieu River, and in New York portions of the State Barge Canal System. Certain commercial waterways form important parts of this system; they include the St. Lawrence Seaway, the Hudson River, and the mainline of the New York State Barge Canal. The Fox River in Wisconsin is an example of a Federal waterway which carries only a light pleasure boating traffic and no commercial traffic.

The conversion of commercial waterways to reccreational use is difficult in the United States. The Corps of Engineers has no authority to operate purely recreational waterways. Consequently, when commercial traffic ceases on an obsolete waterway, the Corps usually seeks to abandon it. Recent examples of abandoned waterways are the Big Sandy, the Muskingum, the Barren, the upper Cumberland, the Osage, the upper Fox River, and the Illinois and Mississippi Canal. Waterways which carry little or no commercial traffic and which may be abandoned in the future include the upper Alleghany, the upper Green, the Kentucky, and the Fox River in Wisconsin. In some cases, these waterways are well adapted to pleasure boating, but the states have shown little interest in rehabilitating, operating, and maintaining them.

Unlike the United States, Ontario has pursued an active policy of operating and improving its recreational waterways. The Ontario waterways not only fulfill local boating needs, but are an important tourist attraction. For instance, about one-half of the boats traversing the Rideau Canal and one-fourth of those on the Trent, are from the United States. The Canadians have estimated that each pleasure boat operating on their waterways adds more than $700 annually to the local economy. The total economic value is measured in tens of millions of dollars. New York is also cognizant of the recreational value of its waterway system, although the cost of operation and maintenance of the waterways is justified for the commercial traffic they carry.

COSTS OF RECREATIONAL WATERWAYS

The operating costs tend to be higher for some items on recreational waterways than on commercial waterways. This is because a higher standard of maintenance is required in order to keep the waterways attractive. These expenses are compensated by a short operating season, operation limited to daytime, less damage and repair to principal structures, and the smaller size of locks, channels, and bridges. Operation and maintenance expenditures for some recreational waterways are given in Table 12.

TABLE 12

RECREATIONAL WATERWAYS OPERATION AND MAINTENANCE COSTS

Waterway	Length (Miles)	No. of Locks	Annual Cost
Rideau Canal, Ontario	147	49	$ 730,000
Trent Canal and Murray, Ontario	259	45	1,306,000
Richelieu River, Quebec	80	10	426,000
Ottawa River, Ontario	117	2	108,000
New York Barge Canal	524	57	6,800,000
Fox River, Wisconsin	110	17	380,000

The New York Barge Canal is a large commercial waterway and is not representative of the group. The greater portion of the Ottawa improvement is formed by a single high-power dam. Statistics for the other waterways indicate an annual operation and maintenance cost of $5000 per mile. Major rehabilitation and modernization work on the Rideau is costing about $1 million annually and on the Trent, $1.2 million annually.

New construction cost data are almost nonexistent. The Fox River canalization project in Illinois is probably the only new recreational waterway under construction in the United States. The estimated 1962 cost of the project is $41 million, or $350,000 per mile of waterway.

USE OF RECREATIONAL WATERWAYS

The primary use of a recreational waterway is for pleasure boating; the intensity of use is measured in terms of boating traffic. The most commonly available statistics are boat-lockages, which are given for 1965 in Table 13.

TABLE 13

TOTAL SEASONAL BOAT-LOCKAGES ON RECREATIONAL WATERWAYS, 1965

Waterway	Boat-Lockages
Rideau Canal	35,320
Trent Canal	76,509
New York State Barge Canal	136,870
Illinois Waterway	31,440
Fox River, Ill. (McHenry Lock)	17,900
Fox River, Wis. (Menasha Lock)	3,609

The intensity of pleasure boat traffic depends largely on the attractiveness of the waterway, its proximity to urban areas, and the shoreside developments. The traffic through McHenry Lock is probably as high as for any lock in the United States and has changed very little since the lock was opened in 1961. On the other hand, the lockages on the Trent Canal have been increasing at about 16 percent per year for the past ten years.

A knowledge of traffic load patterns is necessary for the design of new locks or the reconstruction of old ones. An analysis of hourly traffic data at McHenry Lock yielded the load data in Table 14. On half of the weekends, peak daily traffic exceeds 250 boats per day. The seasonal traffic distribution reflects moderate to heavy weekday traffic in June, July, and August. Weekend traffic is uniformly high at all times from May through September (Table 15).

TABLE 14

TRAFFIC LOADS AT MC HENRY LOCK

	Boats Per Day
Peak 8-Hour Period	580
Peak Day (18.5 Hours Operation)	393
Peak Weekend (2 or 3 days)	325
Peak Week	179
Peak Month	161
Peak Year (3700 Hours Operation)	96.5
Average Day (3700 Hours Operation)	91.5

TABLE 15

SEASONAL TRAFFIC DISTRIBUTION AT MC HENRY LOCK

Month	Average Boats Per Day
May	74.0
June	115.0
July	144.0
August	139.0
September	80.0
October	39.0
November	2.5

Traffic is seldom distributed uniformly throughout a waterway, but tends to concentrate near population centers or important recreational areas. Individual lock data show that the lock receiving the heaviest use on a waterway handles three to five times more traffic than the average lock. A comparison of heavily used locks on different waterways is given in Table 16. It is interesting to note that McHenry Lock is the smallest of the above locks; it measures 20 feet by 60 feet. The others measure: Menasha Lock, 35 by 144; Chaffeys Lock, 33 by 134; Lock Number 42, 33 by 175; and O'Brien (a commercial lock), 110 by 1000. McHenry Lock, however, is the only one that was specifically designed for pleasure boating. It has given excellent performance.

TABLE 16

MEAN DAILY PLEASURE BOAT TRAFFIC AT SELECTED LOCKS, 1965

	Boats Per Day
Fox River, Ill. (McHenry Lock)	91.5
Illinois Waterway (O'Brien Lock)	73.9
Trent Canal (Lock No. 42)	48.0
Rideau Canal (Chaffeys Lock)	24.1
Fox River, Wis. (Menasha Lock)	18.0

Fox River

DESIGN OF RECREATIONAL WATERWAYS

A study of the construction, operation, and maintenance of recreational waterways has led to the following observations:

Channels for pleasure boating need not be as wide or deep as for commercial waterways, and alignment is seldom a problem. The Fox River project in Illinois will have a channel 100 feet wide and 5 feet deep. However, channels slightly narrower and deeper have been used on other waterways. Buoys, daymarkers, and warning signs must be used liberally. The Fox River is deficient in this regard.

Locks and lock areas must be designed and operated with recreational use in mind. Adequate tie-off and waiting areas at each end of a lock and locking discipline are necessary to keep boats from milling about the lock entrances. On commercial waterways fendering is tough and is designed to protect structures from vessels. On recreational waterways fendering must be soft, resilient, and designed to protect small boats from damage by structures. Fendering should be liberally installed inside and outside the lock. Lock crews must be as large or larger than at commercial locks in order to maintain safety and assist boats while locking. Lock areas and grounds require a high standard of maintenance—well painted buildings, lock gates, and machinery, as well as neatly kept lawns, shrubs, and trees. Restroom facilities, refuse containers, and parking areas are generally considered necessities. In fact, nothing reasonable should be overlooked that would contribute to a park-like atmosphere and a pleasant locking experience.

Bridge clearance requirements are not great—15 feet is adequate for most power boats. Movable bridges are an unnecessary expense and should be avoided wherever possible. Channel spans must be clearly marked with buoys or signs, and piers should be fendered.

Dock and Marina requirements on recreational waterways are tremendous and are usually provided by private enterprise. Cruising boaters require launch facilities—overnight dockage, fuel, ice, groceries, repairs, bait, overnight sleeping accommodations or camping areas, rest stops, and information. (See Chapter VIII for a discussion of the new interest in boat cruising and camping.) Parks and public landings should be provided on long reaches of a waterway bounded by private property where boaters cannot leave the water. The spacing of these facilities depends on the intensity of boating activity, the size and type of boats being used, and the habits and preferences of the boaters. Small open runabouts require frequent stops for fuel and stretch breaks; the average spacing probably should not exceed 10 miles. For cabin cruisers and houseboats, the spacing can be about 25 miles.

Natural Features of the waterway have a great effect on its usability for recreation and on the cost of development. Clean, unpolluted water and an esthetically pleasing environment are necessities. The stream in its natural state should have a broad low-water channel with moderate to flat surface slope and low-water discharge adequate for lockage water, seepage, and evaporation. The bed of the stream should provide good foundations for locks and dams. Sound bedrock or dense glacial till are the best foundations. Porous, granular soils or compressible soils cause seepage and stability problems. The stream banks should be higher than the proposed pool levels. Otherwise, the cost of land damages and flowage easements will be excessive. The sediment load of the stream should be extremely low in order to avoid the high costs of maintenance dredging. Flood stage should not submerge lock machinery. The Fox, Kankakee, and Rock Rivers approach these conditions fairly well. However, the streams in central and southern Illinois have inadequate low-flows, high flood stages, high sediment loads, and poor foundation conditions. The cost of canalizing these streams would be several times greater than the cost for the Fox River.

RECREATIONAL WATERWAYS IN ILLINOIS

The pleasure boating waterways of Illinois include all the rivers and canals which are improved for commercial navigation: the Mississippi River, the Ohio River, the Illinois River, the DesPlaines River below Lockport, the Chicago River, the Calumet and Little Calumet River up to Blue Island, the Chicago Sanitary and Ship Canal, and the Calumet-Sag Channel. Public waters not improved for commercial navigation but adequate for some pleasure boating include: the Wabash River, the Galena River up to Galena, the Fox River above Algonquin Dam, the Rock River above Sterling (Lake Sinissippi), the North Shore Channel up to Wilmette, and some pools on the Illinois and Mississippi Canal.

Most of the rivers and streams of Illinois not mentioned above are not public waters, and the public has no legal right to use them. Because the acquisition of additional public waters is extremely expensive, most of the recreational waterways in Illinois are also commercial waterways.

FOX RIVER RECREATIONAL WATERWAY

The Fox River project, the only new recreational waterway being developed in Illinois, is partially completed. The project is the result of many years of study and planning which culminated in the "Survey Report for Development of Fox River: Ottawa to McHenry Dam" in 1962. This report was prepared by the Division of Waterways and has been adopted as the master plan for development of the Fox River (Figure 13).

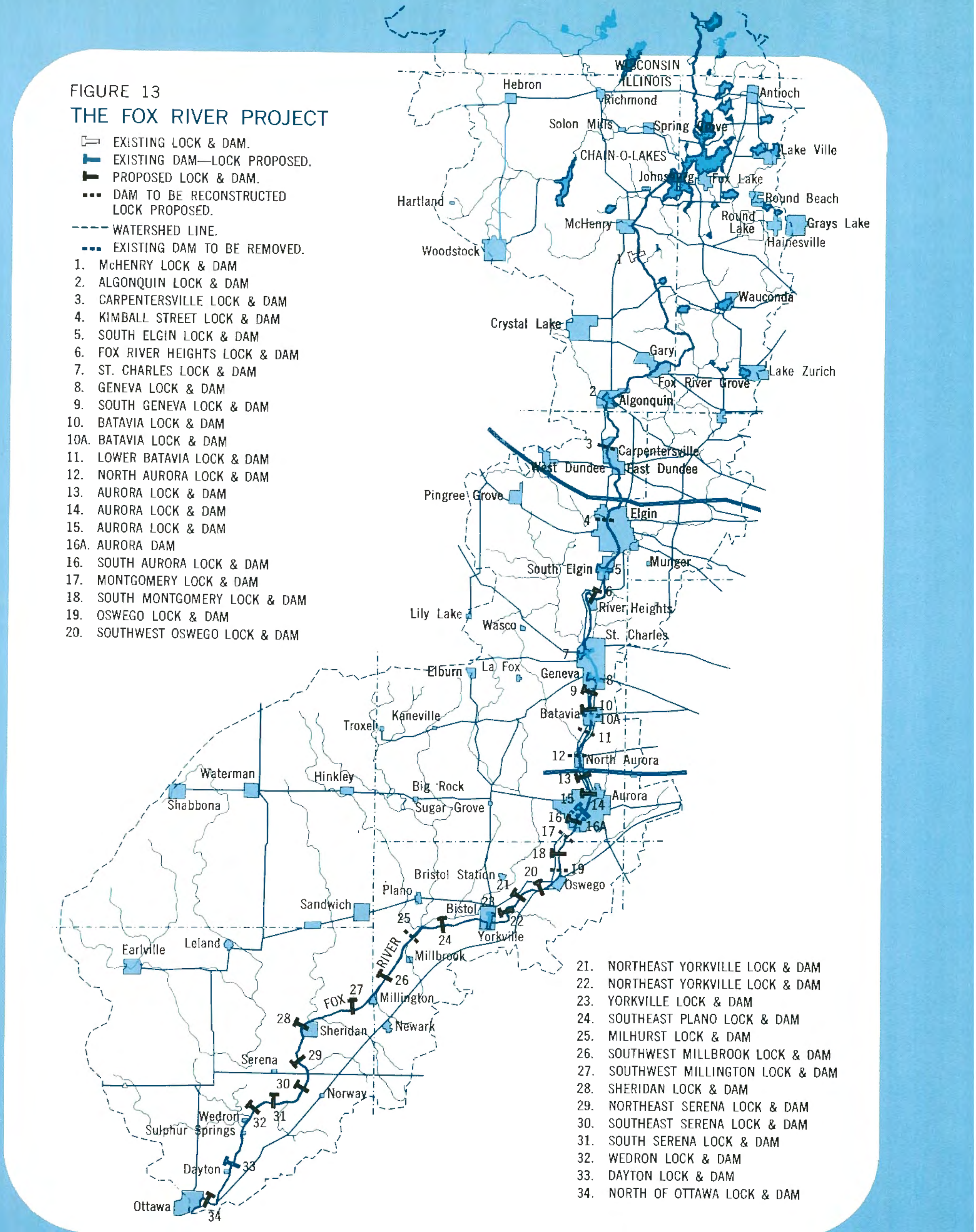
The master plan provides for canalization of 115 miles of the Fox River to provide through navigation for pleasure boats from the Illinois River at Ottawa to the Illinois-Wisconsin state line. The channel will have a bottom width of 100 feet and a minimum depth of 5 feet. Slack-water pools will be created by 34 dams. Each dam will be provided with a lock 20 feet by 60 feet. Eight existing dams and one lock (McHenry) will be incorporated into the project without modification. Seven existing dams will be reconstructed, two dams will be removed, and nineteen new dams will be built. Twelve highway bridges will have to be rebuilt to provide the minimum horizontal clearance of 100 feet and minimum vertical clearance of 15 feet.

The State's interest in recreational navigation in the Fox River and Chain-O-Lakes began in 1923 when the old McHenry Lock and Dam was given to the State by the Fox River Navigable Waterway Association. The dam had been built in 1907 to raise water levels in the Chain-O-Lakes to navigable depths. The lock and dam was operated by the State from 1923 to 1938. In 1938 the old dam was severely damaged, and it was necessary to build a new structure. A contract for a new reinforced concrete dam was awarded in 1939, and the structure was essentially completed in 1940.

Following World War II, several projects were undertaken along the Fox River. They included construction of the Ottawa Sea Wall in 1945, Algonquin Dam in 1947, Aurora Dam in 1951, and several dredging projects on the Fox River between Algonquin and McHenry and in the Chain-O-Lakes.

Numerous requests for other projects along the Fox River indicated the need for a comprehensive survey and study of the entire River to serve as a master plan for development. While the study was

FIGURE 13
THE FOX RIVER PROJECT



underway between 1947 and 1962, several interim reports were made. These reports resulted in construction of the McHenry Lock in 1960 and in rehabilitation of Yorkville, Geneva, and South Elgin Dams in 1961.

Since the adoption of the master plan in 1962, funds have been appropriated for right-of-way acquisition and construction of dams at Millhurst, Montgomery, and Oswego. Through 1965, construction and major repairs have amounted to $1,577,252, and maintenance dredging has amounted to $693,076.

Pollution and right-of-way acquisition have been major problems in carrying out the master plan. Organic and industrial pollution have fouled many reaches of the Fox River, causing fish kills and offensive conditions. Increasing concentrations of nutrients in the Chain-O-Lakes are causing heavy algae growth resulting in discoloration of the water, offensive odors, and degradation of sports fisheries. An intensive effort is being made by numerous State and local agencies to solve the pollution and algae problems. Unless a solution is found, the Fox River and Chain-O-Lakes will be lost as a recreational resource.

Right-of-way acquisition for the various elements of the Fox River project has been difficult. While it is true that a large majority of citizens in the Fox valley enthusiastically support the master plan, there are still many property owners along the river who object strongly to the project. These right-of-way problems will probably delay completion of the project for many years and increase the costs many millions of dollars.

USE OF ACTIVE COMMERCIAL WATERWAYS

Most of the public waterways of Illinois are commercial waterways which traverse some of the most populous regions of the State. Therefore, it is fair to ask why these waterways do not meet the demand for pleasure boating. Part of the problem is geographic; metropolitan areas such as Springfield, Decatur, Champaign-Urbana, and Rockford are remote from waterways. The remaining problems can be grouped under design, operations, esthetic considerations, and development.

All the major physical works of these waterways—the locks, channels, bridges, and navigation aids—have been designed for commercial operations. A pleasure boat operator must understand the dangers inherent in using commercial facilities, and he must have the skill to operate his craft accordingly. Unfendered lock walls and turbulence in the lock chamber can damage pleasure craft unless they are properly moored. In several reaches in the upper Illinois Waterway, the channel is excavated in rock, and the depth outside the channel buoys may be less than 2 feet. Craft leaving the marked channel risk serious damage to the hull, rudders, and propellers. The navigator must understand channel buoys, lights, daymarks, and a host of light and sound signals used at locks, dams, and movable bridges.

At locks, commercial tows have priority over pleasure craft. When locks are congested, pleasure craft may have to wait several hours for lockage. The Corps of Engineers has instituted the "three lockage" rule, which provides that pleasure craft will not be detained for more than three lockages.

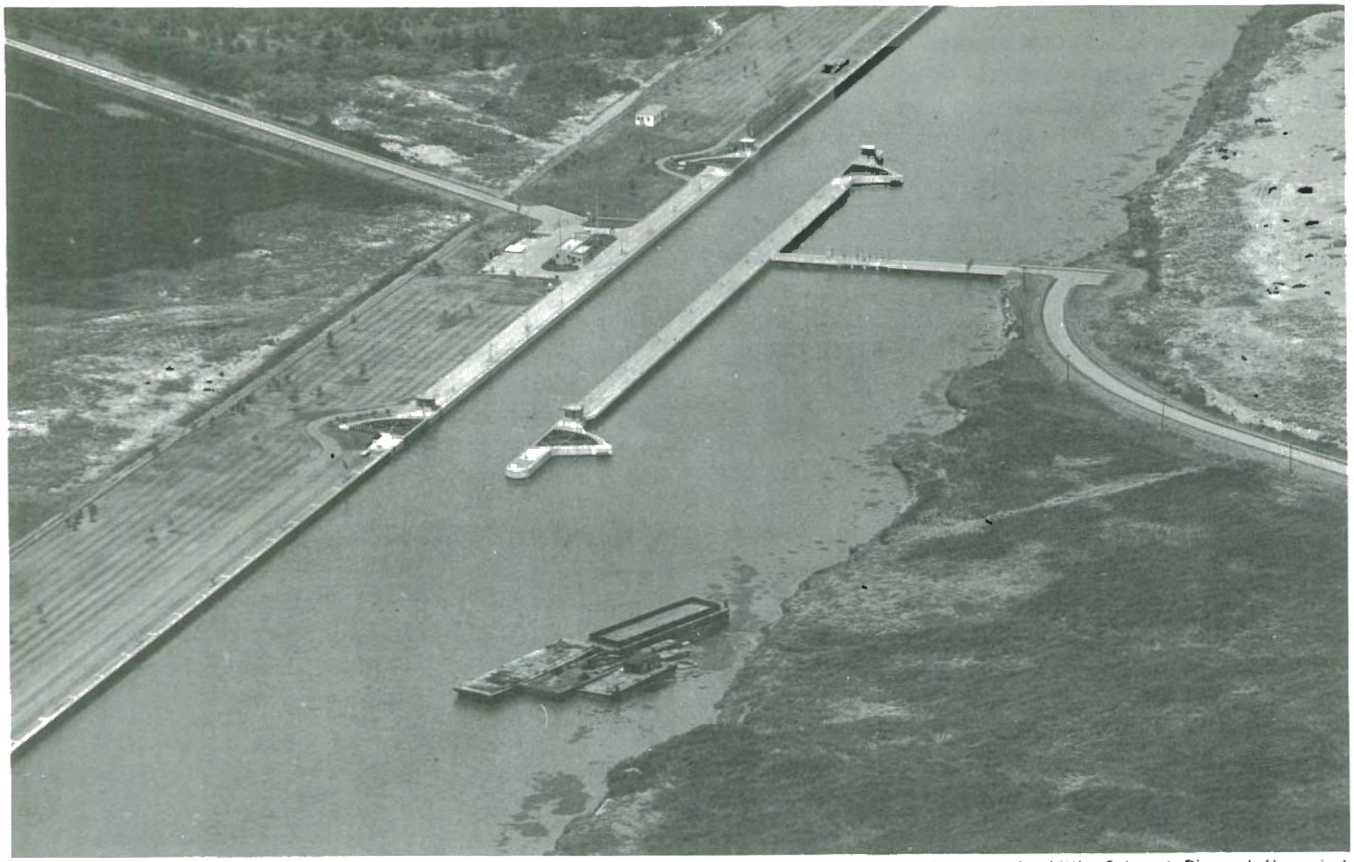
Although most pleasure boaters avoid tows, there is always the danger of collision or capsizing in congested lock areas or in narrow channels. Fortunately, most hazards on commercial waterways can be avoided by adequate knowledge and skillful boat handling.

Commercial waterways are often unattractive, particularly through cities and industrial areas, where waterway banks are lined with docks, materials yards, warehouses, factories, and junk yards. The water is commonly polluted and occasionally covered with oil slick and floating debris. The more attractive reaches are often remote from population centers and do not have sufficient launching, docking, and service areas.

Most of the problems of recreational navigation on commercial waterways cannot be eliminated. However, the following steps would result in greater usability:

- Construction of pleasure boat waiting areas at locks a safe distance from maneuvering tows; each waiting area should have a signalling device for use of small craft that do not have horns or radios;
- Separation of tows and pleasure craft whereever possible by providing separate, parallel, marked channels;
- Implementation of works to decrease water pollution and beautify the waterways should be encouraged;
- Expansion of launching, dockage, and service facilities should be encouraged; and
- Provision of pleasure boat locks at congested commercial locks.

Many Illinois boaters probably avoid the commercial waterways because they do not have proper knowledge, information, and skill. A program of information and education would equip boaters to navigate commercial waterways safely.



O'Brien Lock on the Little Calumet River at Hegewisch

NEW RECREATIONAL WATERWAYS

The increasing demand for pleasure boating in Illinois will result in overcrowding of many public waters, especially near metropolitan areas. The Chain-O-Lakes and some reservoirs in central Illinois are already used to the point of saturation. Intensive pleasure boating invariably means a loss of water space for fishing, hunting, and many less intensive uses. In order to make the maximum recreational use of the public waters, pleasure boating use must be less than saturation.

Saturation can be avoided by greater use of commercial waterways for boating, by controlling the number of boats on crowded waters, or by providing additional boating waters. The number of boats can be controlled directly or indirectly. Limiting the number of use permits issued is direct control. Boating can be indirectly controlled by limiting the number of access points; by restricting the capacity of parking areas, launching ramps, and other shoreside facilities; or by limiting the horsepower of boats. Providing new recreational waterways is the most costly and difficult of the solutions.

On the large reservoirs in downstate Illinois which were built for water supply or flood control, pleasure boating can be provided for a reasonable cost. The costs generally include only the required launching areas, docks, and related shoreside developments. However, the construction of recreational waterways on non-navigable streams is extremely expensive. The cost of converting these waterways includes not only the shoreside facilities, but also the major physical works—locks, dams, dredging, bridges, and navigation aids. Payments for the right-of-way, lands, and land damages must also be included. In addition, annual operation and maintenance costs are high because of the many structures to be maintained, the large work force required for operation

of the locks and dams, and the necessity for periodic dredging to maintain channel depths.

It seems wasteful to undertake an extensive program for construction of new recreational waterways when existing waterways in Illinois are not being used to capacity. Waterways which are not fully used include not only the Illinois and Mississippi Rivers, but also the inactive Illinois and Mississippi Canal.

The Illinois and Mississippi Canal was completed in 1907 after almost 50 years of promotional effort. Western Illinois farmers wanted the Canal as a means to force a reduction in railroad freight rates. Although the Canal never carried a significant volume of traffic, it did bring about reduced freight rates. The present plan to convert the Canal to recreational use is a sensible way to make better use of the State's recreational resources. The plan would provide about 60 miles of waterway suitable for houseboats and other pleasure craft, plus about 30 miles of canoeing water. The navigable portion would include the 29-mile-long feeder canal and 31 miles of the main line between Geneseo and Wyanet. Four locks would be operated in this section, and the remaining locks on the Canal would be secured. The operation and maintenance of the Canal for navigation would cost about $500,000 a year, about one-fourth of the annual cost of a new recreational waterway of the same length.

Traffic

A new recreational waterway is economically justified only if the benefits exceed the costs. The benefits accruing to the waterway depend on the intensity of use, i.e., the traffic. Estimating traffic requires the following steps:

- Estimating present and future population;
- Estimating present and future boat ownership;
- Estimating the number of boats that will use the waterway, including the average number and length of boat trips;
- Estimating traffic distribution along the length of the waterway;
- Estimating peak daily traffic at each lock and access point.

These steps would yield sufficient information to determine the capacity of locks needed and to locate and design adequate access points and shoreside facilities. Unfortunately, present knowledge and data on the patterns and trends in pleasure boating are inadequate for such a study; research and data collection are needed.

Benefits

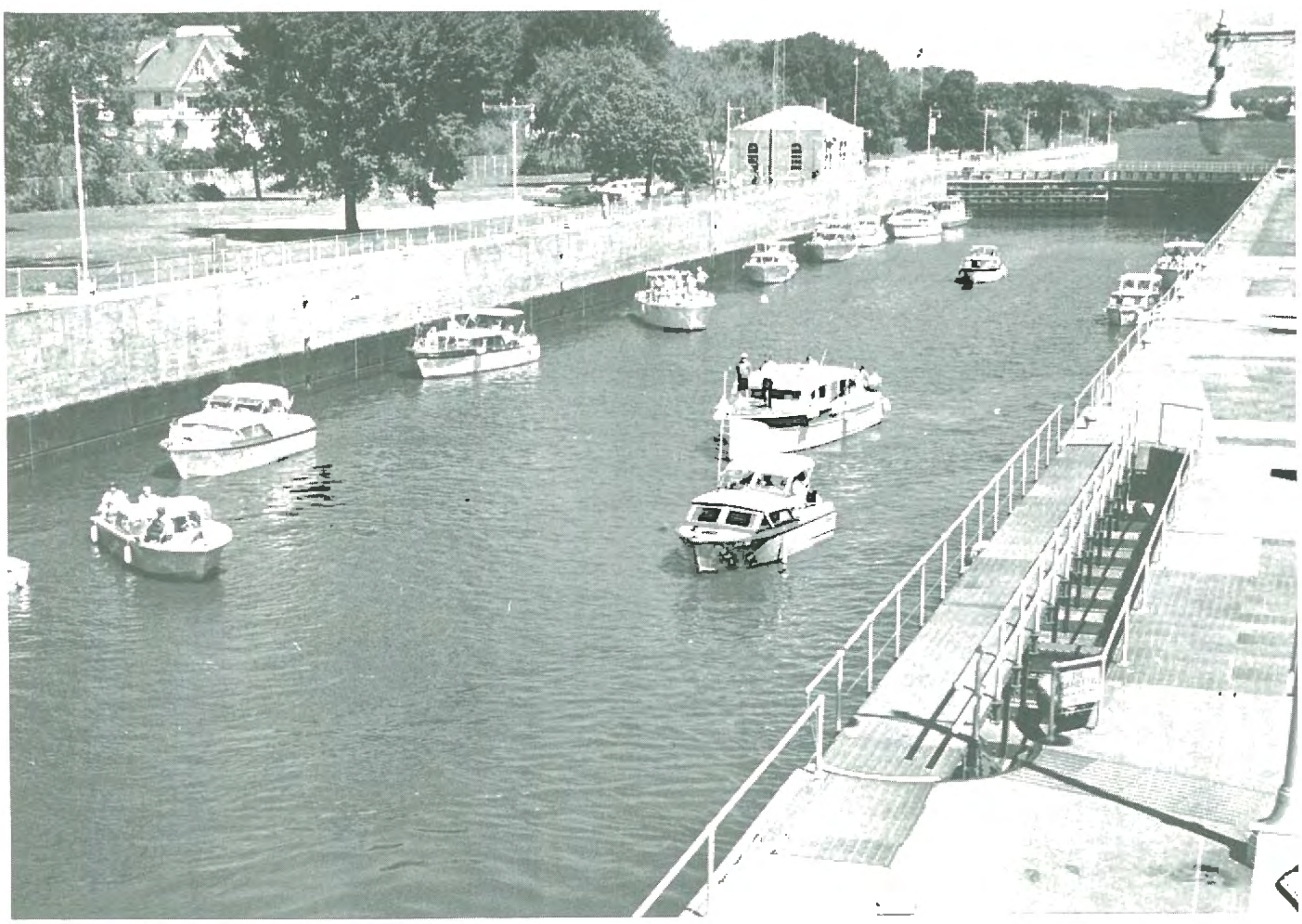
Assuming that a traffic estimate has been made for a proposed waterway, the next problem is to determine the benefits. If an economic comparison of benefits against costs is to be made, the benefits must be translated into dollar values. It is impossible to convert recreational values directly into dollar values; the indirect approach is less realistic but much more practical.

One indirect measure of benefits is to determine what the user is willing to pay. If pleasure boaters are willing to pay collectively more than the cost of the waterway, the project is economically feasible. The problem can be approached in reverse to determine the cost of the waterway per user. On the Trent Waterway in recent years, the annual cost just for operation and maintenance was more than $90 per boat. If the amortized cost of capital improvements were included, this cost would be substantially higher.

Another indirect measure is to estimate the value added to the economy by making pleasure boating possible on a waterway. In Canada, a study of the Trent Waterway showed that the average boater spent $354 on his craft each season. An economic activity multiplier of 2 was applied to bring the estimated value to $708 per boat per year. This simple method of measuring value showed average annual benefits of $10 million for the Trent Waterway. If we applied the same unit value to the pleasure boats in Illinois, disregarding other factors, the economic value would be a staggering $108 million per year.

The foregoing discussion simply points out the problems in estimating pleasure boating benefits. Actually, neither the amount the pleasure boater is willing to pay, nor the net, economic value of pleasure boating is known.

The negative benefits, i.e., damages or lost values, should also be evaluated and subtracted from the gross benefits. For instance, slack-watering of a stream will submerge riffles and cause silt deposits in the pools; water temperatures will probably increase. These changes may reduce or eliminate valuable sport fishes. Thus, changes in fish populations and fishing opportunities should be evaluated. Many recreational uses of water are incompatible. A recreational waterway will increase opportunity for certain activities and decrease it for others. The problem is to determine whether there is a net gain in recreational benefits and whether the adjusted benefits exceed the costs.



CONCLUSIONS AND RECOMMENDATIONS

I. Illinois has an excellent commercial navigation system. Recommendations for the existing system are:

A. The State should continually study and prepare definite recommendations to the Federal Government for the improvement and modernization of the waterway system as the needs arise. In particular, an appropriation of $650,000 over the next two biennia will be required to make a detailed study on the following projects:

1. Duplicate locks on the Illinois Waterway;
2. A new lock on the Mississippi at Alton;
3. A 12-foot channel on the Illinois Waterway and Mississippi River;
4. Widening of the Chicago Sanitary and Ship Canal; and
5. Bridge clearances and alignment on the entire waterway system.

B. The State should encourage greater use of the commercial waterways for pleasure boating and general recreation. The State should study uses of the waterways and the conflicts between recreational and commercial use to minimize problems involved in joint use of the waterways. Particular problems and projects which should be studied now are:

1. Small craft harbor and marina development along waterways;
2. Riverside parks and access areas;
3. Separate pleasure boat channels;
4. A pleasure boat lock at O'Brien Lock;
5. Pollution, particularly nuisances, such as floating debris, oil slicks, and corrosive effluents.

II. For the Port of Chicago, the following is recommended:

A. Submerged lands in the vicinity of Calumet Harbor not now dedicated to park purposes should be reserved for future port expansion.

III. A number of projects for new commercial waterways have been proposed, some of which are underway. The following procedure is recommended for development of new commercial waterways:

A. Proposals for new commercial waterways should be studied by the Technical Advisory Committee on Water Resources, or its successor, and the Department of Business and Economic Development to evaluate their feasibility and compatibility with State economic and water resources planning.

B. Congress should be urged to authorize feasibility studies on those proposals that State studies indicate have merit.

IV. The growing demand for water-related recreation makes it increasingly necessary to develop the waterways of the State for recreational use. For recreational waterways, the following is recommended:

A. The needs for recreational navigation should be considered in all water resources development studies, and special provisions should be added to plans whenever justified.

B. Provisions for recreational boating should be made a part of the plan for the development of the Illinois-Mississippi Canal and Lake Sinnissippi.

C. Funds should be appropriated in the next biennium for continuance of the Fox River project by constructing dams at Millhurst and Oswego and construction of a lock at the Yorkville Dam. In the following biennium, funds should be appropriated for the construction of additional dams from Algonquin to Elgin.

V. The needs for a review of existing legislation or for new legislation should be studied by appropriate State agencies in the following areas:

A. Careless mooring of vessels along navigable waterways;

B. Acquisition of navigation easements, dedications, or other land interests for developing recreational waterways;

C. Effectiveness of port districts in the development of port facilities; and

D. Regulation of the use of water for other purposes such as municipal and industrial water supply, when it has been developed specifically for navigation.

ACKNOWLEDGMENTS

This chapter, prepared under the direction of Mr. John C. Guillou, Chief Waterway Engineer, was written by Mr. Bruce Barker, Assistant Bureau Chief, assisted by Mr. John B. Carlisle, Bureau Chief, Bureau of Water Resources, Division of Waterways, Department of Public Works and Buildings.

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chapter eight
water-related recreation

illinois technical advisory committee on water resources

"We must make a massive effort to save the countryside and establish—as a green legacy for tomorrow—more large and small parks, more seashores and open spaces than have been created during any period in our history."

Lyndon B. Johnson

SUMMARY

Illinois has a great potential in its river valley resources for development of an outstanding system of water-related recreational centers connected by linear parkways. This potential must be preserved and developed to meet the outdoor needs of a growing population with high mobility, extended leisure, and great affluence.

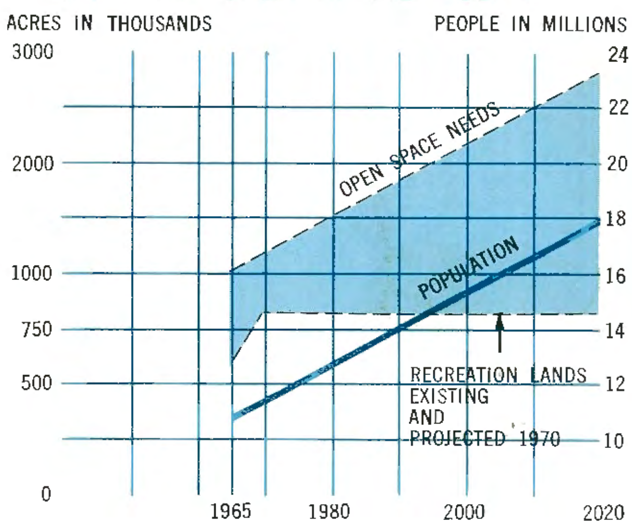
Illinois residents, ranking third highest in the nation in personal income, have the economic potential to acquire land and develop sufficient facilities to meet future requirements for recreation.

Unless an accelerated program is initiated to preserve these land and water resources, they will soon be dissipated by urbanization, pollution, incompatible land and water uses, inadequate and overcrowded facilities, and lack of planning and controls.

Illinois' supply of public open space is only 565,178 acres or 5.7 acres per 1000 population, the lowest in any state. The needs in relation to the population are shown in Figure 1. Nearly one-half of this supply lies in the nine southern-most counties, far removed from Metropolitan Chicago where 62 percent of the State's people live. The greatest water impoundment potential is also located in the southern half of the State. At this time 94.3 percent of the land and 85 percent of the water area of the State is in private ownership.

FIGURE 1

COMPARISON OF POPULATION AND RECREATION OPEN SPACE NEEDS



The bulk of the effort in the State's recreation expansion program should be directed toward increasing the developed water and associated land. Illinois has ample potential recreational land except in the northern Chicago section. This study reveals there also are ample potential recreational water resources, except in the Chicago region. The area having the greatest concentration of population in the State is most seriously in need of both land and water for recreational use. The present recreational resources are shown in Figure 2.

The many Federal, State, and local cooperative development programs exemplified by the seven Corps of Engineers multi-purpose reservoirs projected for south-central Illinois will be a good start toward meeting the current demands for water-related recreation, but a faster rate of acquisition will be needed. Case studies illustrate other ways of developing existing and new facilities.

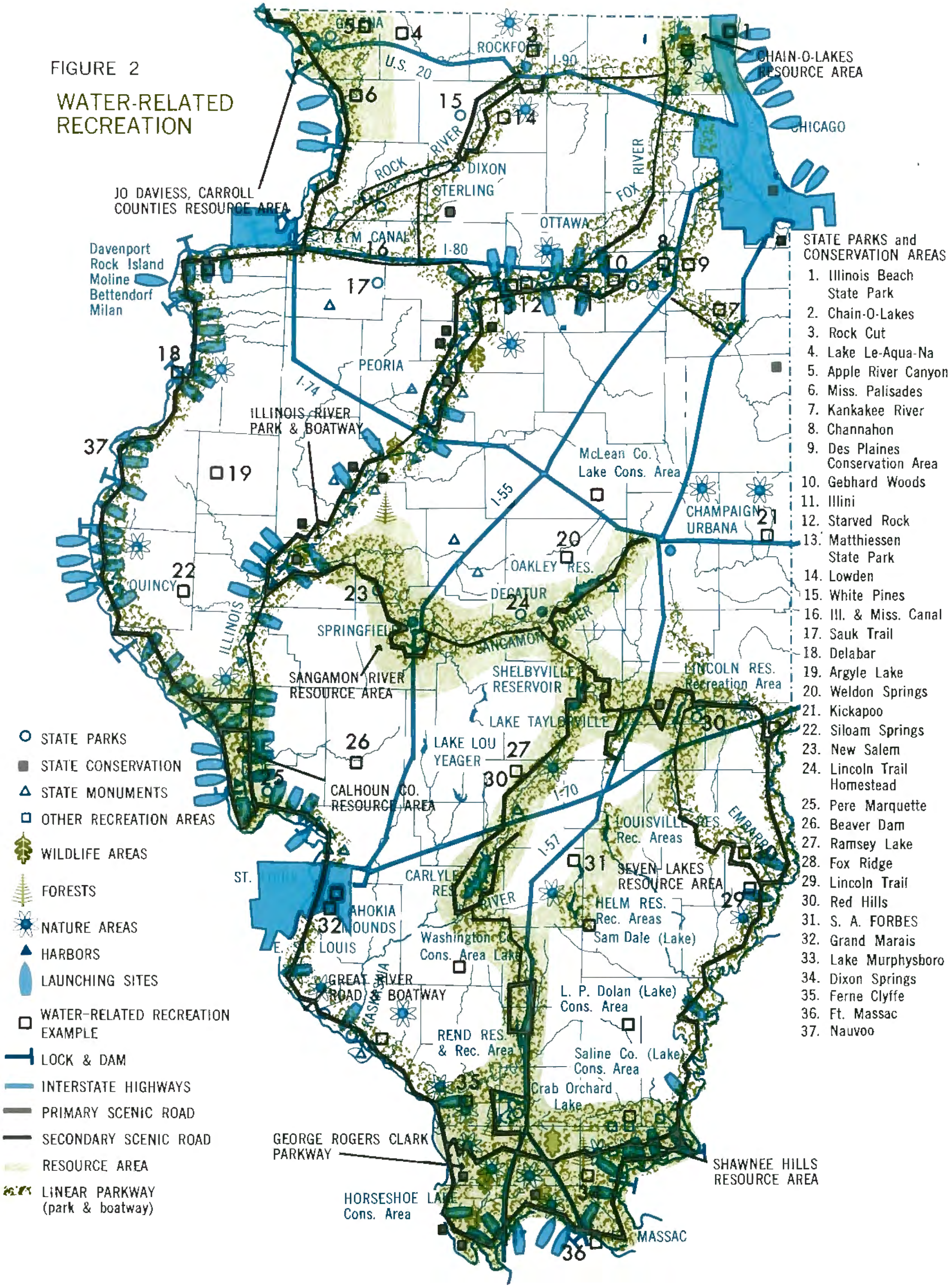
The enthusiasm for water-related sports is growing at a tremendous rate. By the year 2000, swimming will be the most popular of all water sports; the use of pleasure boats is expected to double by 1980, and to be four times greater by the year 2020. Sailboats and canoes are extremely popular where the situations are favorable for their use. Water skiing, fishing, and waterfowl hunting have great numbers of adherents everywhere.

The goal for outdoor recreation in Illinois was summarized in **Outdoor Recreation in Illinois:**

> "To preserve, manage, and develop the outdoor recreational resources of the State to assure residents and visitors of an adequate supply of recreational opportunities to meet existing and expected needs."

FIGURE 2

WATER-RELATED RECREATION



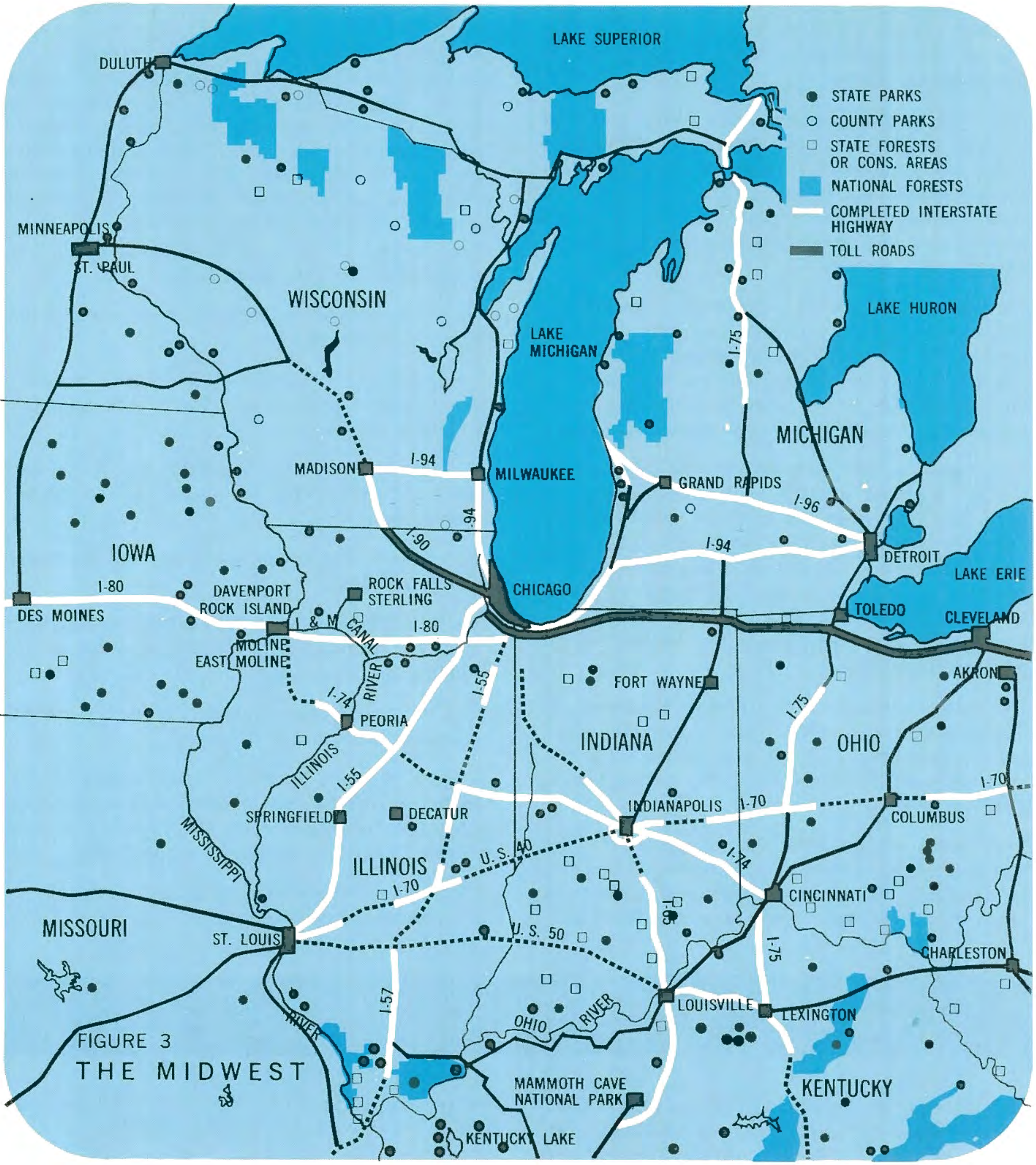


FIGURE 3

THE SETTING

The North American Midwest, generously endowed with natural resources and a favorable climate, has a tremendous capacity for supporting the nation's future population. Already, the influence of economic activity and a rapidly expanding population on the State's basic resources has established the land use patterns on which future generations must build.

Illinois, located in the heart of this thriving region, has the geographic position and adequate resources to play a leading role in this anticipated growth (Figure 3). In addition, it has a favorable climate and adequate rainfall.

While not as scenic as the mountainous states of the East and Far West, the topography of the great plains offers maximum useable acreage for population growth without crowding. The lands are sufficiently rolling to provide good drainage. The rich prairie soils are productive and have excellent water-holding capacity.

The great rivers — the Mississippi, the Illinois, the Ohio, and the Wabash—and Lake Michigan combine to make Illinois an inland port. These rivers and their tributaries offer excellent potential for development of reservoirs to supply the growing demand for water and water-related recreation.

Geographically, Illinois is on the mid-continent interstate highway corridor, with Chicago and St. Louis the focal cities. In the past Illinois' natural and cultural resources have been used primarily for living and working. A new era is approaching when our growing American society, with greater affluence and increased leisure time, is demanding recreational land and water space and facilities at an ever-increasing rate.

The State Recreation Plan, **Outdoor Recreation in Illinois**, published in 1965, analyzed potential needs and the resources available, and prescribed a program to meet these needs in the coming years, 1965 to 1970.

This report recapitulates and enlarges upon the role that the water resources of the State can play in satisfying future recreational and open-space needs in Illinois. Needs are estimated to 2020, with major consideration being given to the years between 1967 and 1980. A number of detailed studies concerning water-related recreation for specific regions and types of facilities are underway. These reports, when made available, should become a part of the State's reference and planning program. The complexity of the subject limits the discussion here to a broad review. Case studies illustrate various projects which will increase the potential for water-related recreation. The case studies describe successful solutions to problems which may be applicable in other areas of the State.

Major considerations in the analysis of water-related recreation in Illinois were:

— Recreational resources of the State, including those of special geographic, historic, archaeological, or cultural significance;

— People of the State—population growth, composition, and projections, the economy, and recreational interests;

— Projected demand for water-oriented recreation and related uses:

  — Direct types—swimming, fishing, hunting with gun and camera, boating, including water skiing, sailing, and canoeing;

  — Indirect types—camping, walking, nature study, touring, and photography;

— Types of action programs recommended for the continuing improvement of water-related recreation throughout the State, each illustrated by a case study of an existing and typical project; and

— Recommendations for early action on critical recreation-conservation problems.

THE PEOPLE AND THE PROBLEM

All projections of future outdoor recreational demand must be based upon a reasonable projection of population, income, leisure time, urbanization, and mobility, and upon the best available knowledge of what and how often activities are sought (Figure 4).

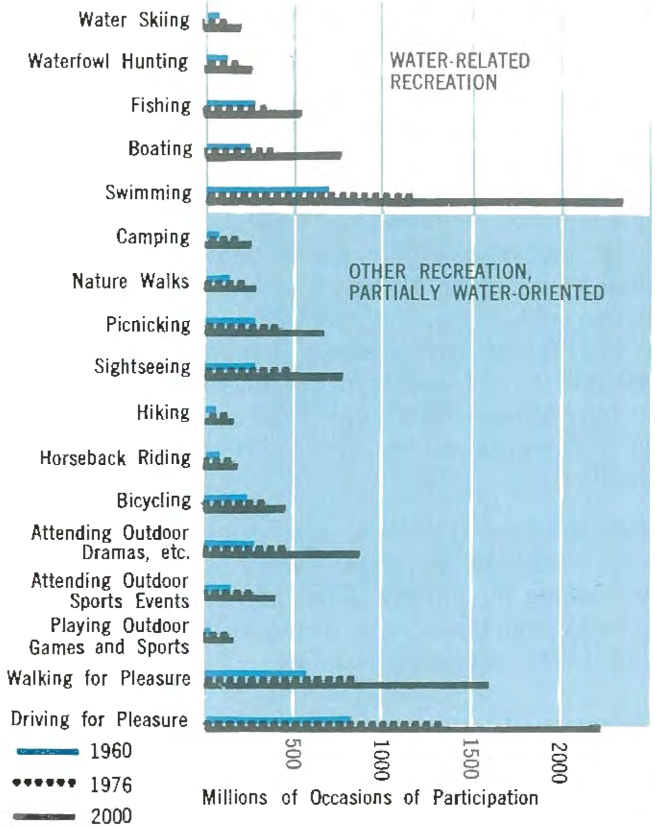
POPULATION

The Illinois population in 1965 was estimated to be 10,650,000. By 1980 it is expected to reach 13 million, and by the year 2020, 18 million. In 1960, about 80 percent of the people in Illinois lived in urban areas, the remaining 19.3 percent in areas classified as rural. (Population and personal income are discussed in detail in Chapter I.)

Eight Standard Metropolitan Statistical Areas had a total of 7,754,932 inhabitants, or 76.9 percent of the 1960 State population (Figure 5). These urban areas are Chicago, East St. Louis, Peoria, Rockford, Rock Island, Springfield, Champaign-Urbana, and Decatur. Concentration of growth in metropolitan counties is expected to continue at the rate of 20 percent in a ten-year period. Rural areas are expected to show almost no increase. Metropolitan Chicago had a 1965 population of 6,674,500, con-

FIGURE 4

OUTDOOR RECREATION IN THE UNITED STATES



centrated in a six-county area. By 1980, the Metropolitan Chicago total is expected to increase to 8,155,000, or 62.7 percent of the total State population; by 2020 to 10,822,000, or 60.1 percent.

The regional approach to planning for outdoor recreation faced by both the Chicago and the St. Louis Metropolitan Areas involves an assessment of population as related to resources on an interstate basis. This approach has been presented effectively by the Outdoor Recreation Resources Review Commission in "The Future of Outdoor Recreation in Metro Regions of the U. S." The entire Metropolitan St. Louis population, in Illinois and Missouri, has been included in analyzing the demand for recreation in southern Illinois. Figure 5 and Table 1 show the present and projected populations for three zones of the State.

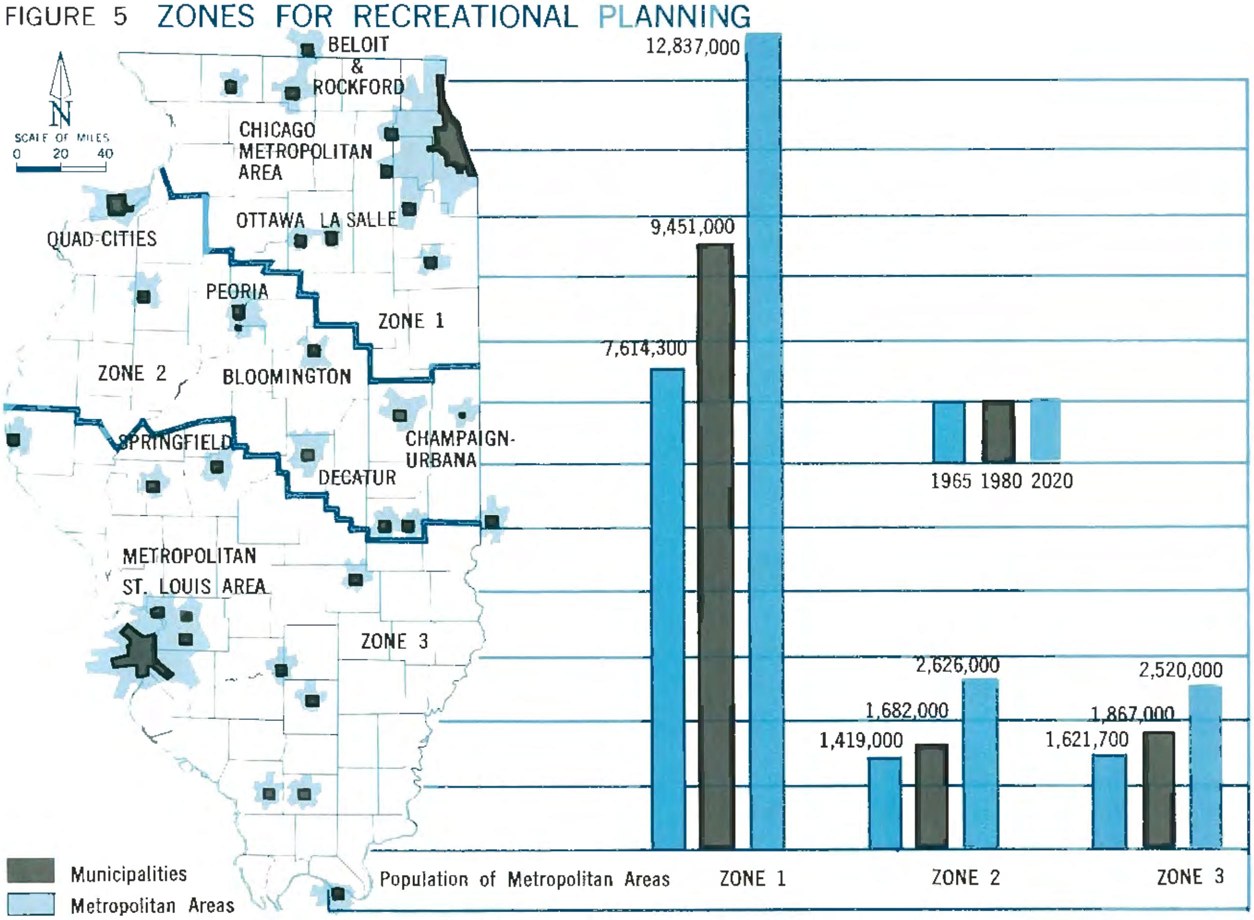
TABLE 1

PROJECTED POPULATION BY ZONES

	No. of Counties	1965	1980	Percent*	2020	Percent*
Zone 1	24	7,614,300	9,451,000	24.1	12,837,000	81.4
Zone 2	27	1,419,000	1,682,000	18.5	2,626,000	85.0
Zone 3	51	1,621,700	1,867,000	15.0	2,520,000	55.4

* Percent of increase over 1965

FIGURE 5 ZONES FOR RECREATIONAL PLANNING



PERSONAL INCOME

A high ratio of employment and a great variety of high-output industries give Illinois a better than national average income. Low income areas in southern Illinois are expected to be improved by 50 percent by 1970, partly from the planned recreation-tourist business. The per capita income is expected to increase 23 percent by 1980. This factor alone will produce a pronounced increase in the demand for recreational land and water space. Thus, an affluent Illinois society will be spending increased amounts of time and money on recreation.

LEISURE TIME

The trend is to a shorter work week and longer paid vacations, which means more leisure time; it is anticipated that by 1980 the length of the work week will have been reduced by 15 to 25 percent. Outdoor recreation is the favored use for leisure time. Recreational areas close to home—within 45 miles—will be needed for the long weekend. Unique, more distant areas will be in demand for vacations.

MOBILITY

Most of Illinois' residents travel to recreational areas by automobile. Illinois has a rapidly improving highway net. Better roads and improved transportation have made the more distant areas accessible. The Interstate Highway System has brought increasing numbers of out-of-state tourists into and through the State, and mobility in general is expected to increase 30 to 35 percent by 1980. An increasing demand for scenic routes with rest stops is anticipated for future years. A constantly growing number of people will be traveling the inland waterways by boat. More access facilities, harbors, and overnight accommodations will be needed.

WATER-RELATED ACTIVITIES

Swimming

Illinois offers very few swimming opportunities. Illinois Beach State Park on Lake Michigan is the only public beach in the entire State Park System. Three State Parks have swimming pools. Two are primarily for use of lodge patrons, and two are for group camps. Only the pool at Dixon Springs is for general public use. Except for a few private and municipal beaches and two national forest park beaches, most Illinois residents have had to depend on urban pools for swimming. In a March 1966 report, the Sanitary Engineering Division of the Department of Public Health listed 1371 pools in the State, of which approximately 365 were public municipal pools, 585 semi-public (schools, colleges, YMCAs), 12 Federal or State, and the remainder private (motels, clubs).

The Need

Swimming is the top ranking water-related recreation in the nation today. By the year 2000, according to the Outdoor Recreation Resources Review Commission, it will surpass all forms of recreation in popularity. "Swimming," besides actual swimming, includes wading, diving, sunbathing, beach games, and scuba diving. It is a favorite of all age groups and is the only form of recreation offered in the regional parks, except perhaps water skiing, that will attract and hold the interest of the teen through college age group. Since swimming is relatively inexpensive, the entire family can enjoy it together.

Most families will spend their summer vacations, even weekends, in places where they can swim, even where the climate is hot and humid. Vacation campers will travel long distances to reach parks with quality swimming facilities.

Major Problem

The problem of providing quality water, free of pollution, has been the main deterrent to the expansion of public beaches in the regional parks in Illinois. Rising pollution levels along lower Lake Michigan and in the Chain-O-Lakes region, if left unchecked, could destroy some of the best natural swimming facilities in the State. Pollution also will be a threat to swimming at the new State-Federal reservoirs, if sanitation in private developments is not controlled.

Boating

Pleasure boating has grown to be a leading recreation in Illinois. The general term "boating" applies to all types of water craft, including the man-powered canoe, rowboat, foldboat, raft, and cycle-paddle boat, the wind powered sailboat or canoe, and the motor driven outboard, inboard, fishing boat, houseboat, speedboat, catamaran, and cruiser. These various types of boats must be considered when assessing existing resources and planning to meet the demand for boating facilities.

Illinois has approximately 2800 miles of rivers and 138,317 acres in interior lakes or reservoirs of at least 40 acres suited for smaller powerboats. By 1970, more than 80,000 additional acres will be made available in new multi-purpose reservoirs.

For touring boaters, there is the great Mississippi River system to explore. For the owners of larger craft, 18 feet or greater, there is the Lake Michigan

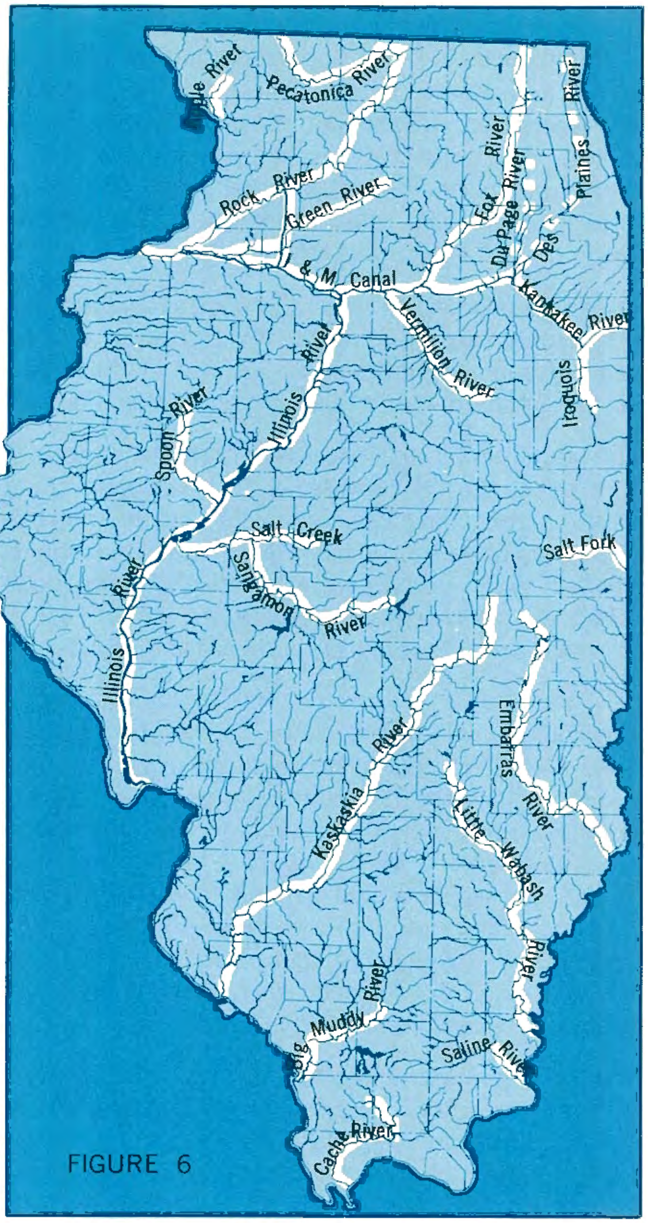


FIGURE 6

STATE DESIGNATED CANOE STREAMS

shoreline of 63 miles and the entire Great Lakes chain. The northern lake states of Wisconsin, Minnesota, and Michigan, plus the Missouri Ozarks and Kentucky-Barkley Lake regions, will continue to attract Illinois boaters in great numbers.

More than 3000 miles of streams in the State, i.e., the Fox, Apple, Rock, Illinois, Sangamon, Embarras, and Kaskaskia Rivers, are suitable for canoeing (Figure 6). Opportunities for canoeing will be greatly increased by the new flood control reservoirs and the Illinois-Mississippi Canal, when it is developed.

Sailing waters exist on the larger pools on the major rivers, such as Peoria Lake. Such areas are particularly well-suited for this use. The new Federal reservoirs will provide additional water space for sailing.

Certain unique provisions for the welfare and safety of boaters have been put into effect in Illinois, and are worth noting here:

— Water Zoning—Illinois was the first state to zone public waters to eliminate conflict between swimmers, fishermen, water skiers, and boaters. Zoning was first used in the Chain-O-Lakes region, the most congested boating area in the State, and second most congested area in the nation. More than 100 restricted water areas have been established in the State.

— Zoning and better law enforcement and equipment have decreased fatal accidents in Illinois from 1961 to 1964 by one-half, even as registrations rose from 100,000 to 160,000.

— The Illinois Boating Council, the first to be organized in any state, includes any group interested in safety on public waters, including the Coast Guard and its auxiliary, power squadrons, Red Cross, and sportsmen's groups.

The Need

Boating has increased substantially and steadily in popularity in the Midwest during the past several years (Figure 7). The rate of increase in manually propelled boats has been gradual and comparable to the increase in general demand for recreation. The big upsurge in boating in recent years has been in engine powered craft, particularly outboards. At the same time, the number of sailboats has increased considerably. The owner of a power boat invests capital and time in his leisure. Of all the types of recreation, it is perhaps the most subject to the socio-economic conditions of the region.

FIGURE 7 BOATING

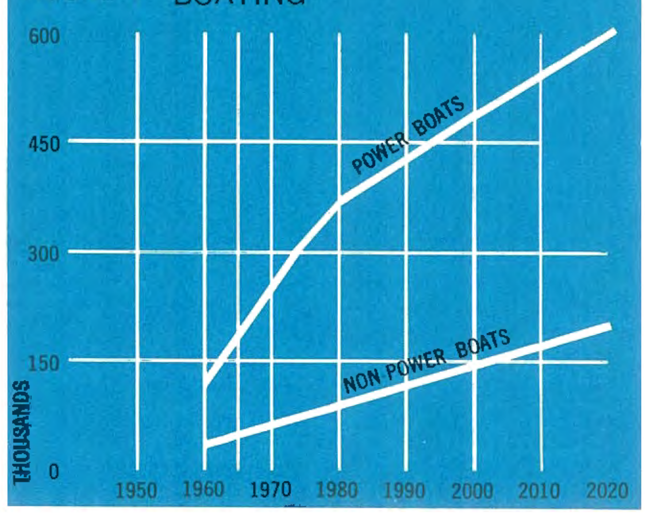
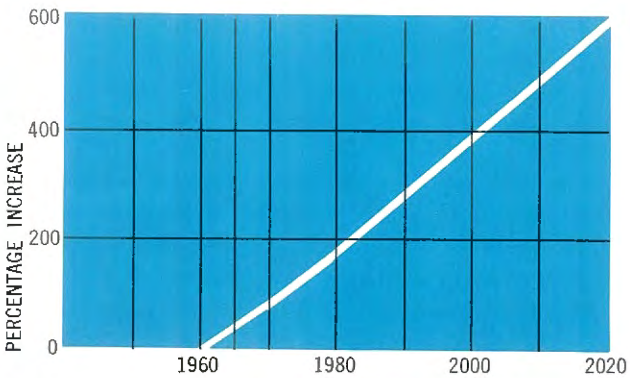


FIGURE 8 WATER SKIING



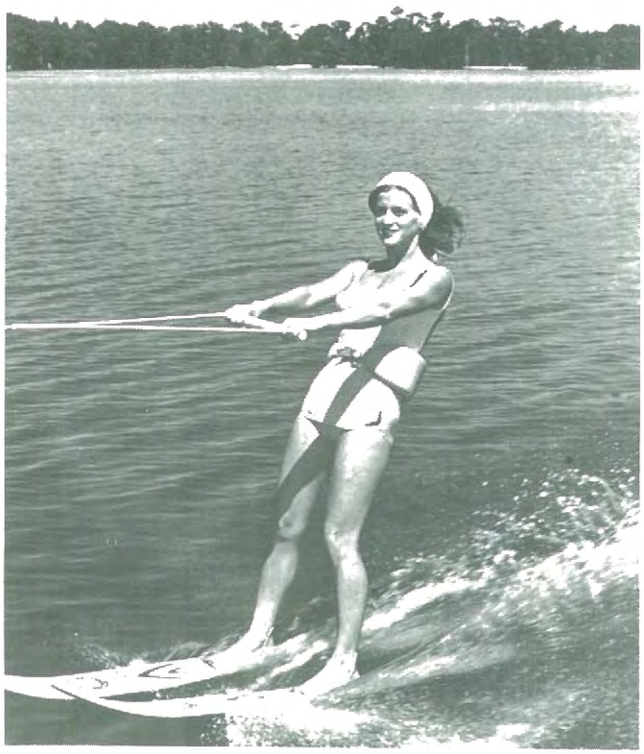
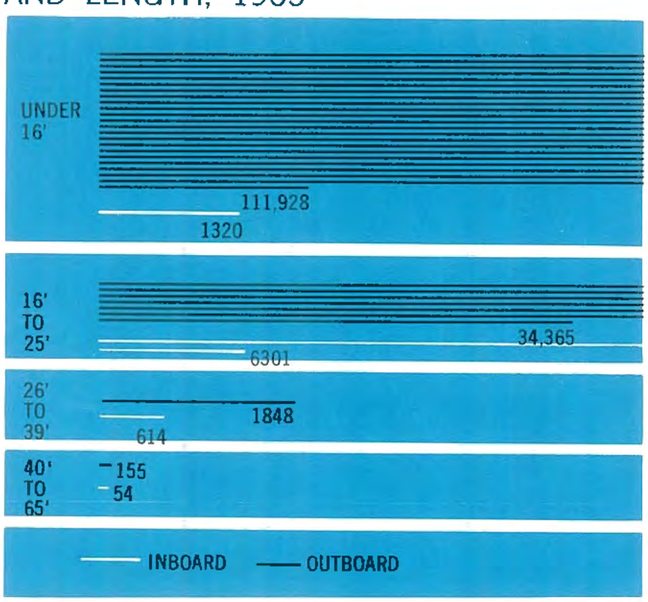


FIGURE 9
BOATS CLASSIFIED BY TYPE OF MOTOR AND LENGTH, 1965



The increase in power boating is caused by the normal influences of rising population, high personal income, and greater leisure time. Additional factors are increased installment buying; better boats, motors, and trailer carriers; improved highways and access points; the growth of water skiing (Figure 8); and an aggressive sales campaign by boat manufacturers and boat clubs.

Boating has grown to be a big business and has had a favorable economic impact upon areas of boating concentration. Chicago ranks second in the nation as an outboard motor distribution center.

The requirement that powered craft be registered with the State has provided a fairly accurate count of the number and types of boats and the distribution by counties as a basis for future projections. The bar graph derived from registration data shows that most State-registered boats are under 16 feet in length and powered by outboard motors (Figure 9).

Provision of more and better harbor facilities on Lake Michigan, the rivers, and the reservoirs will no doubt increase the ratio of larger marina-based craft in future years. Present access and harbor areas are shown in Figure 10. Illinois can conservatively expect a 300 percent increase in power boating activity during the 60-year period 1960 to 2020, if the region's socio-economic growth remains stable, and if adequate access facilities and water space are provided.

The upsurge in boating has already created problems of competition for public water and land access space in the more popular areas such as Chain-O-Lakes. If the projected increase in power boating is to reach 360,000 in 1980 and 600,000 by 2020, there will be a definite need for a continued expansion of suitable and available boating water space and a comparable increase in access facilities convenient to the State's urban centers.

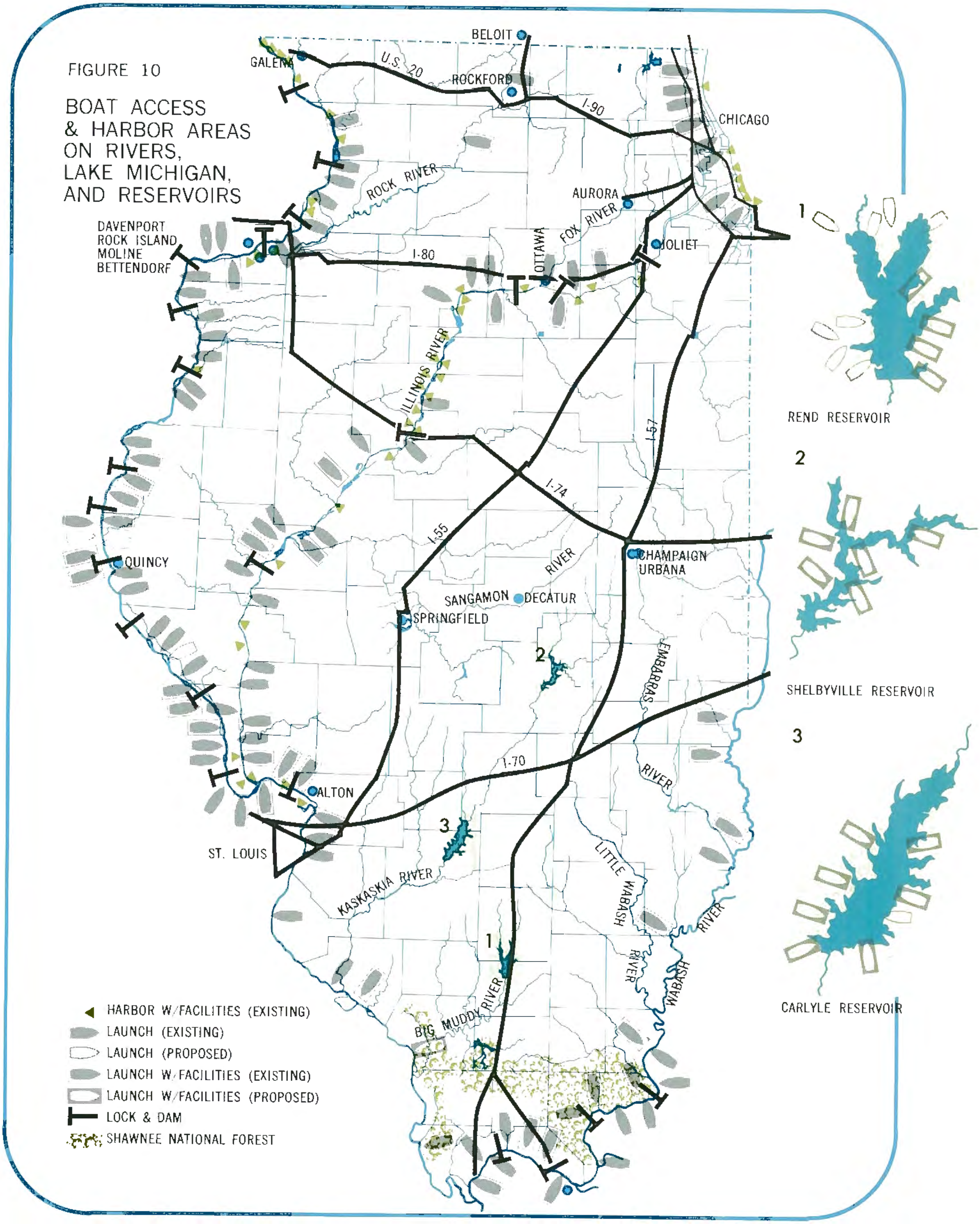
Canoeing is another kind of water-related activity with an increased following, particularly among the younger age groups. Canoe clubs are established in most of the major cities. It is estimated that there are 10,000 canoes in use in Illinois today. By the year 2020, the number is expected to increase to 35,000.

Boat touring, as a distinct kind of boating, is still in its infancy. It has a great potential in Illinois, both as a form of recreation and also as an economic benefit from the many complete boat service centers that will be needed.

For many years, owners of cruising boats with inboard living accommodations have taken extended

FIGURE 10

BOAT ACCESS & HARBOR AREAS ON RIVERS, LAKE MICHIGAN, AND RESERVOIRS



trips on our major rivers. Only recently, however, have small boat owners discovered the fun of exploring. Frequently during the summer, boat clubs now organize overnight group trips with dockage and lodging reserved. Or single families "rough it" with tent camping equipment on one of the many islands in the rivers. There will be a growing demand for waterside dockage, boat lodging, and restaurant facilities for these boat tourists.

Fishing

Fishing in Illinois is an important form of recreation, a sport for the entire family and for all ages (Figure 11). Participants are drawn from all strata of society, all economic and educational levels. It is the magnet that draws visitors to the public lake-centered parks or conservation areas. Only a small financial outlay is required, and for some people fishing furnishes both recreation and a food supply.

Fishing is big business. Illinois license sales in 1965 brought in more than $1,340,000. It is estimated that sport fishermen spent more that $5 million while on trips, and their equipment was valued at an estimated $7 million. Four hundred and twenty nine inland water commercial fishermen caught about $512,000 worth of fish with $805,000 worth of fishing gear in 1965.

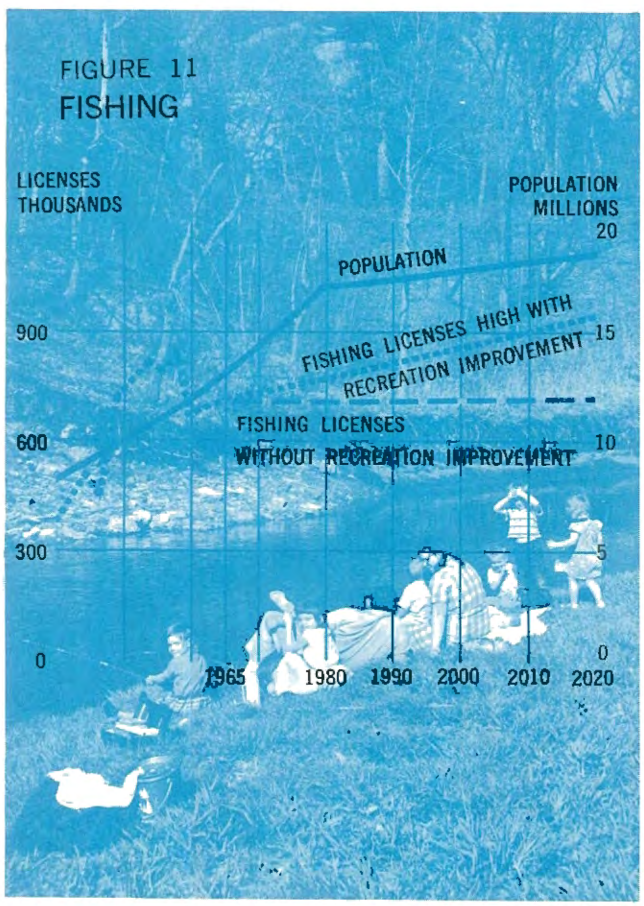
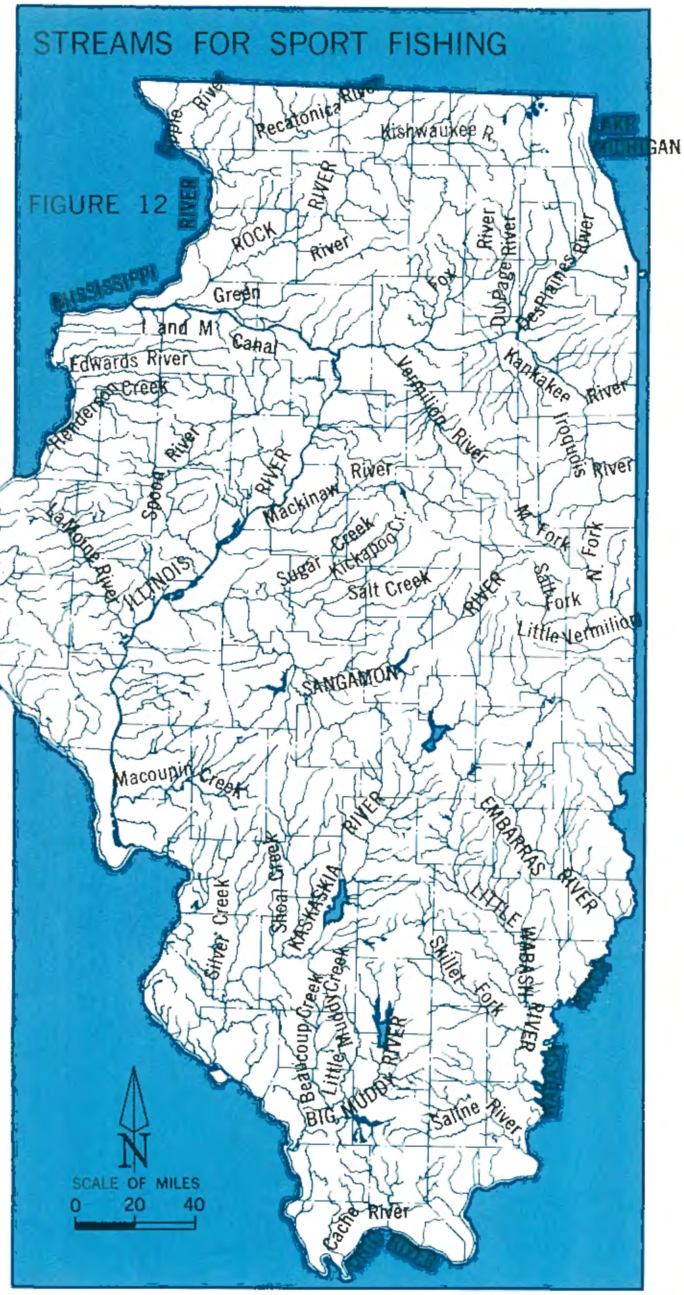


FIGURE 11
FISHING



STREAMS FOR SPORT FISHING
FIGURE 12

Present Resources

Illinois is notably lacking in public waters. A recent inventory gives 59,988 impoundments with an acreage of 196,300. Of these, 2068 impoundments were six acres or more, for a total water surface of 152,143 acres. Fishable rivers and streams in the State total 9351 miles. Streams for sport fishing, both public and private, are shown in Figure 12.

Analysis of this water resource shows that approximately 96 percent of the total number of impoundments and 85 percent of the streams are privately owned and controlled. The only public access and use area on many streams is at the bridges or where the road right-of-way is on a stream bank. These limited areas are wholly inadequate to meet the public fishing needs, particularly near urban centers. Many of the best public fishing waters are too great a distance from major urban centers. Research has generally shown that 85 percent of today's fishermen seldom travel more than 50 miles to fish. However, quality fishing is extending the travel range of some sportsmen, even beyond 100 miles.

Water quality is another vital factor that has limited the fishing potential in recent years. Repeated instances of fish killed from stream pollution by inorganic industrial wastes, domestic organic sewage, and agricultural chemicals have been recorded. In the Saline River Basin, for example, the fish population has been almost eliminated because coal and oil recovery operations discharge salt and oil residues into the tributaries. For years most of Chicago's streams and lower Lake Michigan have been too polluted to support adequate fish life.

Stream dredging, levee construction, siltation, and extreme fluctuation in stream levels have eliminated thousands of acres of formerly choice fishing. Intensive farm practices, including fall plowing, have contributed to increased turbidity and other problems, destroying the suitable fish habitat in many of the conservation lakes and large backwater lakes.

Competition with other water uses has limited both the fish habitat and the enjoyment of fishing. Power boating and water skiing, until brought under zoning control, almost eliminated fishing as a sport in the Chain-O-Lakes region. Since the establishment of water zoning there, fishing opportunities have returned. In each of the new State and Federal impoundments, large areas of the water surface are being zoned for fishing. Fish management programs are planned for operation as soon as each reservoir fills.

The State Sanitary Water Board is making progress in clearing up pollution in certain streams. Methods are being explored for the conversion of selected streams from private to public control, through easement or purchase. Counties are slowly assuming more responsibility in the development of conservation lakes for public use. An increasing number of farm owners are developing small fishing-lake resorts to supplement farm incomes.

The Division of Fisheries of the Illinois Department of Conservation has evolved and adopted a practical fisheries program to aid in protection, management, scientific research, and development of the fishery resource of the State. This operation is in complete accord with the North American Fish Policy as expressed in the Illinois Advisory Board's policy statement published in March 1962.

The Need

The future demand for fishing in Illinois is predicated upon a strong, positive approach to improving the fishery program and the education-information program. Progress is dependent upon a continuous program, with adequate financing and authority directed exclusively to the development of this fishery resource.

The actual number of persons fishing in Illinois in 1965 was nearly 1,500,000. To the 705,000 license holders should be added the non-licensed fishermen, including 125,000 property owners and their families, and 670,000 fishermen under 16. After rising to a high of 831,934 in 1955, sport fishing license sales unexpectedly leveled off in recent years to about 700,000, in spite of the increased population. The basic reason for this arrested gain include:

— Increased urbanization with a corresponding lack of convenient, quality fishing and water acreage;

— A change of recreational interest from fishing to boating, swimming, pleasure driving, and field sports, particularly among the urban population and teen age groups;

—Competing fishing opportunities in northern states and access to these more distant fishing areas;

— The need for better court procedures in cases concerning fishing, hunting, and boating to clear the way for effective law enforcement, primarily in the Chicago Metropolitan Area;

— An affluent society—more families going out-of-state for weekend and vacation fishing;

— Inadequate funds to intensively manage State-owned and other public waters;

— Inadequate public relations and educational programs.

Recommendations for improving the quality and number of fishing facilities are contained in the final section of this chapter.

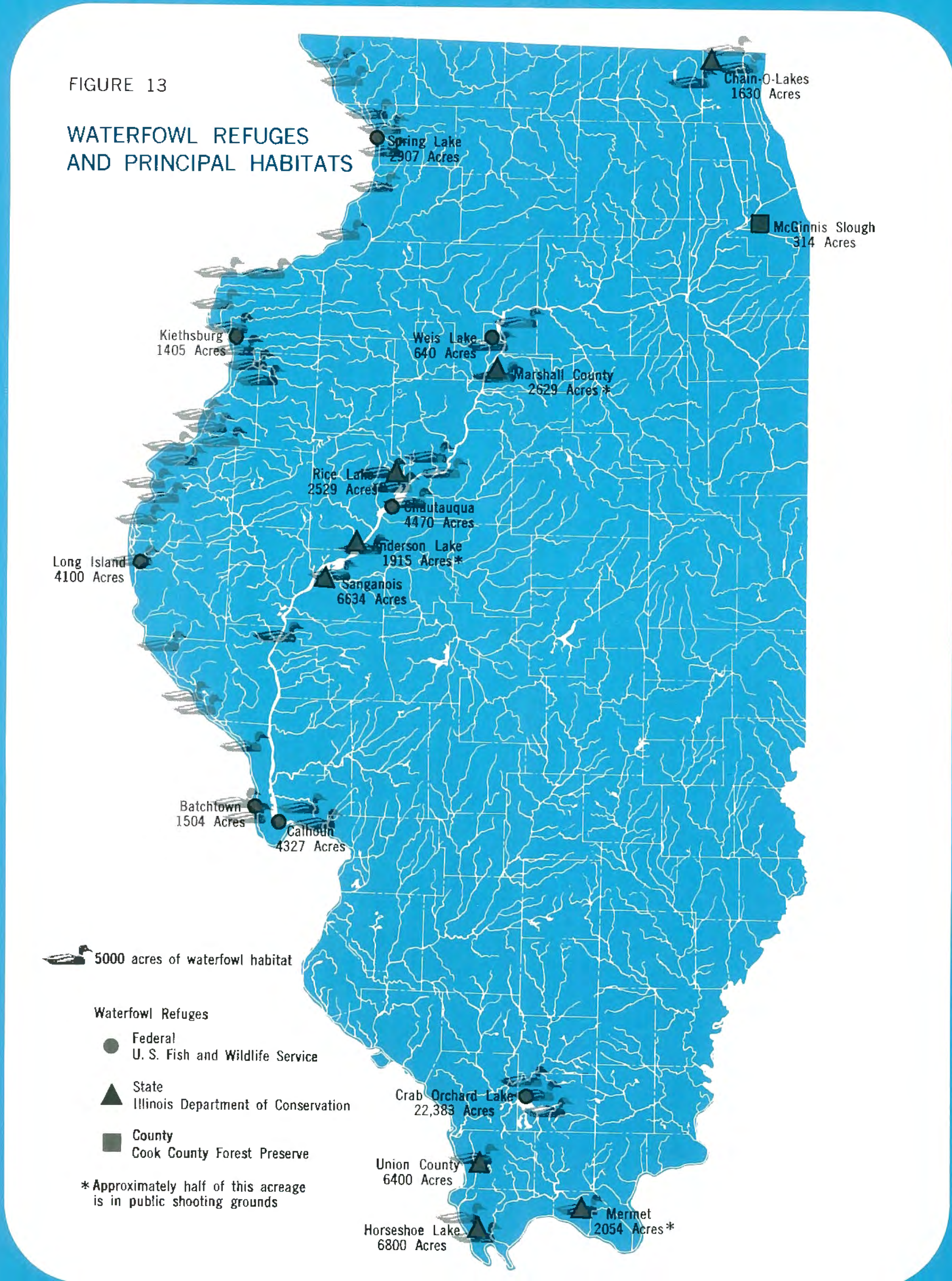


FIGURE 13
WATERFOWL REFUGES AND PRINCIPAL HABITATS
Chain-O-Lakes
1630 Acres
Spring Lake
2907 Acres
McGinnis Slough
314 Acres
Kiethsburg
1405 Acres
Weis Lake
640 Acres
Marshall County
2629 Acres*
Rice Lake
2529 Acres
Chautauqua
4470 Acres
Anderson Lake
1915 Acres*
Long Island
4100 Acres
Sanganois
6634 Acres
Batchtown
1504 Acres
Calhoun
4327 Acres
5000 acres of waterfowl habitat
Waterfowl Refuges
Federal
U. S. Fish and Wildlife Service
State
Illinois Department of Conservation
County
Cook County Forest Preserve
* Approximately half of this acreage is in public shooting grounds
Crab Orchard Lake
22,383 Acres
Union County
6400 Acres
Mermet
2054 Acres*
Horseshoe Lake
6800 Acres

WATERFOWL HUNTING AND BIRD SANCTUARIES

By virtue of its location, Illinois is a key state in the patterns of waterfowl migration. Several migration routes from Canada merge over Illinois into the single concentrated route of the Mississippi Flyway. In particular, the Illinois River valley, located in this migration path, has a tremendous recreational potential for waterfowl hunting. In fact, Illinois is now one of the top waterfowl hunting areas in the nation, but the State's resources are severly limited, despite its locational advantage (Figure 13). Of the fourteen states in the Mississippi Flyway, Illinois now ranks thirteenth in available waterfowl habitat, with 80,000 acres in prime waterfowl lands and 200,000 acres of secondary wetlands.

This has come about primarily because thousands of acres of riverside lakes and marshes have been leveed and drained. The Illinois Department of Conservation presently controls more than 43,000 acres of waterfowl area. Because of increasing demands for land, the present amount of waterfowl habitat is expected to be further decreased, as portions of these lands not under Department of Conservation jurisdiction are converted to other private uses. Competition for these waterfowl lands may also be expected to come from the demand for land for other recreational uses.

Providing opportunity for hunting is a basic objective of waterfowl preservation, but other interests are equally concerned. As recently as 1962, less than 4 percent of the visitors at National Wildlife Refuges were hunters, which indicates the interest of bird watchers, wildlife enthusiasts, and sightseers in wildlife preservation.

State and Federal agencies are taking steps to preserve waterfowl and waterfowl habitat. Most significant of these include:

— A Mississippi Flyway Management Plan, in operation since 1958, has been a guide for research and improved management practices. The result has been improved habitat conditions and, in the case of the Canadian Goose, a remarkable flock recovery.

— In 1962, the Federal Government authorized $105 million to acquire, maintain, create, and improve waterfowl habitat over a seven-year period. This fund was authorized primarily to acquire waterfowl nesting or production areas in the prairie pothole country of Minnesota, South Dakota, and North Dakota—the prime duck producing area of the United States. Some acquisition is taking place in Illinois to provide rest areas on the migration routes.

— Canadian and United States Departments of Agriculture programs reflect an increasing interest in waterfowl problems. An International Waterfowl Committee, with representation from these Departments, the U. S. Department of the Interior, and the Canadian Department of Northern Affairs and Natural Resources, is exploring possible means of preserving habitat where it is most needed and of strengthening the international program of waterfowl management.

— A National Recreation Plan is being developed. A number of states including Illinois have recreation plans. The process of implementing such plans is now underway. The preservation of waterfowl and of waterfowl hunting as a recreational activity is contained in such plans.

The Need

It is plain that the need for waterfowl habitat is not being met, and the necessary program for its development and preservation is not being undertaken. The responsibility falls on the State to take measures to stop the steady decrease in waterfowl populations.

Waterfowl hunting as a recreational activity is in constant demand in Illinois. The extent to which this demand is met is directly related to the number of birds in the Flyway and to the hunting regulations (Table 2).

The threats to the waterfowl population are valid cause for concern and have brought about the many programs now underway. To the traditional natural threats of disease and weather have been added the man-made threats of insecticides, water pollution, and destruction of resting and feeding places.

> "Habitat for waterfowl tomorrow is still available; the breeding stock is adequate; and a good management program with long-range planning is underway. These are the necessary ingredients. Whether they will be dissipated through lack of interest and aggressive support is entirely up to the public. If enough citizens believe that the perpetuation of waterfowl is important, the job will be done. It is not too late." Daniel H. Jansen, **Waterfowl Tomorrow,** 1964.

TABLE 2
WATERFOWL HUNTING

Year	Waterfowl Hunters Duck Stamps Sold	No. of Waterfowl in Flyway
1934	42,687	6,600,000
1955	125,000	11,000,000
1963	42,860	6,600,000

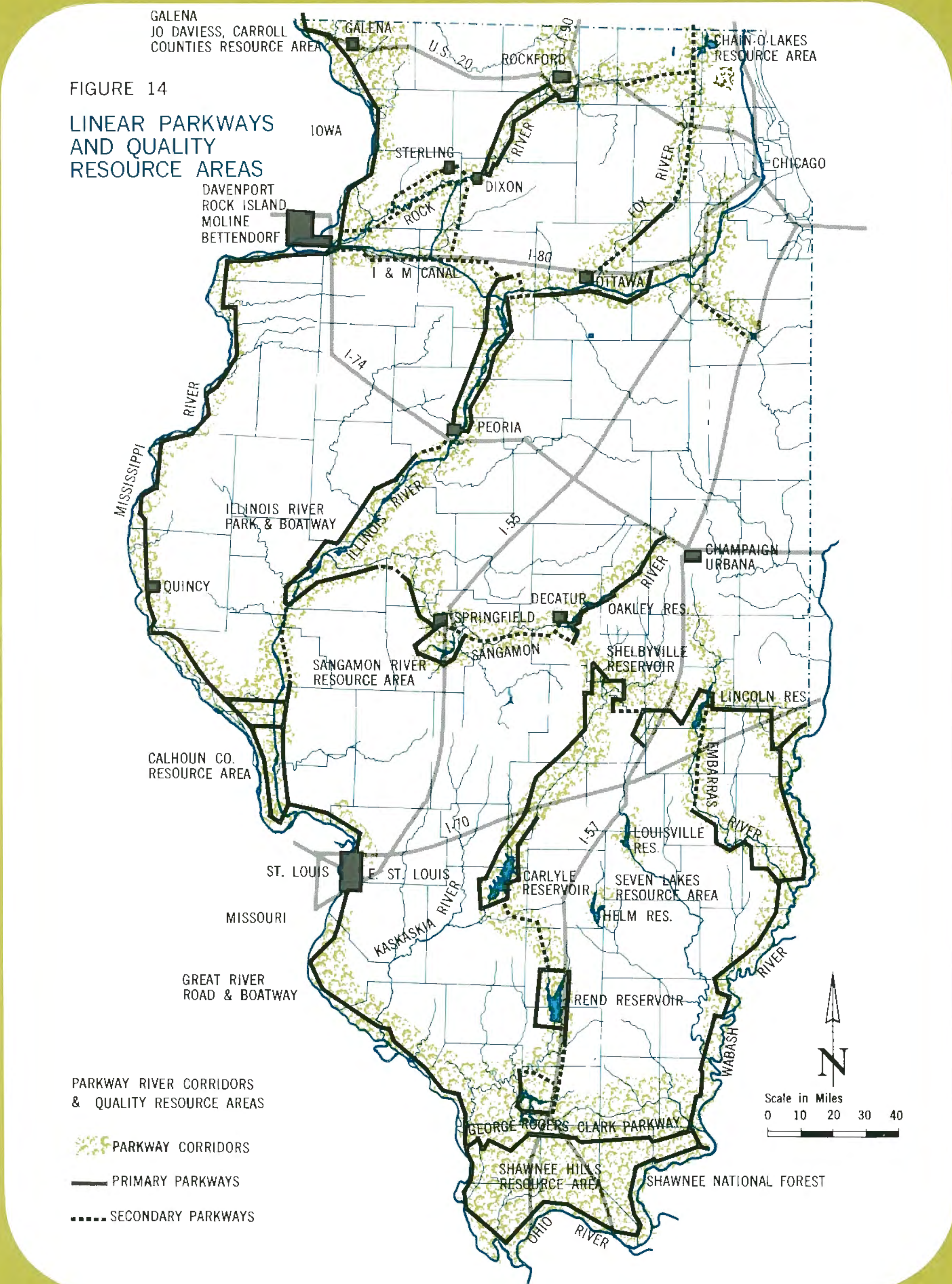
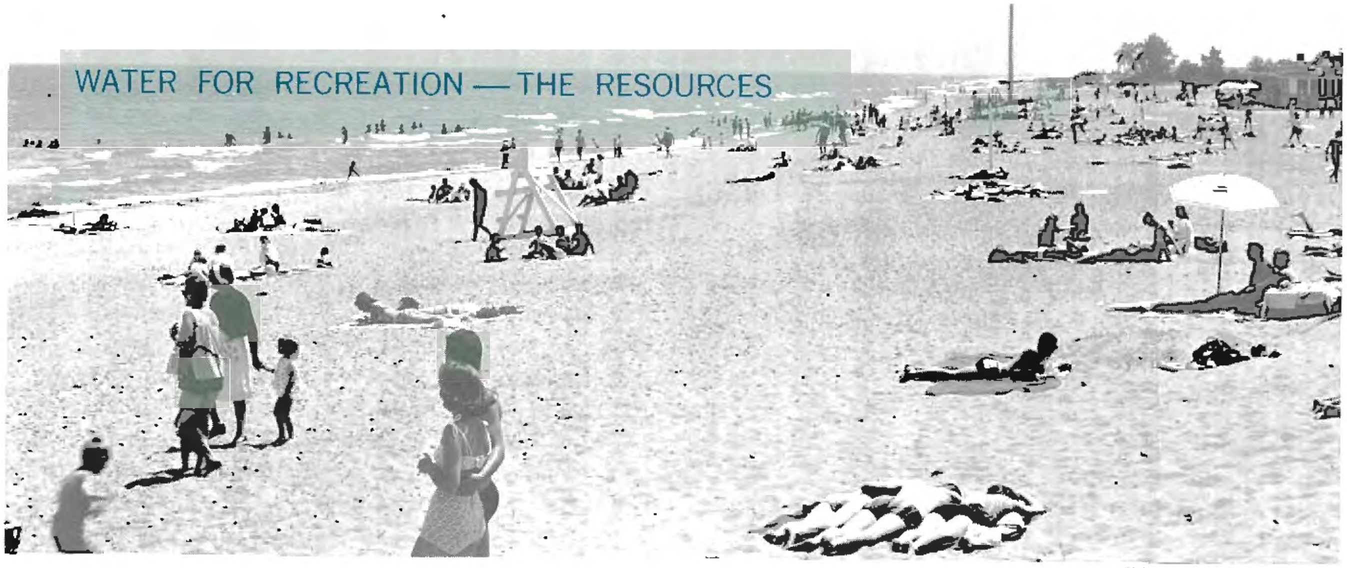


FIGURE 14
LINEAR PARKWAYS AND QUALITY RESOURCE AREAS
GALENA
JO DAVIESS, CARROLL COUNTIES RESOURCE AREA
GALENA
U.S. 20
I-90
ROCKFORD
CHAIN-O-LAKES RESOURCE AREA
IOWA
STERLING
DIXON
ROCK
RIVER
FOX
RIVER
CHICAGO
DAVENPORT
ROCK ISLAND
MOLINE
BETTENDORF
I-80
I & M CANAL
OTTAWA
I-74
MISSISSIPPI
RIVER
PEORIA
ILLINOIS RIVER PARK & BOATWAY
ILLINOIS
RIVER
I-55
CHAMPAIGN
URBANA
QUINCY
DECATUR
RIVER
SPRINGFIELD
OAKLEY RES.
SANGAMON
SANGAMON RIVER RESOURCE AREA
SHELBYVILLE RESERVOIR
LINCOLN RES.
CALHOUN CO. RESOURCE AREA
EMBARRAS
RIVER
I-70
I-57
LOUISVILLE RES.
ST. LOUIS
E. ST. LOUIS
CARLYLE RESERVOIR
SEVEN LAKES RESOURCE AREA
MISSOURI
KASKASKIA
RIVER
HELM RES.
RIVER
GREAT RIVER ROAD & BOATWAY
REND RESERVOIR
WABASH
N
Scale in Miles
0 10 20 30 40
PARKWAY RIVER CORRIDORS & QUALITY RESOURCE AREAS
PARKWAY CORRIDORS
PRIMARY PARKWAYS
SECONDARY PARKWAYS
GEORGE ROGERS CLARK PARKWAY
SHAWNEE HILLS RESOURCE AREA
SHAWNEE NATIONAL FOREST
OHIO
RIVER

WATER FOR RECREATION — THE RESOURCES



Illinois Beach State Park

Recreational needs are defined as the lands, waters, and facilities required to balance supply and demand and thus provide adequate recreational opportunities. It is the great river systems, their adjoining lands, and the major landscape resource areas that should form the framework of our future recreational preserve, as previous studies have pointed out (Figure 14). These river corridors and resource areas have three basic ingredients needed for maximum recreational potential—water, varied topography, and forests.

The major rivers and their tributaries give the State 5488 miles of waterway potential. They flow through meadows, rolling hills, and bluffs offering contrasting relief, variety, and scenic vantage points. Trees still clothe the riverbanks and the adjoining hills giving fresh greens and flower color to the spring, cooling shade in the summer, and brilliant colors in the fall.

Since earliest time, man has traveled the riverways and settled on their shores. Thus, we find the story of civilization in historical sites and artifacts in these river corridors. Great men of history—Farther Marquette, George Rogers Clark, and Abraham Lincoln—traveled the rivers and river trails.

The Mississippi and the Illinois Rivers on the great Midwest Flyway offer rest and feeding ground for the migratory ducks and geese. The backwater lakes and wetlands also provide a home for fish along the shores and a great variety of waterbirds, songbirds, and animals.

Seven new multi-purpose Federal Reservoirs—Carlyle, Shelbyville, Rend, Lincoln, Helm, Louisville, and Oakley—are either under construction or in the planning stage, and will soon add more than 80,000 acres of water surface. Reservoirs, built for flood control and water supply for industrial or conservation purposes, provide 72,500 acres of water surface. The interior rivers and streams are a great potential source for more artificial reservoirs.

In addition to resources within the boundaries of the State, the availability of the resources of neighboring states must be recognized, particularly in their accessibility to residents of cities or areas near the boundary lines. For instance, residents of Chicago are within reasonable distance of Wisconsin Dells and the Wisconsin lake areas, as well as the Dunes State Park in Indiana. Residents of the St. Louis area make use of the Ozark country and other facilities in Missouri and Arkansas. At the southeastern part of the State the great Kentucky-Barkley Lake complex, with the Land Between-the-Rivers Lakes Recreational Area, is a tremendous recreational resource for Illinois residents. Such facilities bear little relation to state boundaries, but are a regional resource.

With all of this potential, certain basic deficiencies must be recognized as vital to the long range recreational program for Illinois.

Natural lakes in Illinois are limited. Lake Michigan's 63 miles of shoreline is supplemented by only 9400 acres of glacial lakes such as the Chain-O-Lakes and 18,350 acres in river backwaters.

Illinois has the lowest ratio of total state park acreage to its population of any state in the nation. Illinois has 5.6 percent of the nation's population, but its residents must share only .05 percent of the country's recreational land. Consequently, existing facilities are overburdened, and more than half of Illinois' residents vacation out-of-state, with a resulting loss to the State's economy of more than one-half billion dollars per year.

Certain areas within the State have a unity and a potential for recreational development and use that qualifies them for individual consideration as Resource Areas. Following are analyses of the most outstanding of such areas within Illinois.

SHAWNEE HILLS

The great abundance of rock, the steep hillsides, and magnificent timber make the Shawnee Hills region at the southern tip of the State an outstanding recreational resource. A unique feature is the high linear ridge that extends from the Mississippi River on the west to the Ohio River on the east. Some 90 significant sites have been identified along this ridge as having an outstanding recreational potential. Rock islands, bluffs, natural bridges, springs, caves, escarpments, stone forests, lakes, waterfalls, amphitheatres, canyons, sink holes, fluorspar mines, timber, wildlife, and southern cypress and tupelo swamps are common. This unique area could become the focus for a recreational roadway or extensive system of trails to connect existing and potential recreational areas.

Since 1930 the idea of a parkway, to be known as the George Rogers Clark Recreation Way, along the crest of the Shawnee Hills has been studied and recommended as perhaps the State's most outstanding recreation feature. Today's emphasis on pleasure driving has heightened interest in this project which would give access to the State's largest concentration of high quality recreational resources. This potential has high priority, particularly in light of the Bureau of Public Roads' current emphasis on scenic highways. Mild winters would make it a year-round attraction.

The addition of water-related recreation by building several conservation lakes to supplement the existing lakes and streams would help to make this parkway an outstanding vacation and tourist center. A drawing which suggests the facilities needed in a parkway is shown in Figure 15.

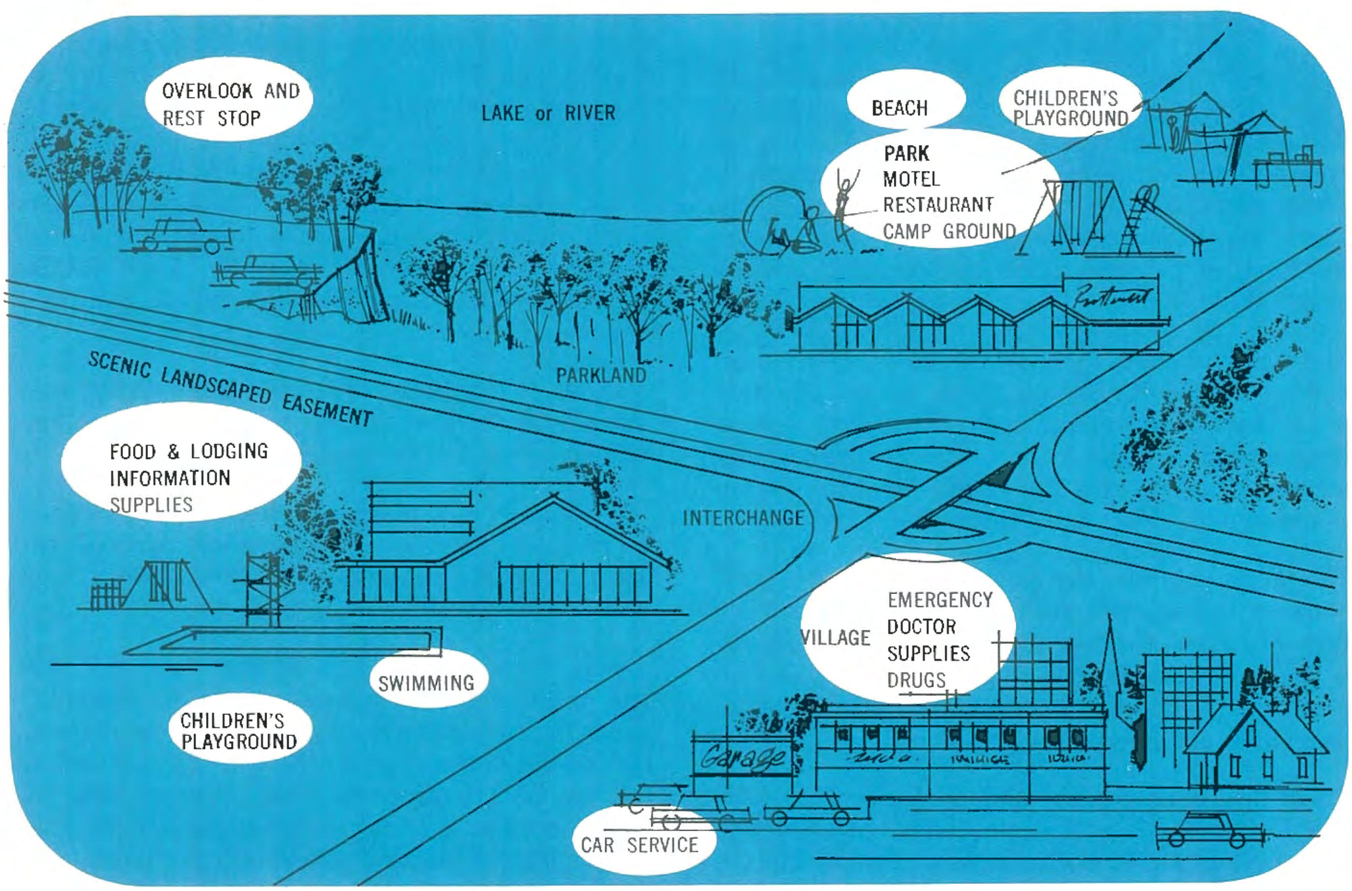


FIGURE 15 TOURIST AUTO PASSING THROUGH A PARKWAY

The Department of Conservation and the Department of Business and Economic Development, together with a local sponsoring group, Southern Illinois, Inc., have jointly applied to the Economic Development Administration for a planning grant to prepare a study of the George Rogers Clark Recreation Way.

CALHOUN-JERSEY COUNTY AREA

The Calhoun County landscape rises sharply along one substantial tree-covered ridge between the Illinois and Mississippi Rivers. At the southern tip of the County, the Illinois meets the Mississippi above a low pointed mud flat. Like the Galena area, the great ruggedness and beauty of this county can be attributed to a lack of glaciation. Some of the most picturesque river cliffs of the entire State are to be found on either side of Calhoun County and on the east side of the Illinois extending south to the Alton area. Throughout Calhoun County the rural scene is enhanced by the large apple and peach orchards.

Within the area small streams, springs, ravines, and hollows descend from the elevated plains to the water's edge of the Illinois and Mississippi. In Pere Marquette State Park at Grafton some 60 or more species of trees have been identified. Pecans, Red Cedars, and Butternuts flourish.

In the spring, Shadbush, Redbud, Wild Plum, and Dogwood flower and the apple orchards of Calhoun County add their array of blossoms. Flowers, ferns, berries, mosses, lichens, and mushrooms abound.

During migration, hundreds of bird species can be seen flying up and down the river flyways or migratory highways. Mockingbirds, Thrush, Wren, Towhee, Meadowlark, Oriole, Cardinal, Hawks, Vultures, and an occasional Eagle or Osprey may be seen along with Herons, Bitterns, Ibises, Cormorants, Grebes, Loons, and even Pelicans. Ducks, Geese, Sea Gulls, Sandpiper, and Snipe are all a rare addition to the landscape.

History, too, plays its part in the personality of the region. Many interesting Indian legends surround the cliffs. Father Jacques Marquette, in his discovery of the Illinois country, tells of seeing the Piasa bird paintings on the cliffs as he "coasted along the rocks frightful from their height and vastness." According to legend, the Piasa bird was an evil Manitou who devoured the warriors of the Illinois. A replica of one of these paintings may be seen on a rock near Alton, where Piasa Creek flows into the Mississippi.

Here, then, is a second major recreational resource area at the junction of the Mississippi and Illinois River Parkway routes, in proximity to the St. Louis and East St. Louis metropolitan complex.

JO DAVIESS — CARROLL COUNTIES

In Jo Daviess and Carroll Counties three major ridges lie at right angles to the Mississippi River, with outstanding views of the river 300 feet below. The main valley between two of these ridges was created by the Apple River, a small stream of clear, cool water, which has cut through strata of limestone, dolomite, and shale, leaving massive cliffs. These rise high above the water in a gorge 5 miles in length called the Apple River Canyon. Its course is marked by long, wide stretches of quiet, deep water, alternating with ripples of shoal water where the river crosses from one side of its narrow valley to the other. About 60 varieties of trees are found within the first mile off the Canyon course. Shrubs and vines are rampant, and nearly 500 species of herbaceous plants have been identified in the Canyon. The ridgelines carry twisting country roads down their spines, offering exciting scenic drive possibilities. Such roads might reveal Charles Mound, the highest point in Illinois; the Black Jack Lead Mine; Pilots' Knob; and the historic town of Galena itself.

Galena offers an outstanding opportunity for historical restoration. Many of its homes and the stores on Main Street were built before 1856 and most of them before 1900. Many of the buildings are considered to be the finest examples of period architecture in the Midwest. They were the homes of nine Civil War generals, including General Ulysses S. Grant. An active restoration program has been initiated, but needs further support.

CHAIN-O-LAKES AND ILLINOIS BEACH

The Chain-O-Lakes and Illinois Beach Resource Area has become tremendously important as a regional recreational center for Metropolitan Chicago. The region contains Illinois' largest concentration of natural lakes and its only state park beach.

A record number of visitors use these state parks and lake areas each year. Botanists have said that the area once had a greater variety of trees, flowers, and shrubs than any similar location in the world. Portions of this unique region have been preserved by the State Department of Conservation and the Illinois Nature Preserves Commission. The Illinois Chapter of the Nature Conservancy has preserved the Volo and Wauconda Bogs, excellent examples of the tamarack bogs once common to this region.

Much of the attractiveness of this natural lake area has been lost to urban expansion. However, the major elements, the hills and lakes, are still there, and portions of the land and water could still be acquired for public open space.

SANGAMON RIVER VALLEY

The Sangamon River valley lies almost entirely within the prairie landscape. The meandering river, lined by a ribbon of trees, flows through rich farm lands.

It is important that this natural, rural prairie scene, which was frequented by Abraham Lincoln, be preserved as a linear parkway, at least from Lincoln Trail Homestead State Park to the Illinois River.

RIVER CORRIDORS

It is fitting that river corridors be included at this point, since they constitute a linear water-related recreational resource in themselves and serve as connecting scenic routes between major landscape recreational resource areas.

— **The Mississippi River** has been established as a parkway route. The Great River Road, from the Gulf of Mexico to Canada, forms the entire western boundary of Illinois. It connects the distinctive Shawnee Hills region on the south with the unique Calhoun County hills, where the Mississippi and Illinois Rivers join, and the Galena-Jo Daviess and Carroll County historic and scenic hill country on the north. In between lie the historic cities of St. Louis, Nauvoo, Quincy, Savanna, and the scenic Mississippi Palisades State Park. National parkways, existing and proposed, are shown in Figure 16.

— **The Illinois River** has a great potential as a boatway and scenic drive. Starting at the Mississippi River and the Pere Marquette State Park-Calhoun County Resource Area, the river winds up through the heart of Illinois past Havana, Peoria, Bureau, and the Illinois and Mississippi Canal, and Starved Rock State Park. The Illinois branches into the Fox River corridor, continues to the Chain-O-Lakes and Illinois Beach dunes area, or continues out the Cal-Sag Canal corridor to Chicago and Lake Michigan.

Ohio and Wabash Rivers — These two river corridors bounding the State for a distance of 335 miles offer a wide variety of relatively untouched recreational potential. The 135 miles of Ohio River, with its wide expanse of navigable water and many stretches of accessible shoreline, offers a great reserve to help meet the expanding pleasure boating demand. The Wabash River in its natural state provides good recreational boating opportunities throughout its 200 mile frontage length.

Existing roads and highways following these two rivers should be upgraded and supplemented by new scenic routes to form a parkway connecting the many historic, scenic, and recreational areas in the corridor. The Shawnee National Forest fronting on the Ohio River for a distance of 100 miles offers great opportunities for general recreational development. An Ohio River Basin Comprehensive Survey is now underway by the U. S. Army Engineers Division, Cincinnati, Ohio.

Other river corridors that should be included in the total linear resource plan are the Rock, the Kankakee, the Sangamon, the Embarras, the Big Muddy, and the Kaskaskia.

FIGURE 16
NATIONAL PARKWAYS
AND PROPOSED PARKWAYS

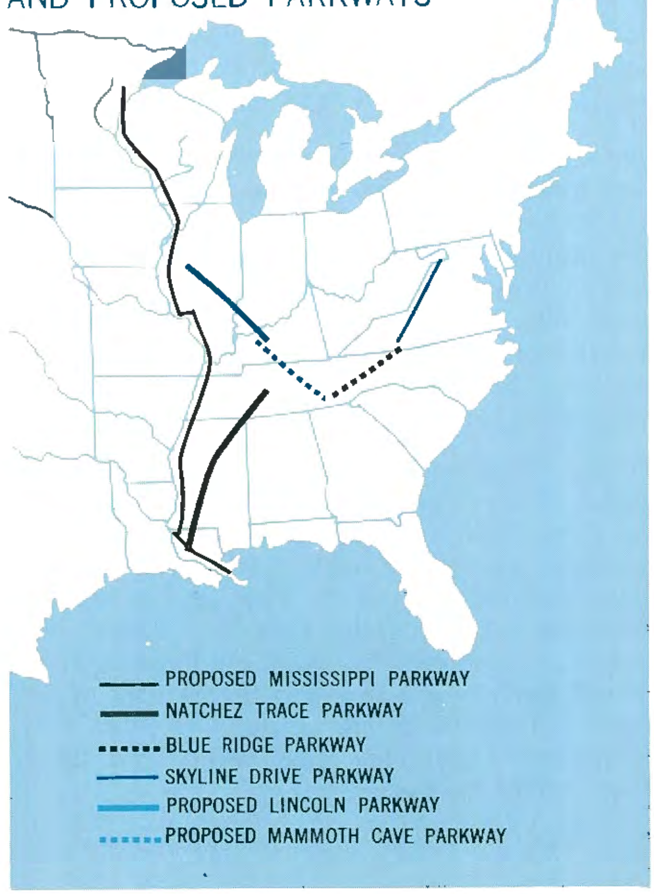
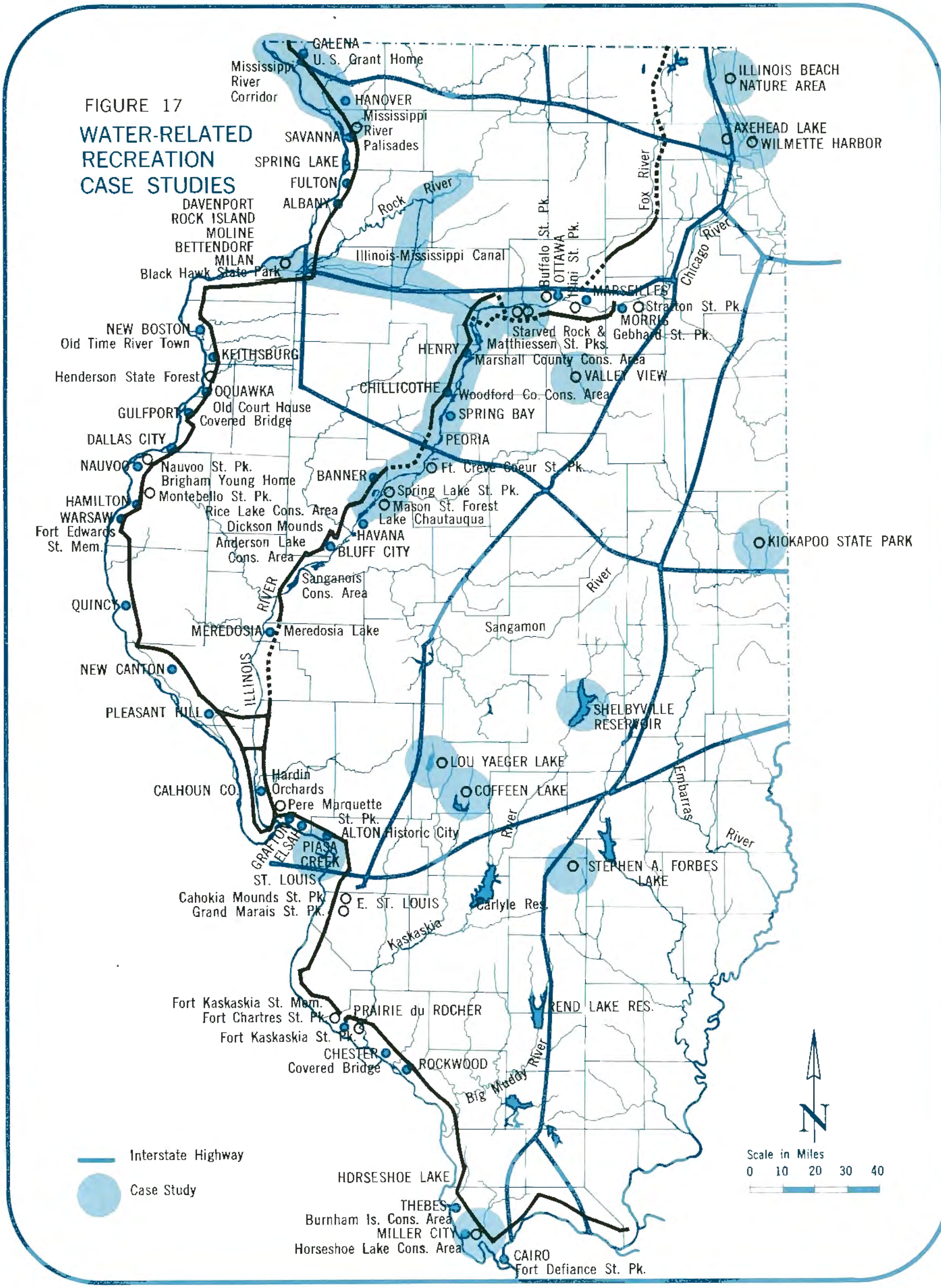


FIGURE 17

WATER-RELATED RECREATION CASE STUDIES



CASE STUDIES

The following case studies are selected as examples of typical recreational developments — solutions which might well be applied elsewhere. They may involve nothing more complicated than making use of a natural situation by building access roads and parking areas so that people can get to a recreational area. Some are complex solutions involving construction and various degrees of financing and any number of private and public agencies. The case study projects were chosen to illustrate specific accomplishments in water-related recreation — a how-to-do-it demonstration for such development (Figure 17).

CASE STUDY 1.

MISSISSIPPI RIVER CORRIDOR

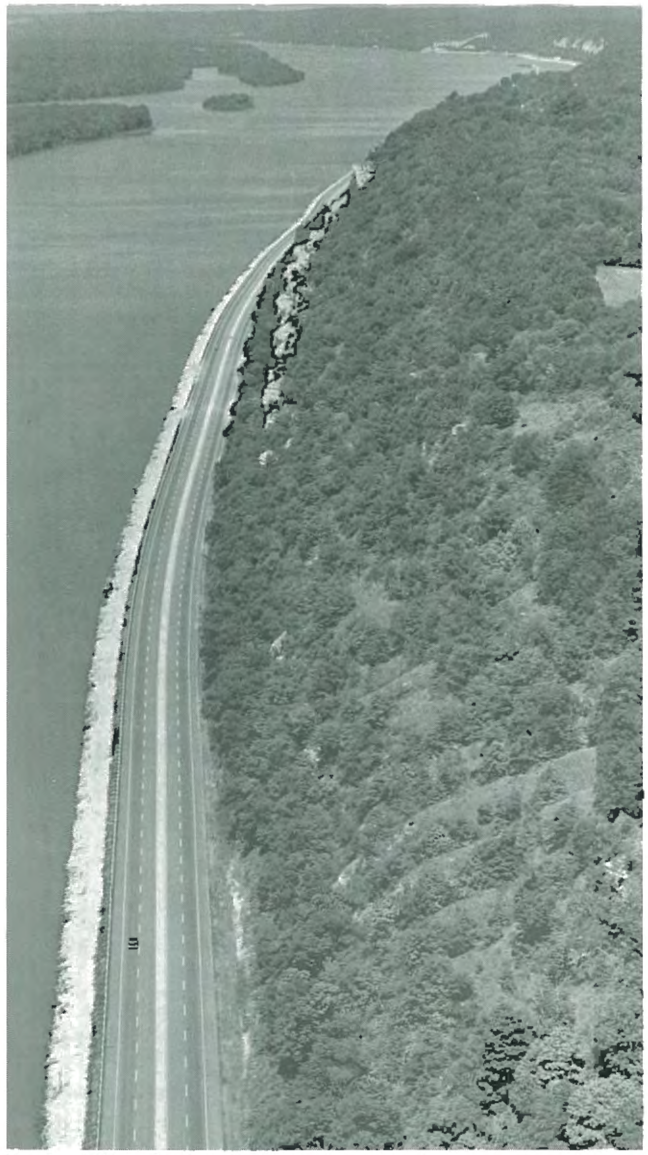
Recreational Development of the Great River Road

This is a project of tremendous proportions concerned with the problem—and the opportunity—of making available to great numbers of people all the recreational opportunities possible on the Mississippi River. The river corridor presents an almost unlimited list of things to be done, to be seen, and to be studied. It offers recreation for people of almost every conceivable interest. From this standpoint, it solves the problem by furnishing recreation for a maximum number of people and at the same time conserving great natural beauty and areas of historical significance.

The establishment of the Mississippi River Parkway has given Illinois a dramatic opportunity to highlight some of its best river valley scenery, focus on the history of a colorful era, and link many existing public and private recreational facilities with an interesting travel experience. The abundance of water and flood plain bluff land within this corridor makes it one of the most significant features in the long-range State Outdoor Recreation Plan.

The Project

This project, known as the Great River Road, is in the very early stages of development, but when completed will provide the motorist with a scenic parkway from Canada to the Gulf of Mexico paralleling both sides of the River. Naturally, a number of Federal, State, and other public agencies are concerned with it. The Mississippi Parkway or Great



The Great River Road at Grafton

Dedication of River Trail

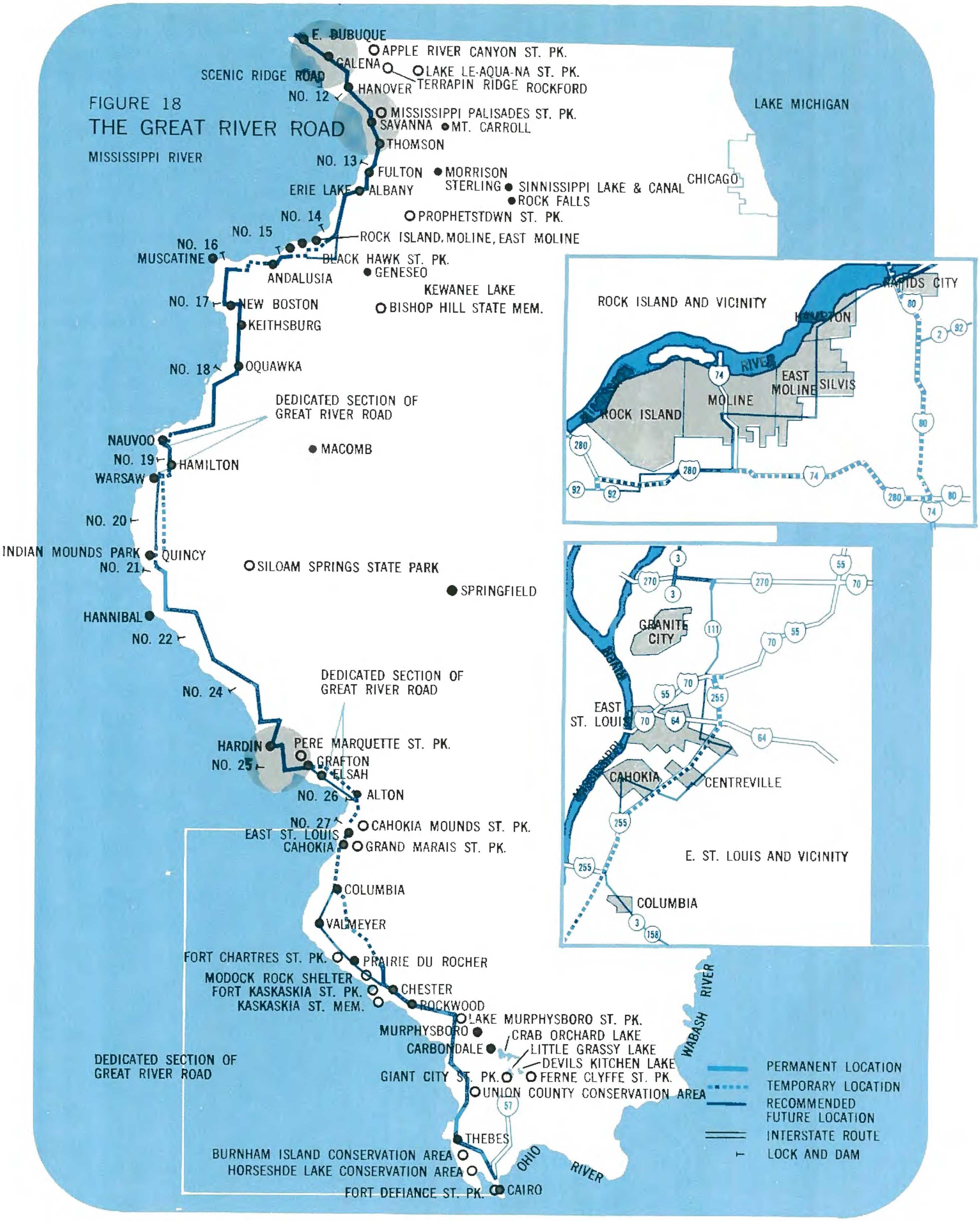


FIGURE 18
THE GREAT RIVER ROAD
MISSISSIPPI RIVER
E. DUBUQUE
APPLE RIVER CANYON ST. PK.
GALENA
LAKE LE-AQUA-NA ST. PK.
SCENIC RIDGE ROAD
TERRAPIN RIDGE
ROCKFORD
HANOVER
NO. 12
LAKE MICHIGAN
MISSISSIPPI PALISADES ST. PK.
SAVANNA
MT. CARROLL
THOMSON
NO. 13
FULTON
MORRISON
STERLING
SINNISSIPPI LAKE & CANAL
CHICAGO
ROCK FALLS
ERIE LAKE
ALBANY
NO. 14
PROPHETSTOWN ST. PK.
NO. 15
ROCK ISLAND, MOLINE, EAST MOLINE
NO. 16
MUSCATINE
BLACK HAWK ST. PK.
GENESEO
ANDALUSIA
KEWANEE LAKE
NO. 17
NEW BOSTON
BISHOP HILL STATE MEM.
KEITHSBURG
NO. 18
OQUAWKA
DEDICATED SECTION OF GREAT RIVER ROAD
NAUVOO
MACOMB
NO. 19
HAMILTON
WARSAW
NO. 20
INDIAN MOUNDS PARK
QUINCY
NO. 21
SILOAM SPRINGS STATE PARK
SPRINGFIELD
HANNIBAL
NO. 22
NO. 24
DEDICATED SECTION OF GREAT RIVER ROAD
HARDIN
PERE MARQUETTE ST. PK.
NO. 25
GRAFTON
ELSAH
NO. 26
ALTON
NO. 27
CAHOKIA MOUNDS ST. PK.
EAST ST. LOUIS
CAHOKIA
GRAND MARAIS ST. PK.
COLUMBIA
VALMEYER
FORT CHARTRES ST. PK.
PRAIRIE DU ROCHER
MODOCK ROCK SHELTER
FORT KASKASKIA ST. PK.
CHESTER
KASKASKIA ST. MEM.
ROCKWOOD
LAKE MURPHYSBORO ST. PK.
MURPHYSBORO
CRAB ORCHARD LAKE
CARBONDALE
LITTLE GRASSY LAKE
DEVILS KITCHEN LAKE
DEDICATED SECTION OF GREAT RIVER ROAD
GIANT CITY ST. PK.
FERNE CLYFFE ST. PK.
UNION COUNTY CONSERVATION AREA
WABASH RIVER
THEBES
BURNHAM ISLAND CONSERVATION AREA
HORSESHOE LAKE CONSERVATION AREA
OHIO RIVER
FORT DEFIANCE ST. PK.
CAIRO
ROCK ISLAND AND VICINITY
RAPIDS CITY
HAMPTON
RIVER
EAST MOLINE
SILVIS
MOLINE
ROCK ISLAND
E. ST. LOUIS AND VICINITY
GRANITE CITY
EAST ST. LOUIS
CAHOKIA
CENTREVILLE
COLUMBIA
PERMANENT LOCATION
TEMPORARY LOCATION
RECOMMENDED FUTURE LOCATION
INTERSTATE ROUTE
LOCK AND DAM

River Road Plan was prepared by the U. S. Bureau of Public Roads and the National Park Service in 1958. Several State and Federal comprehensive development programs currently in progress generally follow this plan.

In 1965 the State of Illinois dedicated the Mississippi River Trail (Boating Trail), thus expanding the parkway concept to satisfy both the boating and motoring public along its 581-mile border. Figure 18 is a map of the Great River Road, as presently recommended by the Illinois Mississippi Scenic Parkway Commission. Figure 19 shows the Calhoun-Jersey County area; Figure 20, the area of the parkway near Galena; and Figure 21, the area at Mississippi Palisades State Park near Savanna. These maps illustrate possibilities for development of the parkway and boatway in sections of the Mississippi River Corridor. Figure 22 illustrates proposed parkway land controls and Figure 23 shows facilities and areas needed in a boatway development.

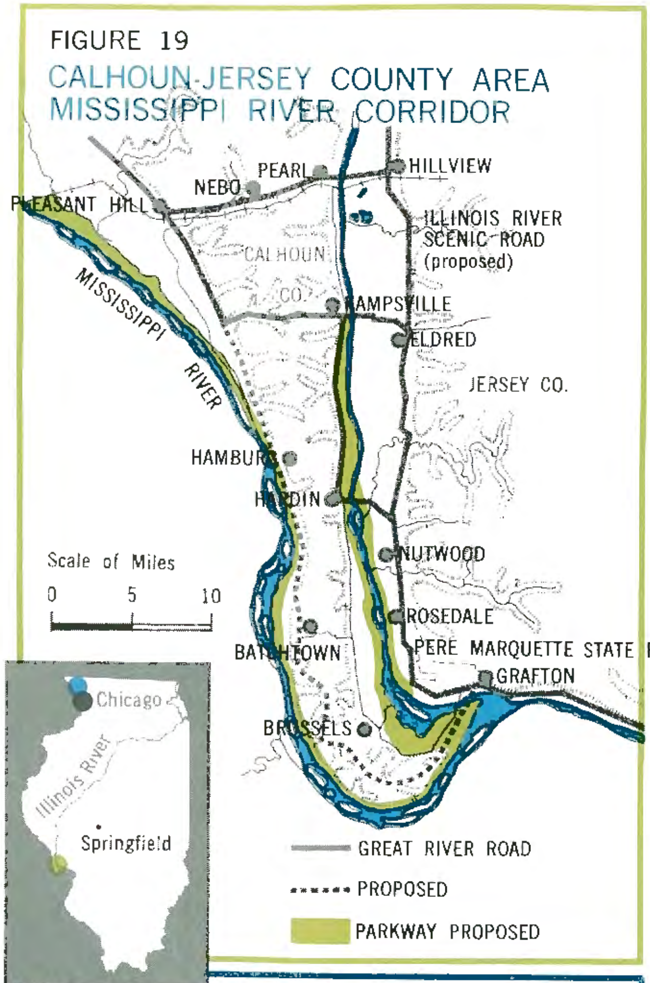


FIGURE 19
CALHOUN-JERSEY COUNTY AREA
MISSISSIPPI RIVER CORRIDOR

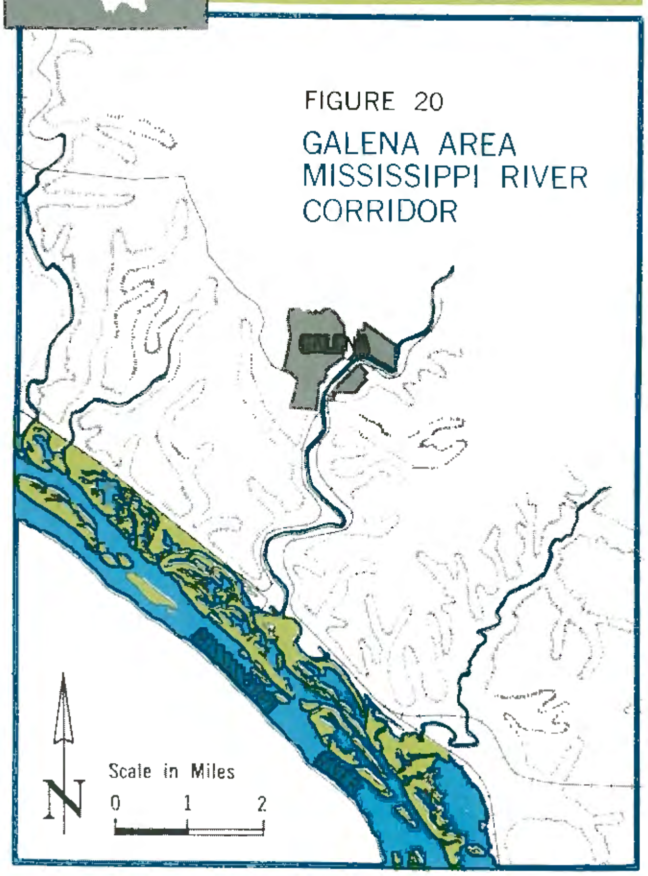


FIGURE 20
GALENA AREA
MISSISSIPPI RIVER
CORRIDOR

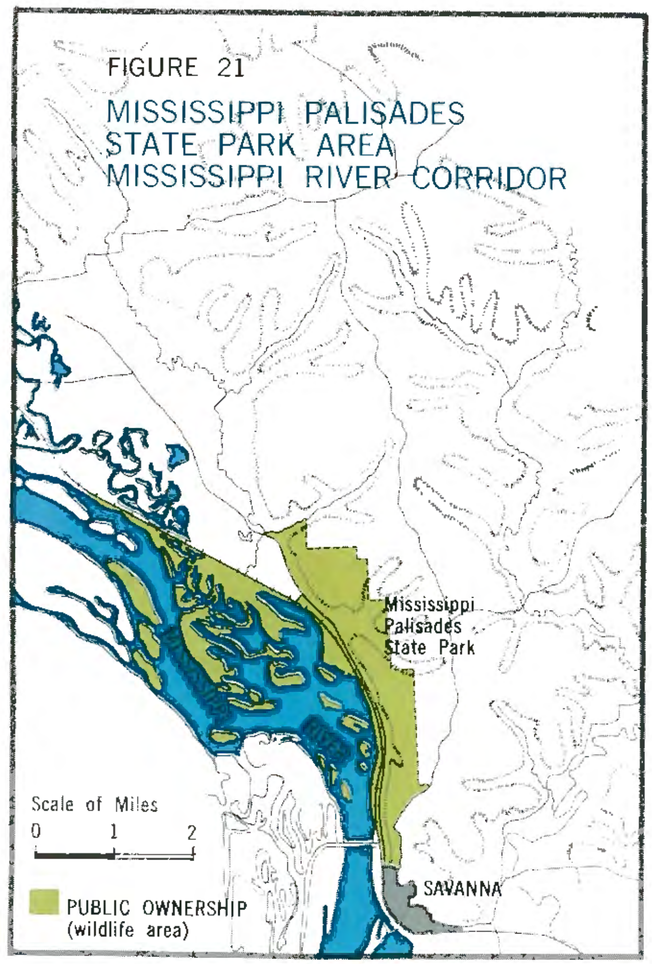
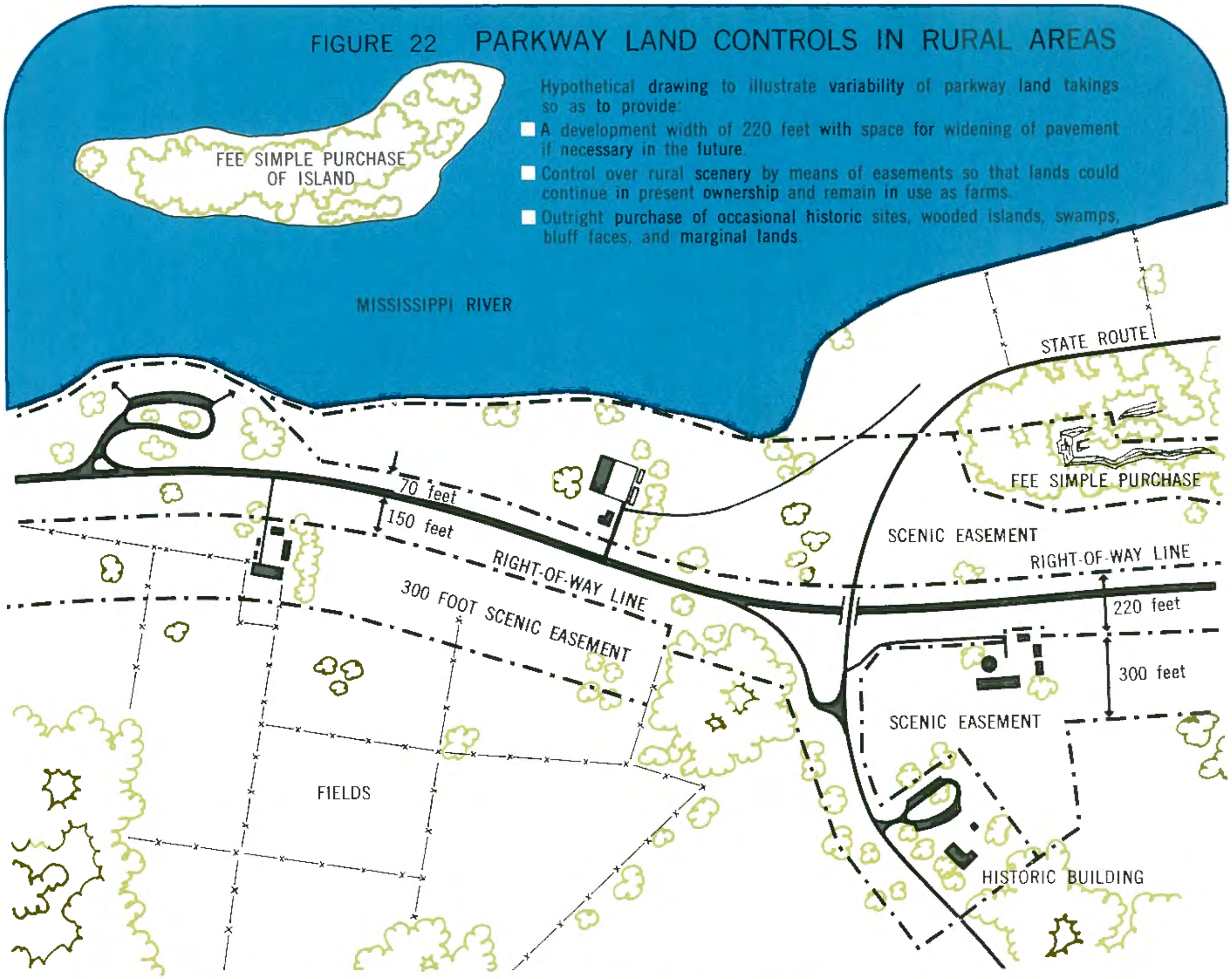


FIGURE 21
MISSISSIPPI PALISADES
STATE PARK AREA
MISSISSIPPI RIVER CORRIDOR

FIGURE 22 PARKWAY LAND CONTROLS IN RURAL AREAS



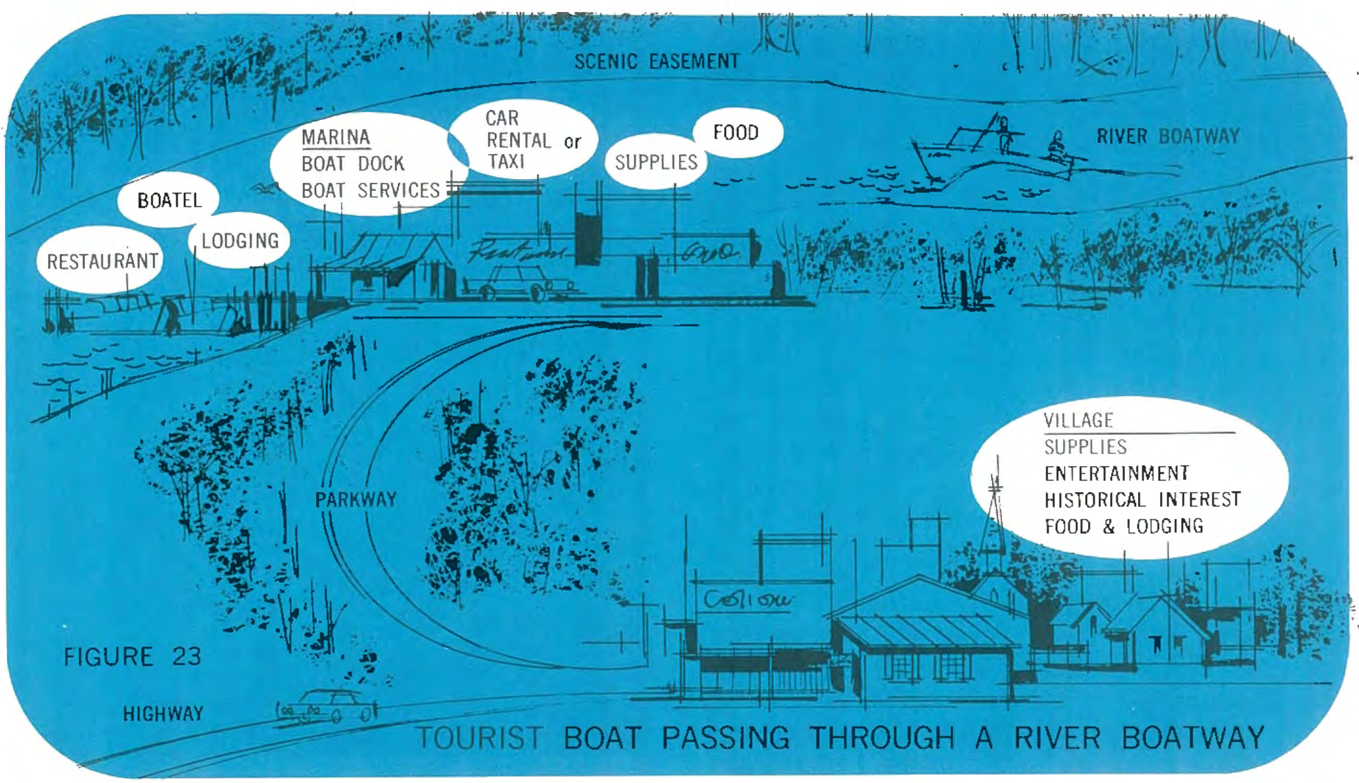
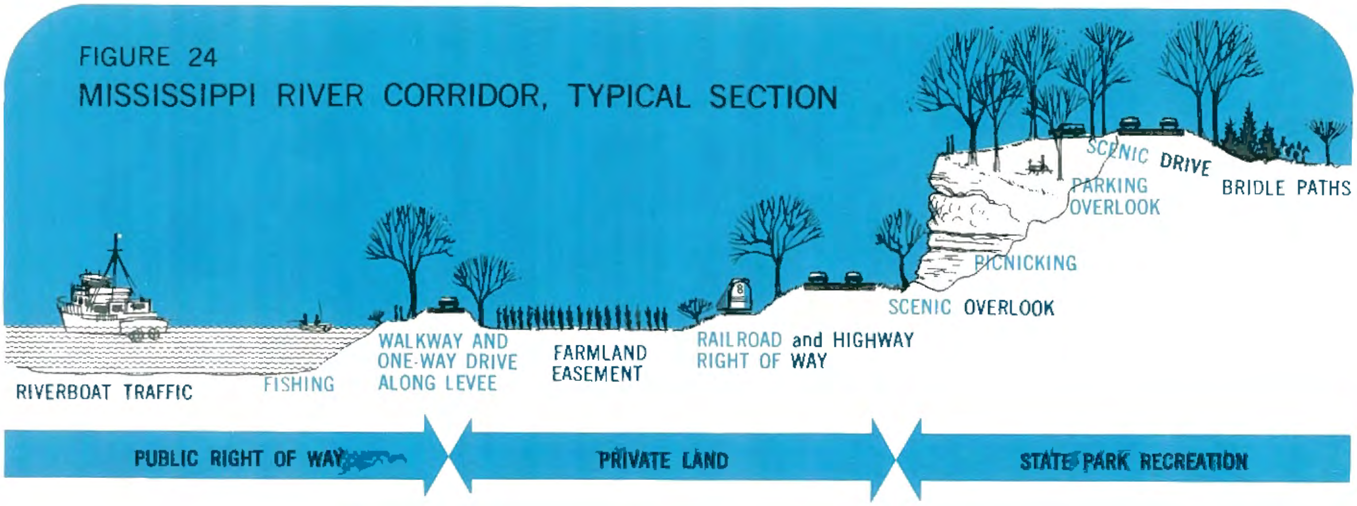


FIGURE 23 TOURIST BOAT PASSING THROUGH A RIVER BOATWAY

FIGURE 24
MISSISSIPPI RIVER CORRIDOR, TYPICAL SECTION



The Corps of Engineers is planning and zoning for resource management on Corps' lands. The U. S. Fish and Wildlife Service is making similar long-range management studies for its wildlife refuges. The U. S. Bureau of Public Roads and the State Division of Highways are embarked on a program to "tailor" the existing selected highway to better meet parkway needs. The Department of Conservation is coordinating and assisting in these Federal programs. In addition, the Department is proceeding with a program of acquisition and facility construction to increase river access areas, harbors, state parks, memorials, overlooks, nature preserves, and wildlife refuges.

The Mississippi River Corridor is formed by a narrow flood plain contained between two regular lines of bluffs. The plain is cut by the meandering main stream of the River, thousands of islands and backwater bays, and the broad fertile farm lands. The drawing in Figure 24 shows a typical cross section of the proposed development of the River Corridor.

The highway selected for the Great River Road generally follows along the base of the bluff. In a few places the road follows the top of the bluff, presenting sweeping panoramic views of the River and plain, as occurs at Chester. Only in a few areas, such as the section between Nauvoo and Hamilton, does the main stream flow against the Illinois shore, creating a true riverside drive. The views to the west over much of the way include a panorama of bottom-land farms, backwater bays, river levees, a fringe of distant trees along the River, and the bluffs on the Iowa and Missouri side.

At Fountain Bluff a short side trip presents outstanding vistas up and down the River. For the travelers who wish to see more of the River, there will be many possible short side trips to the river locks, launching sites, bridge crossings, ferries, levee-top drives, and riverside parks. It is anticipated that regular excursion trips on the River will be offered at major state parks, such as Pere Marquette, and at river ports, such as Alton, Quincy, and Rock Island.

The new Kinkaid Creek Reservoir located in Jackson County lies partly within the Shawnee National Forest and will adjoin Lake Murphysboro State Park. When completed, it will provide an additional major scenic-recreational tourist center for both the Mississippi Parkway Corridor and the Shawnee Hills Resource Area. This 4500-acre reservoir is being developed by the State Department of Public Works and Buildings, Division of Waterways; State Department of Conservation; the U. S. Forest Service; and Kinkaid Conservancy District. It is an excellent example of Federal, State, and local cooperation in the development of a multi-purpose reservoir for regional economic rehabilitation.

A unique emblem now marks the entire course of the Great River Road through Illinois from Cairo to East Dubuque—a river pilot's wheel with twelve spokes, ten of which represent the states in the U. S. that border the Mississippi and two for the Canadian provinces. Already dedicated sections of the Great River Road are found between Cairo and East St. Louis, between Alton and Grafton, and

Mississippi Palisades State Park

between Hamilton and Nauvoo. The balance, or temporary route, follows existing Illinois highways that are near the River and parallel it.

In the reserve for eventual development is a scenic drive along the Calhoun County Ridge, opening up distant vistas of both the Mississippi and Illinois Corridors and near views of orchards, pastures, and woodlands. It is the great number and variety of points of interest and activities offered, rather than the outstanding scenery, which should be emphasized in the Illinois section of the Mississippi Parkway Corridor.

Whether on the River or on the Road, each of the 581 miles offers existing or potential tourist attractions. These range from the thriving, modern city of St. Louis to the sleepy, historic village of Nauvoo; from the noisy, active concentration of boats in the Alton River Pool 26 to the quiet, empty stretches in Pool 12 near Galena (Figure 20). The traveler can watch the great flocks of Canadian Geese arrive at Horseshoe Lake or explore the archaeological Cahokia Mounds; he can golf at Grand Marais, ride horseback at Pere Marquette, picnic on Nine Mile Island, or camp at the Mississippi Palisades State Park (Figure 21).

While there is only one Mississippi River, the approach used in this case can be applied to many lesser streams or scenic corridors, using existing facilities and natural features. Conservation and preservation also become part of such a project.

CASE STUDY 2. ILLINOIS-MISSISSIPPI CANAL AND LAKE SINNISSIPPI

Preservation of an Historic Towboat Canal

The 100-mile Illinois-Mississippi Canal, one of the most nearly operable and most complete of the towboat canals, has a unique potential as a water-related parkway by virtue of its natural beauty, historic value, single ownership, and its location. Not only is it parallel to the New York-Chicago-San Francisco Interstate Highway, but it is also in one of the most densely populated and rapidly expanding areas of the nation.

The Canal lies in a region of expanding urban population which, with nearly 10 million people, has no national parks, no national forests, and too little land and water area in other public recreational use. Studies have indicated that this region should have a minimum of 40,000 additional acres of large-scale recreational lands to meet the most conservative projection of needs. Interstate Highway 80 closely parallels the Canal throughout its 100-mile length.

This project provides a variety of recreational opportunities, not only to people within the State, and more particularly those living throughout the great length of this facility, but also to the long-distance traveler on the interstate highway.

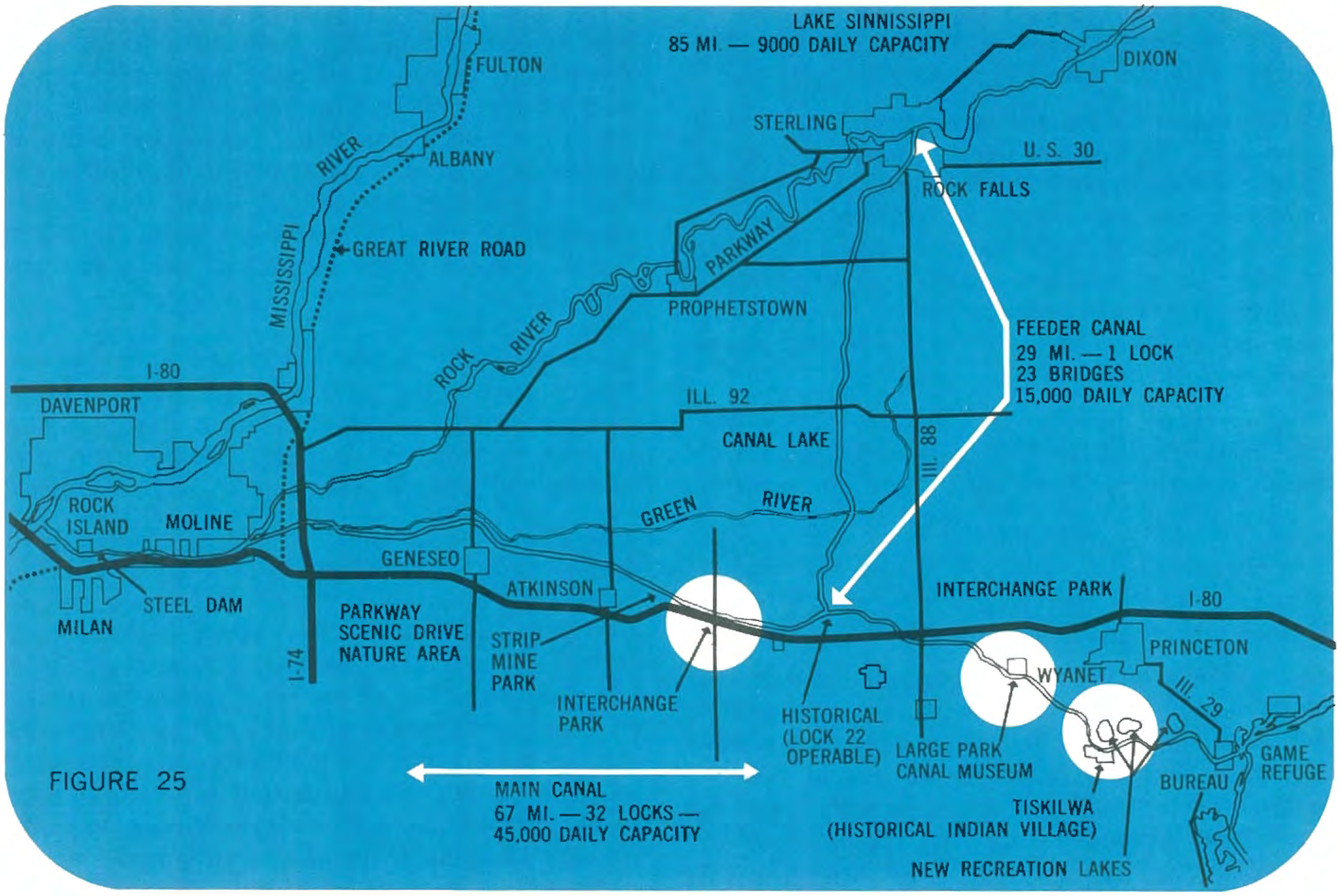
Development of the Illinois-Mississippi Canal for recreation would capitalize on a unique existing asset, which otherwise would serve little or no useful purpose and in time would be almost completely obliterated.

The Project

The Illinois-Mississippi Canal was constructed by the Federal Government as a connector for commerce between the heavily traveled Mississippi River and the Great Lakes. This route, planned since the Civil War, was finally built in 1907, in the twilight of the towboat era. The Illinois-Mississippi Canal was one of the last of the great towboat canals to be constructed, which accounts for its remarkable state of preservation. As the Canal was neither able to compete with rail transportation nor to be converted economically for use by self-powered tows, its importance as a commercial water route rapidly dwindled. It was scheduled to be abandoned in 1952.

Over the years, however, the use of the Canal had changed from commerce to recreation. This recreational use of the Canal, which has now continued over a period of years, was gradual at first and more intensive in recent years. There was a spontaneous outcry for preservation of the Canal. The people who used the beautiful Canal for recreation were joined by those who realized that the Canal and Lake Sinnissippi had increased real estate values in the area and by the cities which used the feeder lake waters as a source of hydroelectric

Illinois-Mississippi Canal



ILLINOIS AND MISSISSIPPI CANAL AND LAKE SINNISSIPPI, DEVELOPMENT PLAN

power. These groups supported Federal and State legislators in a plan to preserve the Canal along its entire length for recreational development and use, as well as the feeder lakes, Lake Sinnissippi, and Steel Dam.

In a period of vanishing shoreline, expanding population, and increased public demands for open space, the potential for recreational use of the Canal is significant. Studies estimate that the Illinois-Mississippi Canal area, after development for recreational use, will draw attendance of 3 million visitors per year, of which 20 percent will be out-of-state tourists.

The General Development Plan for the Canal and Lake Sinnissippi (Figure 25) suggests the nature of the ultimate recreational development and use as:

— Ten large parks, more than 100 smaller parks, eight specialized parks, scenic drives, youth hostel centers, nature areas, game refuges, tourist centers, historical museums, towboat rides. Figures 26, 27, and 28 show proposed park and lake developments.

— Land acquisition of approximately 9000 additional acres, to supplement the 6000 acres already in public ownership.

— Increased fishing opportunities through an intensive fish management program. (Present fishing use of the Canal is 600,000 man days per year.)

— A wide variety of songbirds, waterbirds, animals, and plant life to offer a continuing source of enjoyment to bird watchers and naturalists.

— One hundred miles for canoeing, small power boating, and hiking on the Main Canal and Feeder Canal.

— Lake Sinnissippi—the main feeder lake—8.5 miles, 2400 acres of power boating water, public launching sites, 17 miles of shoreline, a proposed large state water-related park (Figure 29).

— Steel Dam—feeder lake—1800 acres; 9 miles of boating and fishing; undeveloped linear parkway of 7 miles from Milan east.

The project is interesting in that it takes advantage of the recreational potential of an existing facility intended for another use. Such assets are to be found in many areas or communities.

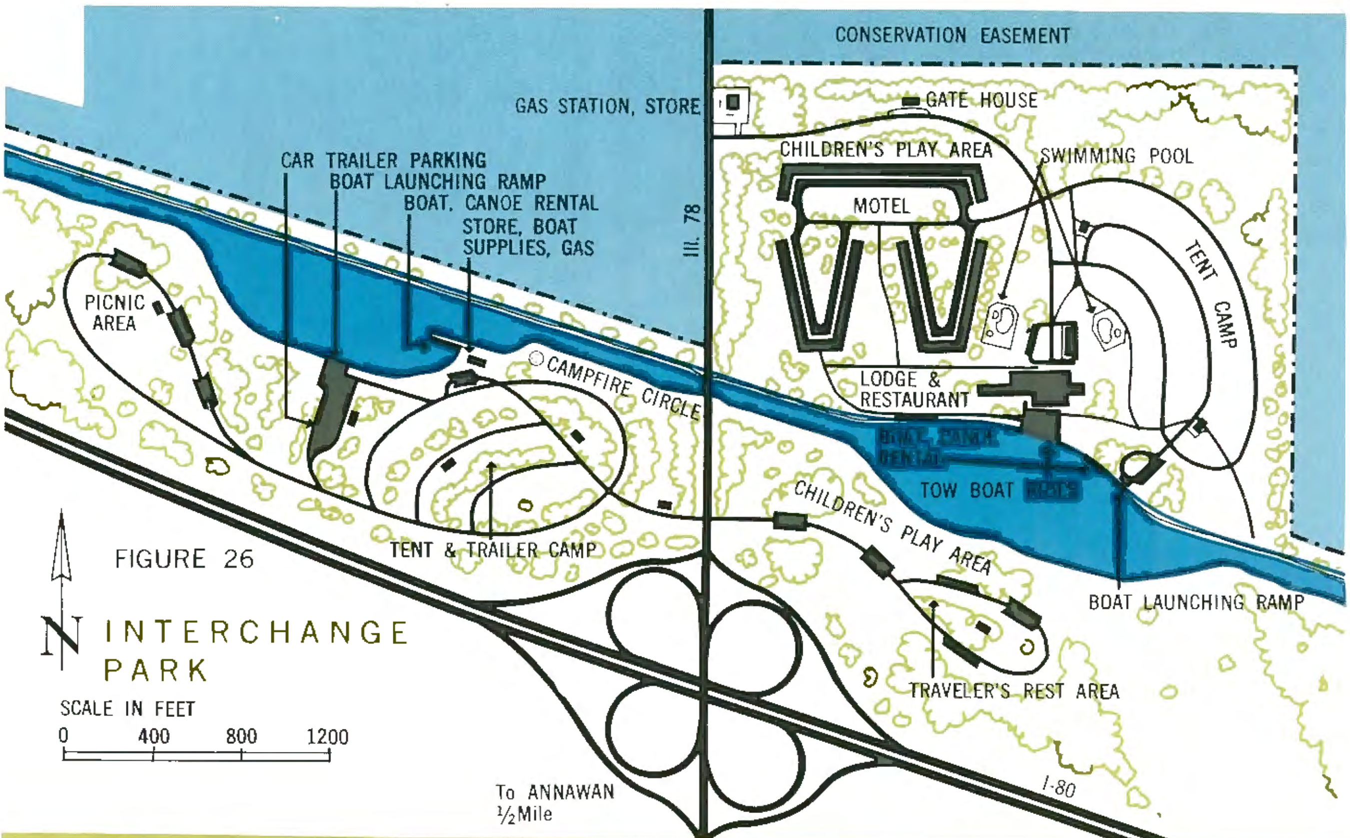


FIGURE 26

INTERCHANGE PARK

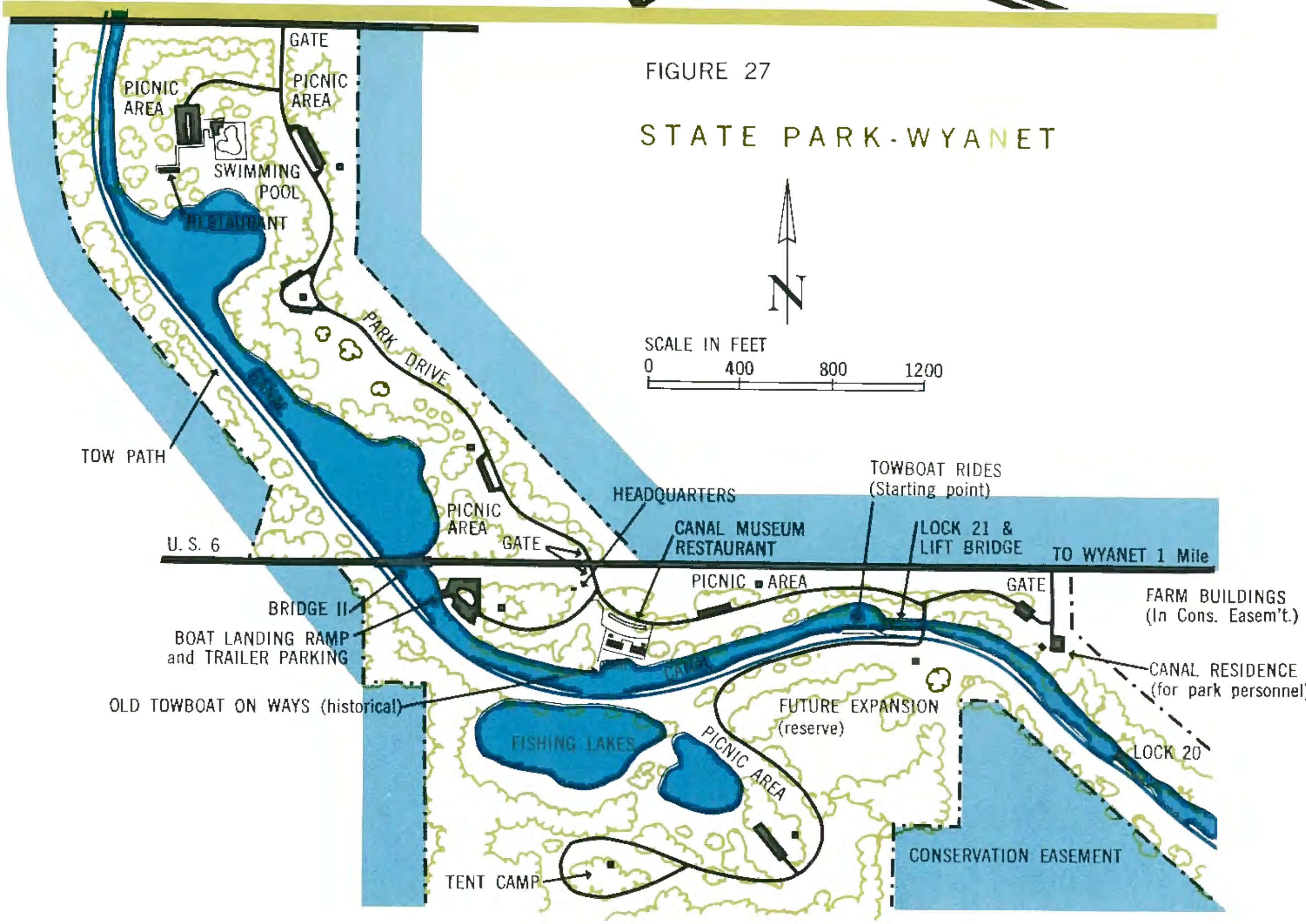


FIGURE 27

STATE PARK-WYANET

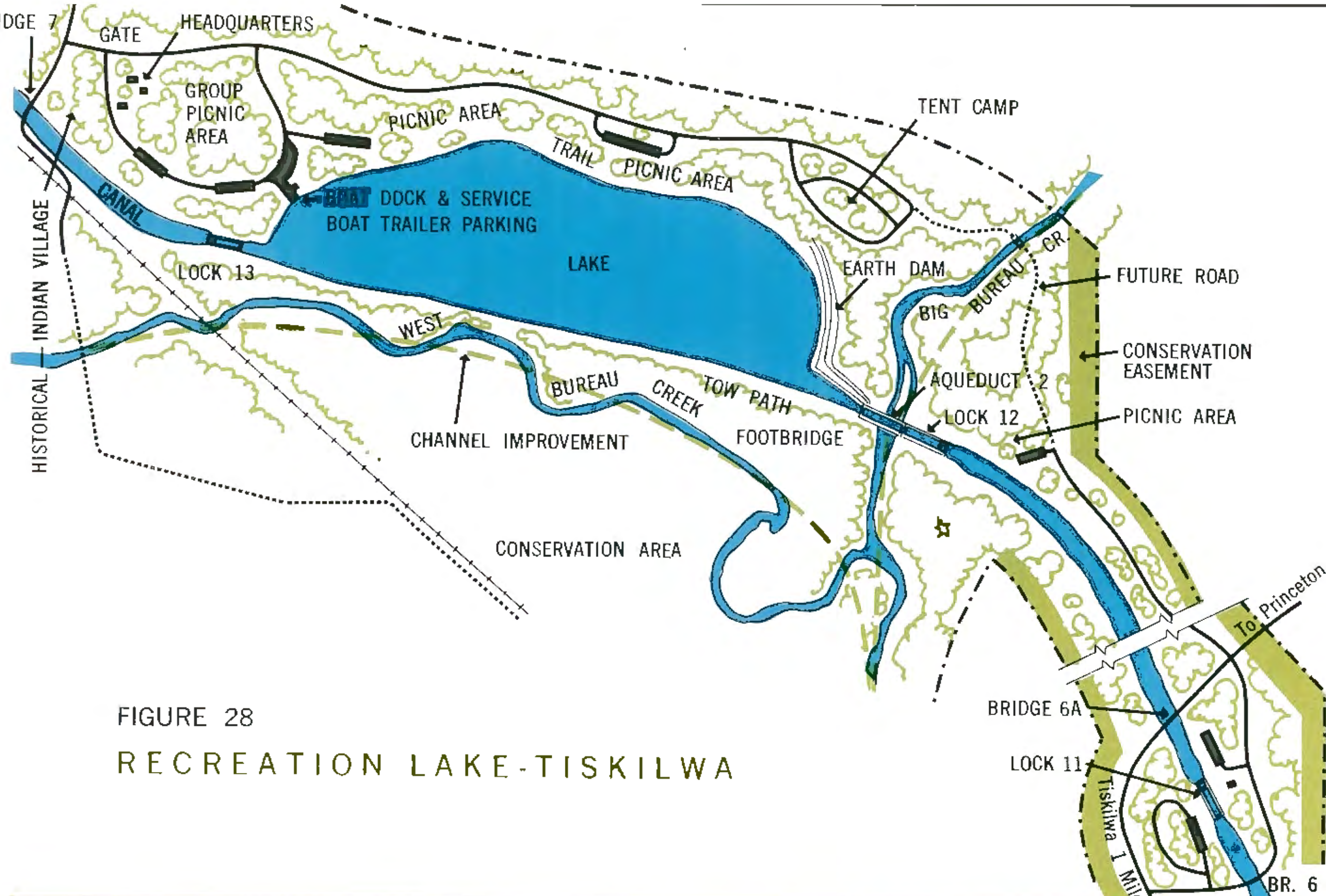


FIGURE 28

RECREATION LAKE-TISKILWA

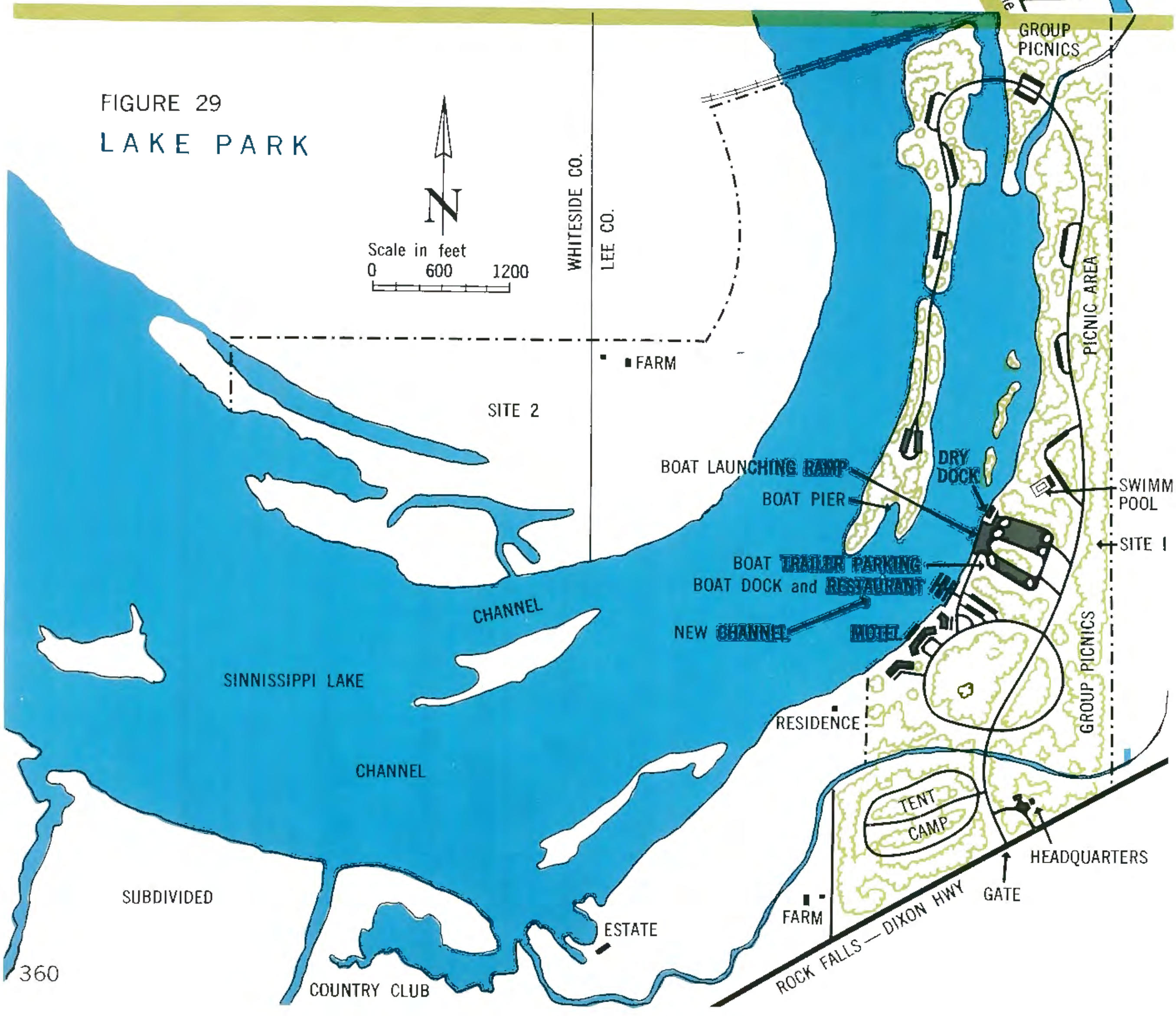


FIGURE 29

LAKE PARK

CASE STUDY 3. THE ILLINOIS RIVER CORRIDOR

A Potential Linear Parkway

The Illinois River Corridor forms a vital waterway link between Metropolitan Chicago and Greater St. Louis, two major tourist attractions in the Midwest. Along its 327 mile length there is a wide variety of prairie scenery, thriving cities, historic and archeological points of interest, as well as a large reserve of potential landscape resources.

Here, then, is an opportunity to develop an outstanding linear parkway, designed to serve a growing urban population and offer the out-of-state visitor a memorable tour through the heartland of Illinois.

Such a parkway is a recreational resource for travelers who enjoy the movement of travel, but may want to stop at convenient distances for refreshment, for play, or for a few days visit and exploration. As envisioned, the Illinois River Corridor is well suited to the traveler by automobile or boat, or the hiker.

The Project

The terrain in the Illinois River Corridor is interesting, comparatively varied, and definitely suited for a variety of recreational activities. The river scenery varies from broad flood plains with marginal lakes and marshes to picturesque narrows flanked by high wooded ridges. Tributary streams appear as deeply incised valleys and ravines.

Beginning at Chicago, the entire River has been harnessed by locks and dams into a series of navigation pools, making it safe and enjoyable for small craft. With a relatively small watershed, the damage from flooding beyond the natural river bank is minimal. Unlike the Mississippi valley, there are relatively few miles of levees to obstruct the boaters' view of the surrounding countryside, or the motorists' view of the River from the paralleling highways.

Figure 30 shows a typical cross section of the proposed River Corridor.

Throughout most of its length, highways parallel the River on both sides. The locations vary in both elevation and proximity, offering intimate views and more distant panoramas from the high bluffs.

Approximately 30 harbors with launching sites and other facilities have been developed at riverside communities and at Pere Marquette State Park. In addition, there are 28 launching sites spaced out along the entire length of the Corridor. Several projects to improve the harbor and launching sites are either in process or in the planning stage.

A parkway corridor along the Illinois would connect with the proposed tributary parkway corridors of the Sanagamon River, the Illinois-Mississippi Canal, the Fox, the Kankakee, and the DesPlaines Rivers, and three interstate routes.

Four segments of the River Corridor between Havana and Ottawa have been selected to illustrate various resource potentials of this proposed parkway. The Corridor from Pekin to Ottawa is shown in Figure 31.

— **The River Lake-Mason State Forest Complex** north of Havana is a major resource area now partly in State and Federal ownership (Figure 32).

— **Chautauqua Lake** was established as a 4500-acre Federal waterfowl refuge, with 80 percent of the area in water surface. The Lake is an extremely productive sport and commercial fishery, and the refuge is popular as a nature study area.

— **Rice Lake Conservation Area,** developed for a refuge and for fishing and hunting, camping, and picnicking, is owned by the State.

— **Spring Lake Conservation Area** has been developed on the shores of this popular 1285-acre

FIGURE 30
ILLINOIS RIVER CORRIDOR, TYPICAL SECTION

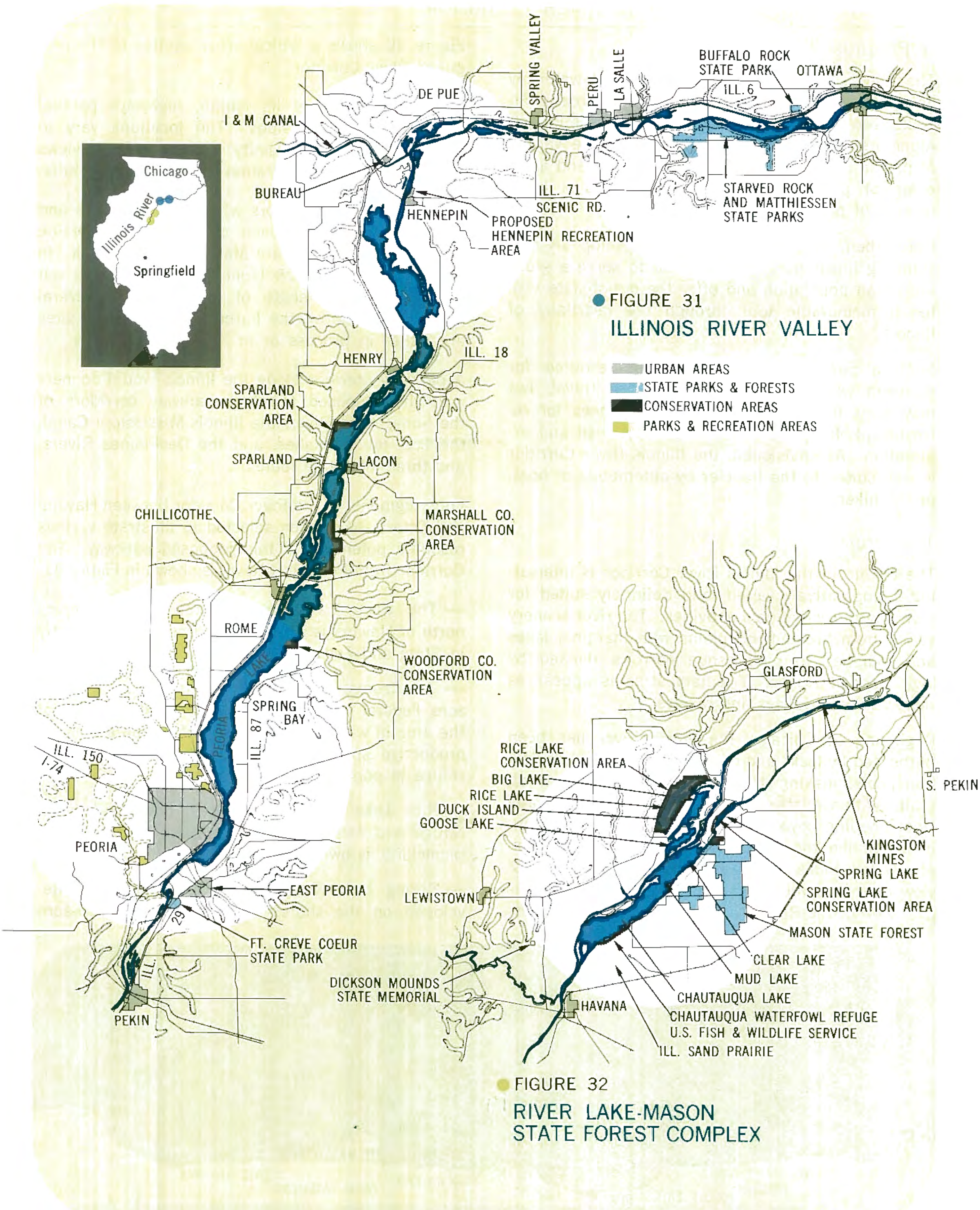


FIGURE 31
ILLINOIS RIVER VALLEY
URBAN AREAS
STATE PARKS & FORESTS
CONSERVATION AREAS
PARKS & RECREATION AREAS
Chicago
Illinois River
Springfield
DE PUE
SPRING VALLEY
PERU
LA SALLE
BUFFALO ROCK STATE PARK
OTTAWA
ILL. 6
I & M CANAL
BUREAU
HENNEPIN
PROPOSED HENNEPIN RECREATION AREA
ILL. 71
SCENIC RD.
STARVED ROCK AND MATTHIESSEN STATE PARKS
HENRY
ILL. 18
SPARLAND CONSERVATION AREA
SPARLAND
LACON
CHILLICOTHE
MARSHALL CO. CONSERVATION AREA
ROME
WOODFORD CO. CONSERVATION AREA
PEORIA LAKE
SPRING BAY
ILL. 87
ILL. 150
I-74
PEORIA
EAST PEORIA
FT. CREVE COEUR STATE PARK
29
ILL.
PEKIN
FIGURE 32
RIVER LAKE-MASON STATE FOREST COMPLEX
GLASFORD
S. PEKIN
RICE LAKE CONSERVATION AREA
BIG LAKE
RICE LAKE
DUCK ISLAND
GOOSE LAKE
KINGSTON MINES
SPRING LAKE
SPRING LAKE CONSERVATION AREA
MASON STATE FOREST
LEWISTOWN
CLEAR LAKE
MUD LAKE
DICKSON MOUNDS STATE MEMORIAL
CHAUTAUQUA LAKE
HAVANA
CHAUTAUQUA WATERFOWL REFUGE U.S. FISH & WILDLIFE SERVICE
ILL. SAND PRAIRIE

fishing lake. Included are facilities for camping, picnicking, boat launching, and boat rental.

— **The Mason State Forest** has limited picnic and camping facilities and is popular as an upland game hunting area.

Considerable potential resource area is still available (undeveloped), including a strip mine area north of Rice Lake, and the Illinois Sand Prairie Region north of Havana. It is recommended as a future nature preserve. When fully developed, the area will offer a wide range of recreational opportunities.

— **The Peoria Area** includes one of the larger progressive metropolitan cities in the State. Assisted by the Forest Park Foundation, the Peoria Park District has launched a major open-space land acquisition program which will include sections of the Peoria lakefront and large tracts along wooded bluffs. Recently, the Tri-County Planning Commission, for Peoria, Woodford, and Tazewell Counties, was authorized to make a comprehensive Illinois riverfront study for the three counties. The study will put strong emphasis upon water-related parks and recreation.

— **The Detweiler Marina,** one of the best small harbors in the State, has been developed by the Peoria Park District for public use. It has 350 mooring spaces, a service concession, a large launching ramp, and dry dockage. In the ultimate plan, restaurant and park facilities will be added. Peoria Lake is popular with sailing enthusiasts.

— **The Woodford County Conservation Area** on the east side of the River opposite Chillicothe includes a river lake area of 2790 acres, with an adjoining 2897 acres of shorelands owned by the State. It has been developed as a waterfowl refuge, with limited facilities for camping and picnicking. Water-related recreational uses of the area include fishing, boating, and hunting.

— **Marshall County Conservation Area,** only 5 miles upstream, is a similar development. Both areas are on the proposed scenic river drive (Route 87).

— **The Hennepin Region** includes the historic river town of Hennepin and the new Jones and Laughlin steel plant. The riverside drive from Lacon to Hennepin is one of the most scenic sections of the proposed parkway.

— **Senachwine and Goose Lakes,** although privately owned, are favorite resting places for migratory waterfowl.

— **The Illinois-Mississippi Canal** is a future linear parkway and historic canal that joins the Illinois River at Bureau. (See previous Case Study.)

— **Starved Rock State Park** is a scenic, historic, and well-equipped park fronting on the River. Many of the park facilities for camping, picnicking and hiking are enhanced by a close association with the River. Boat launching facilities are available, and an excursion boat ride through the lock is one of the opportunities offered to the visitor.

Similar facilities could be developed in areas where a series of recreational locations can be connected as a parkway.

CASE STUDY 4. SHELBYVILLE FEDERAL RESERVOIR

The Potential of Multi-Purpose Federal Reservoirs

A facility such as the Shelbyville Reservoir provides recreation on a regional basis for people with many interests and requirements. Such a development draws people from a distance; many of them may stay for an extended period. Overnight facilities range from tent camping areas to modern lodge-hotels.

Shelbyville is a multi-purpose reservoir with planned benefits including flood control, storage of municipal and industrial water supply, fish and wildlife habitat, and recreation. Many intangible benefits are also considered. Such a development helps to stabilize the economy in the valley in which the lake is constructed and encourages civic and industrial development.

The Project

Opportunities for water-related recreation will increase tremendously with the completion of the seven large Federal-State reservoirs in south-central Illinois. These reservoirs, now in various stages of planning or construction by the U. S. Army Corps of Engineers, will have a total of more than 80,000 acres of water. This will increase the State's lake water resource available for recreation by 50 percent.

Carlyle Reservoir on the Kaskaskia is almost complete; Shelbyville Reservoir upstream will be completed in 1969. Rend Lake on the Big Muddy River will be finished in 1970. In addition to the Lake, it will have two large sub-impoundment waterfowl refuge areas. Lincoln Reservoir on the Embarras is authorized for construction. Oakley Reservoir on the Sangamon, Louisville on the Little Wabash, and Helm on Skillet Fork are in the planning stage. Lincoln and Louisville Reservoirs will be scenic, with long narrow waterways, high, heavily wooded banks and many caves. Helm Reservoir and Stephen A. Forbes State Park are only 6 miles apart and could be developed as one unit.

Of equal importance are the thousands of acres of public shore lands that will be acquired for recreational development or placed in reserve.

Properly developed, the reservoirs will give Illinois the first opportunity to lure Illinois' vacationing families away from the lake states of Minnesota, Wisconsin, and Michigan; from the Kentucky-Barkley Lakes; and from the Lake of the Ozarks. The longest distance between Illinois' seven reservoirs is only 110 miles, or two hours' driving time. Their oval grouping provides an opportunity to link them by parkways and create a recreational lake region. This region, near several cross-country interstate routes, should develop into a prime tourist resort complex.

The reservoirs will have different natural characteristics. Planners can take advantage of these differences to create at each reservoir distinctive recreational communities. On a regional basis, this should provide the wide variety of recreational interest and scenery needed to attract and hold tourists and vacationists.

The Shelbyville Reservoir has been selected to illustrate the great potential for conservation and recreation available in each of the multi-purpose Federal-State reservoirs and the cooperative effort of the people and all levels of government needed to develop these resources.

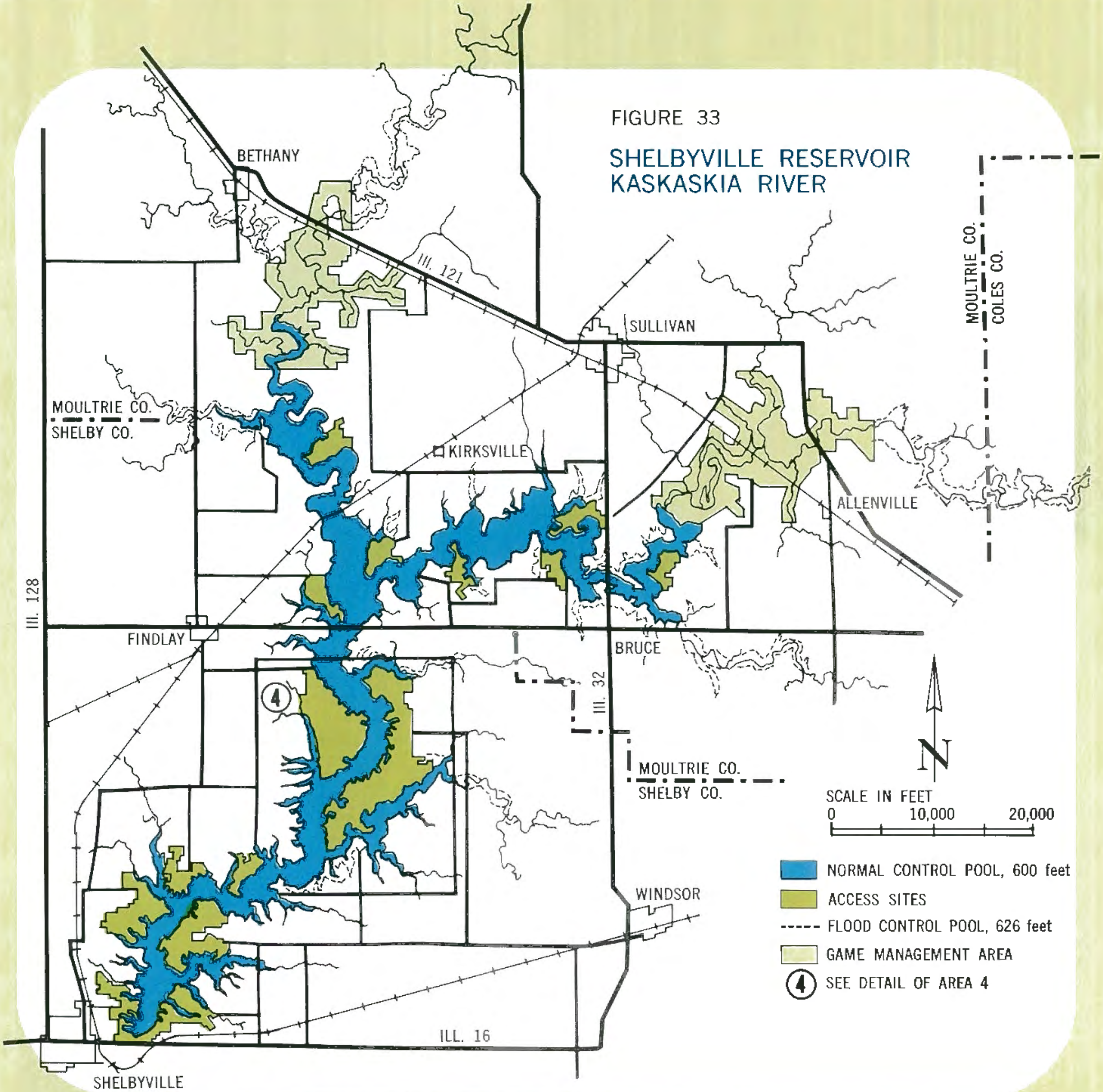
The Reservoir is on the Kaskaskia River 70 miles upstream from its companion, Carlyle Reservoir, and 220 miles above the mouth of the Kaskaskia where it joins the Mississippi River (Figure 33).

Via high speed highways, it will be within easy driving range of major population centers. Driving range is: Chicago, 2.5 hours (150 miles); St. Louis and Peoria, 2 hours (110 miles); Springfield, 1 hour (60 miles); Decatur, 30 minutes (30 miles). A network of local county roads will provide ready access to all parts of the lake shore. Shelby County's existing airport is being expanded; a feasibility study is being made for a small airport at Sullivan.

The Shelbyville Reservoir will have a seasonal pool of 11,100 acres for recreation. Surrounding the lake are 23,000 acres of public land available for recreation. The meandering, heavily wooded shoreline with the many deep gorge-like bays is similar to that of the Ozark lakes. No privately owned lands will border the perimeter of the Reservoir.

PUBLIC PARKLAND

Scattered along its 175 miles of shoreline will be many sections readily adaptable for access sites and intensive park use — beaches, marinas, campgrounds, picnic areas, lodges, and cottages (Figure 34). Backed up by relatively level open farmland, these areas can be developed in depth, providing the necessary space for large numbers of visitors.



Steeper, bluff shorelines will offer pleasing vistas and areas for walking, sightseeing, and photography.

Two potentially outstanding state parks are to be located on opposite shores of the Reservoir, 5 miles above the dam. These two parks will have a combined area of more than 3400 acres. Each will have a swimming beach and marina with launching ramps, docks, and service concession for boat supplies and rental. Overnight accommodations will include campgrounds for families and groups, a lodge with a restaurant, and vacation cottages. Other supporting developments will include picnic areas, a riding stable, nature and lakeside trails, and a nature center. The State will provide four access sites varying from 123 to 193 acres in size, equipped with launching, camping, and picnic facilities.

Also under State administration will be two areas for intensive upland wildlife management totaling approximately 6100 acres along the upper reaches of the West Okaw and Kaskaskia. Waterfowl hunting opportunities are expected to be limited because of the small amount of shallow water for good duck habitat.

Intensive surveys of fisheries are being made in the Kaskaskia River Watershed by the Illinois Natural History Survey and by the Department of Conservation. Based on preliminary findings, it is believed that the Shelbyville Reservoir will have good sport fishing. There are at least sixteen species of fish of interest to anglers in the River. Natural fish food will develop rapidly as the new Reservoir forms.

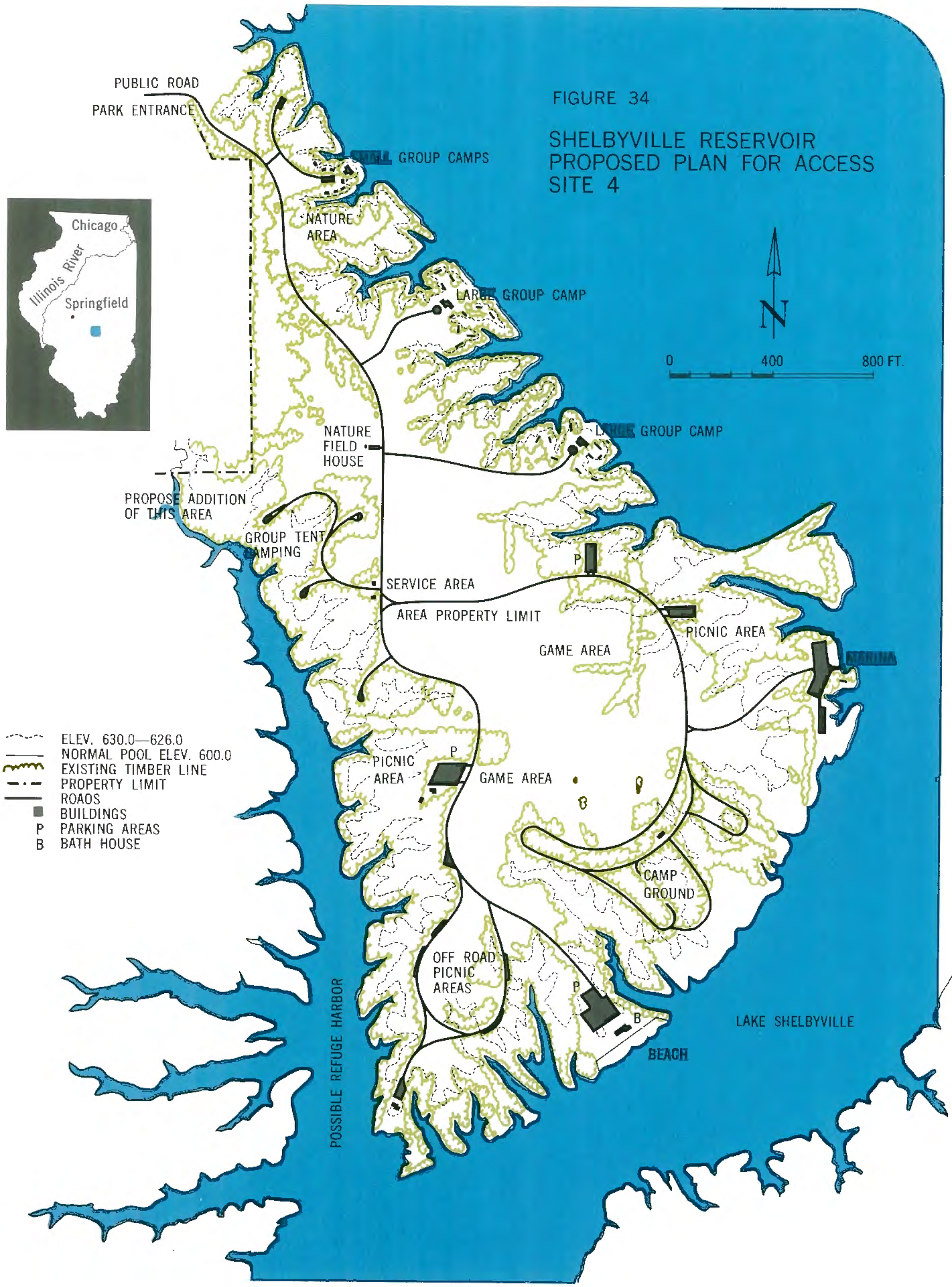


FIGURE 34

SHELBYVILLE RESERVOIR PROPOSED PLAN FOR ACCESS SITE 4

That excellent game fish, the largemouth bass, is the only species that will have to be stocked. A dominant largemouth bass population is a primary goal of the Department of Conservation's fish management program.

The Corps of Engineers will develop and administer thirteen access sites. Individual sites will vary from 59 to 580 acres, with facilities primarily for picnicking and boating access. In addition, there will be provision for boat dock concessions. Portions of these areas have been reserved for future development. A number of camping areas have been placed in reserve for such groups as Scouts, 4-H clubs, and similar semi-public organizations.

Land and Water Zoning

The Reservoir waters will be zoned to specify areas for incompatible water uses. Generally, speed boating and water skiing will be confined to the wider sections of the Reservoir. A no-wake rule will be enforced in all fishing, shoreline, estuary, and harbor areas. Boating will be excluded at all beaches.

In many ways, Shelbyville and Carlyle Reservoirs complement each other. The larger and wider Carlyle pool will be better adapted for speed boating, water skiing, and sailing, and for day and weekend visitation. Scenic Shelbyville Reservoir has a potential as a high quality, lake-centered vacation development not generally available in Illinois. The lake itself, long and narrow with many deep bays, will be excellent for swimming, fishing, and slow-speed boating.

A high degree of cooperation and coordination among Federal, State, and local governmental authorities has been established on the Shelbyville project. Planning for the use of the Reservoir for conservation and recreation has been a coordinated effort between the U. S. Corps of Engineers and the Illinois Department of Conservation. Plans were reviewed by the Bureau of Outdoor Recreation and the U. S. Fish and Wildlife Service. The U. S. and Illinois Public Health Services cooperated in a study of mosquito control and pollution.

The citizens of both Shelby and Moultrie Counties have had the foresight to comprehensively plan and zone around the entire Shelbyville Reservoir project (Figure 35). Enforced zoning should eliminate many of the problems of unregulated growth that have developed around similar reservoir projects in the past.

The Corps of Engineers is responsible for the natural resources of the Reservoir project area, including purchase of lands, construction of the Reservoir, development and operation of thirteen public access areas, control of all project lands through zoning and regulations, and maintenance after completion.

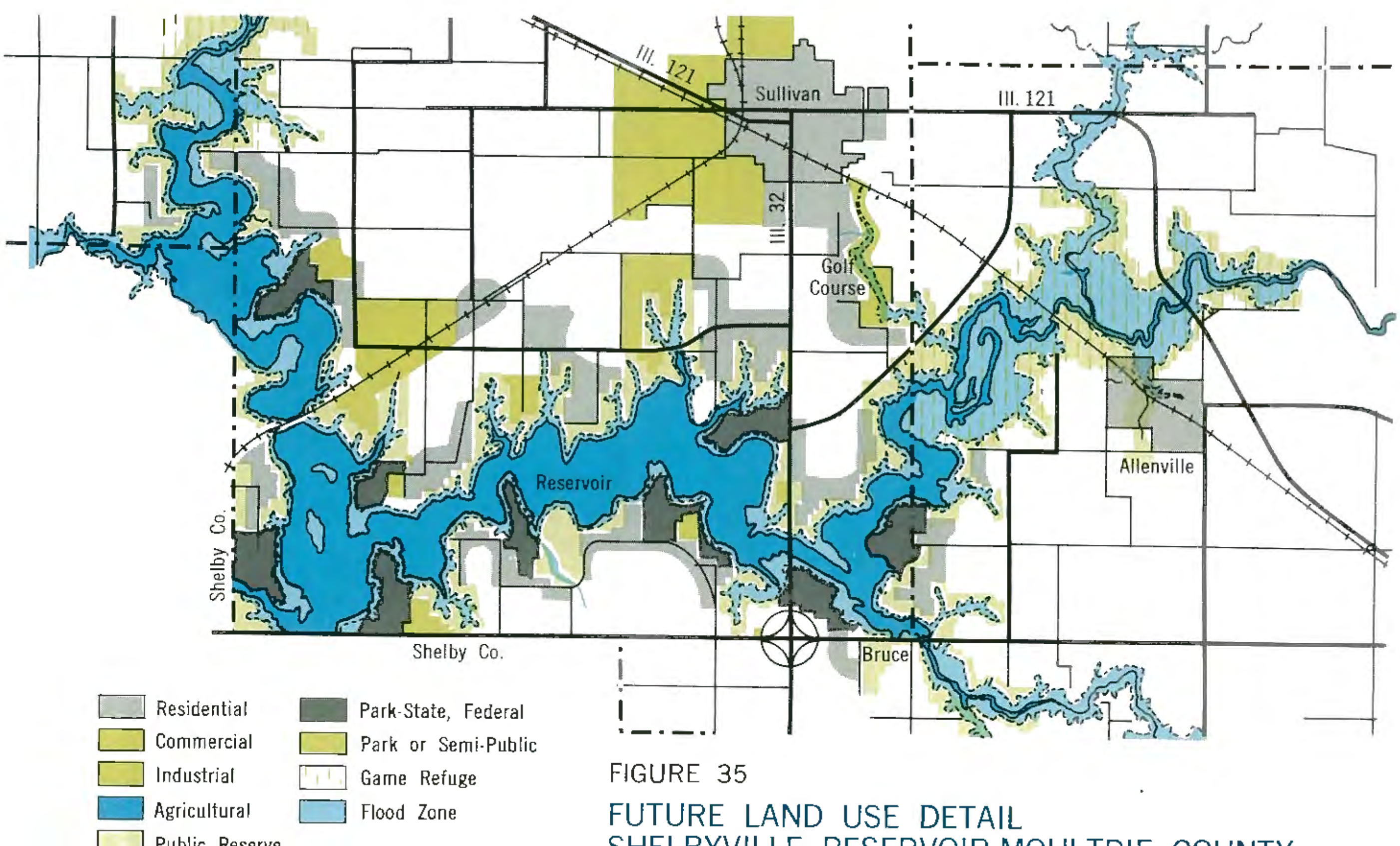


FIGURE 35

FUTURE LAND USE DETAIL
SHELBYVILLE RESERVOIR-MOULTRIE COUNTY

The Department of Conservation is responsible for the development, operation, and maintenance of two major state parks and four access sites; management of fish, game, and forestry; enforcement of boating regulations; and for providing a wide variety of facilities and services.

Another commendable cooperative effort now being investigated is the expansion of water service from both the cities of Shelbyville and Sullivan to parts of the public and private developments around the Reservoir. This would mean a considerable saving in development and maintenance cost at the public recreational areas. The Reservoir is scheduled to be filled by 1969 and the parks and main access areas completed by 1972.

The Corps of Engineers estimates that the visitor days at Shelbyville Reservoir will total 4.69 million by 1972. If a figure of $3.40 per capita were adopted to represent average expenditure for each of those visitor days, an additional $15.9 million would be added annually to the gross business of the Reservoir vicinity. According to the Department of Conservation, 4.69 million visitors estimated by the Corps of Engineers may easily be doubled by 1980, with a corresponding increase in regional business.

The Shelbyville project is a major undertaking involving much money, effort, and cooperation among public agencies at all levels. As one of a group of reservoirs, it is a regional resource, but is the kind of facility that could be developed in other areas of the State. Potential reservoirs and their current status are shown in Chapter V and Chapter II. Most if not all of these have potential for recreational development.

CASE STUDY 5. STEPHEN A. FORBES STATE PARK

A Conservation-Recreation Lake

One of the pressing problems is that of providing recreational facilities within a short driving distance, or even reasonable hiking range, of large numbers of people. Except those for tent camping, such facilities are basically for day use. Where there are no natural lakes, a satisfactory solution is to build artificial lakes, surrounded by public lands, large enough to serve the visitors anticipated. Figure 36 indicates the facilities necessary in a water-oriented vacation park.

The Project

Illinois is notably lacking in natural lakes. However, it has a high potential for development of artificial lakes, especially in the western and southern half of the State. Twenty-one State conservation lakes, with a water area of 3750 acres and adjacent public lands of approximately 20,900 acres, have been built since 1947.

Seven new lakes now under construction will add approximately 1225 acres of water surface. The original plan, to have a lake in each county, has been generally followed in the past.

Stephen A. Forbes is typical of the multi-purpose lake parks now being developed for recreation by the State Department of Conservation (Figure 37). Stephen A. Forbes Park, southeast of Vandalia and

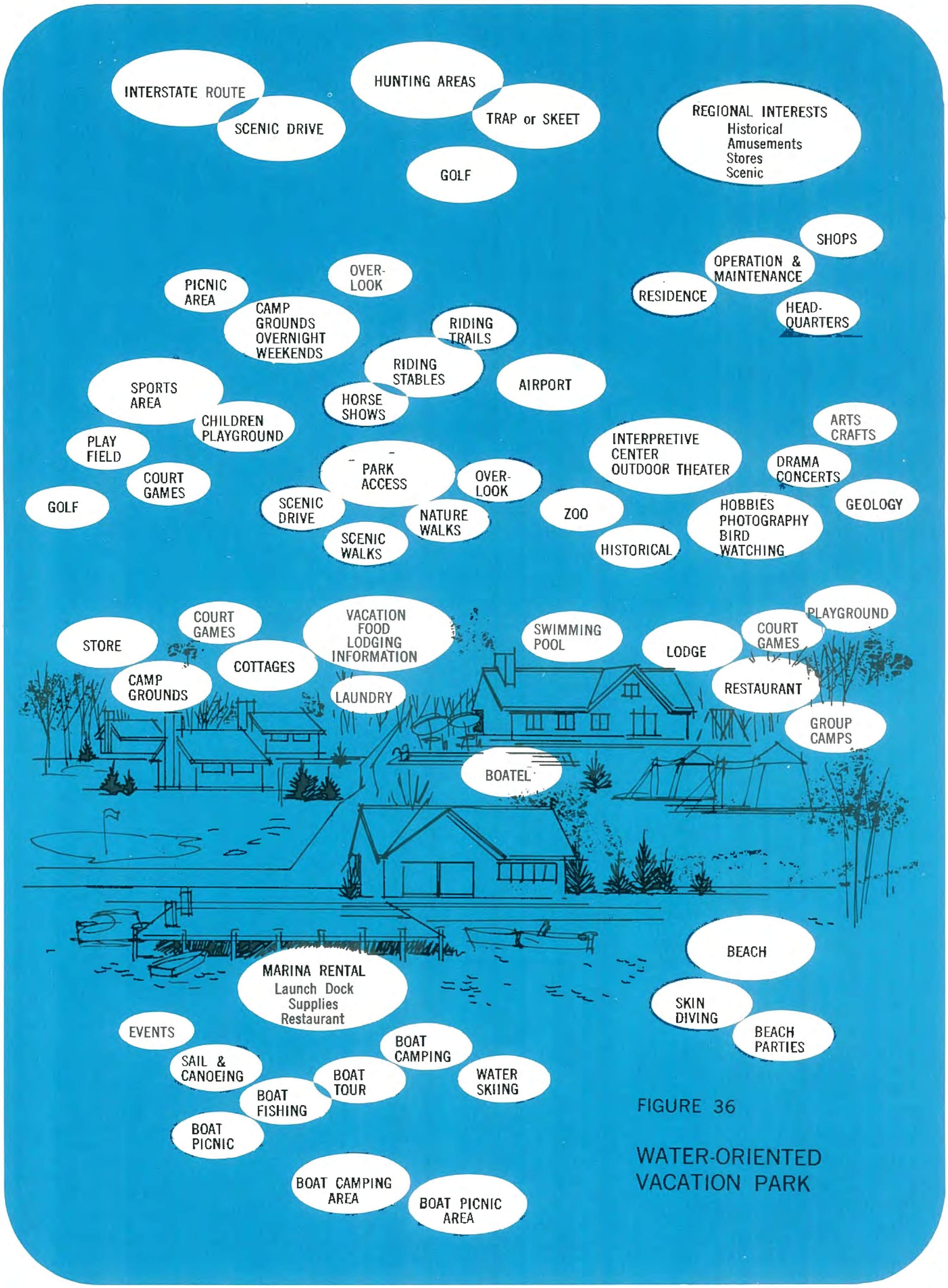


FIGURE 36

WATER-ORIENTED VACATION PARK

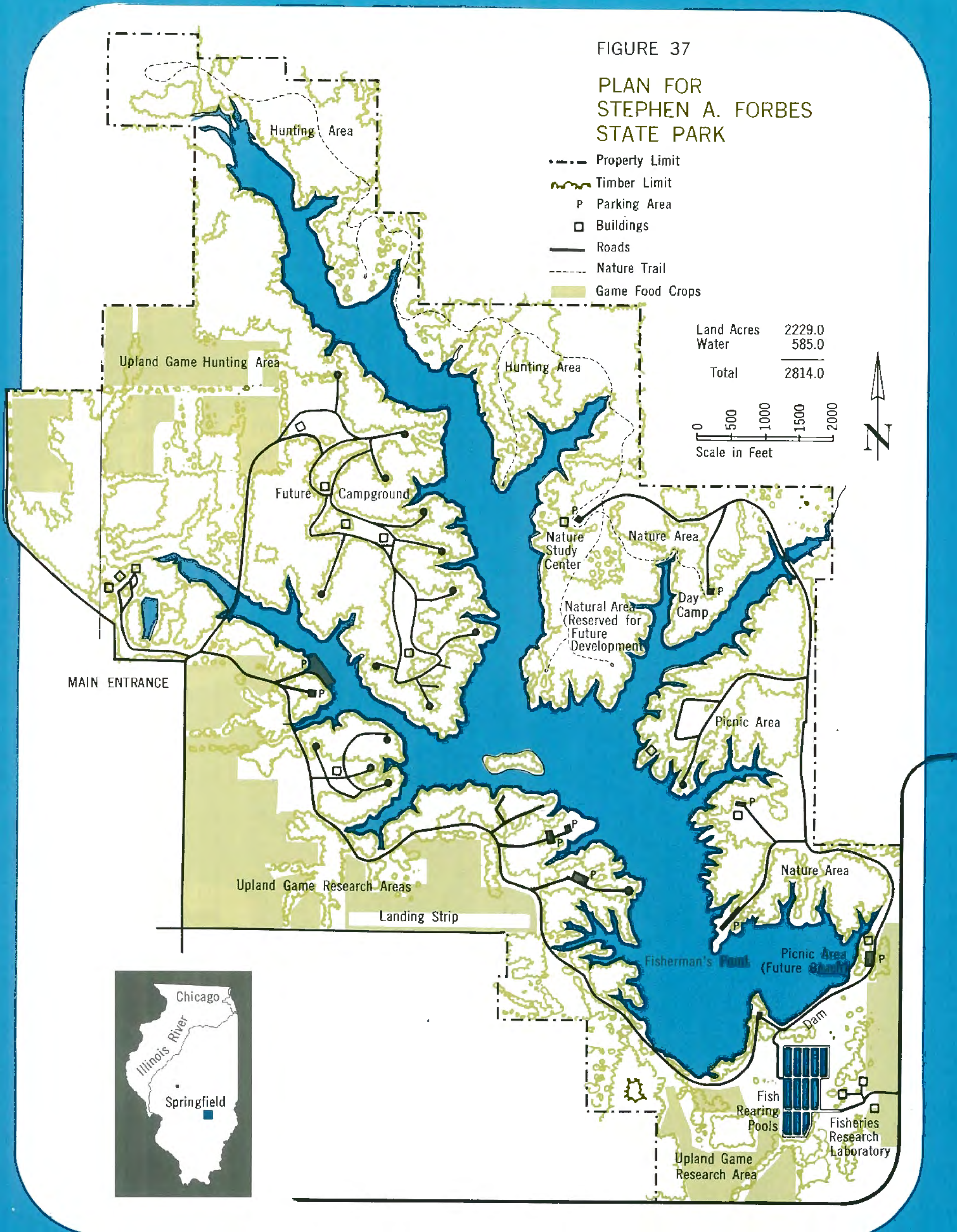


FIGURE 37

PLAN FOR STEPHEN A. FORBES STATE PARK

85 miles east of St. Louis, is readily accessible by two major highways. Interstate 57 from Chicago to St. Louis passes 10 miles to the west, and east-west tourist route U. S. 50 is 6 miles to the south.

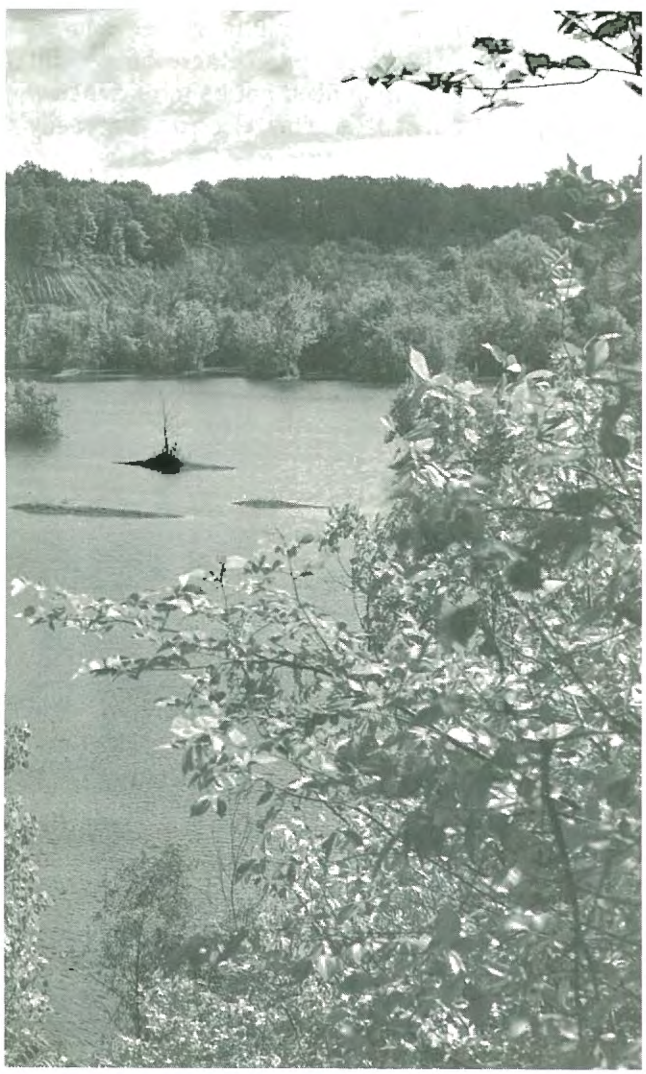
The meandering shoreline and many fingered bays give the 585-acre Forbes Lake a natural appearance. The gradually-sloping shoreline is accessible and safe for all types of water-related use. The water is unpolluted and relatively clear. The surrounding lands are relatively level and well shaded with native hardwoods. Planned and under construction in the 2229 acres of public land surrounding the Lake are a large camping complex; picnic areas; a nature area with a nature center building; a boat marina with dock, launching ramp, and food concession; and a swimming beach. Below the dam, a fishery research laboratory and a series of fish rearing ponds will provide an on-the-site demonstration of modern fish biology practices.

An upland game preserve for controlled hunting in the marginal areas is an innovation that promises to extend the recreational use of the Park into the late fall season. An air strip has been constructed along the west boundary.

Water zoning restricts the use of power boats in the upper half and in the bays of the Lake and has helped to maintain a balance of good fishing and still left space for boating.

By popular demand, the area was opened in late 1964, before all facilities were completed. With roads, the marina, and a few picnic and camp sites finished, the Park and Lake attracted 131,795 visitors in 1965. A record catch of 73 bass in four hours by two men indicates the excellent fishing potential at Forbes Lake.

This project has direct application to any county or region in need of public recreational facilities. By cooperative effort between local officials and agencies and the Department of Conservation, sites can be selected, lands acquired, and the facility constructed with a minimum of cost and effort.



CASE STUDY 6.

KICKAPOO STATE PARK

Reclamation of a Strip Mine Area

This project is concerned with two problems—providing recreational areas and facilities and reclaiming strip mining refuse areas.

Large sections of Illinois have an underlying strata of valuable soft coal deposits. Most of these deposits are relatively close to the surface and can be extracted by open pit or strip mining.

Early mining operations, with no reclamation controls, left large areas of very limited value. Characteristically, these mined-out areas have been left as a series of parallel, high, sharp ridges alternating with deep valleys. The valleys often become filled with water and are known as strip mine lakes.

More than 108,000 acres were mined before the Open Cut Land Reclamation Act of 1962 made it mandatory for the mining operator to reclaim the disturbed land. Gradually, 76 percent of the total area affected by strip mining has been reclaimed for crops, pasture, forest, wildlife habitat, and industrial and recreational uses. Most of the 17,871 acres affected since the Act was passed is in the process of being reclaimed.

In recent years, a number of strip mine lake areas near urban centers have been successfully adapted for water-related recreation. For example, near Canton in Fulton County a private resort and subdivision is being developed in an old strip mine lake region.

New types of equipment and new mining techniques can leave behind a more favorable topography for a lake-centered park. This planned landscape can be developed as a part of a mining operation to leave broader, flattened ridges, and broader connected valley "lakes."

Kickapoo State Park has been selected as a case study to illustrate the potential recreational resource which can be developed in a strip mine lake area (Figure 38). The Department of Conservation has used Kickapoo Park as a research project to develop inexpensive methods of reclamation and adaptation for park uses.

Salt wells first attracted the Indians to this area. Rich coal deposits near the land surface were discovered and removed in an early strip mining operation leaving a typical "badlands" situation. Nature, assisted by the State, gradually reclothed the hills with trees, herbaceous materials, and native grasses.

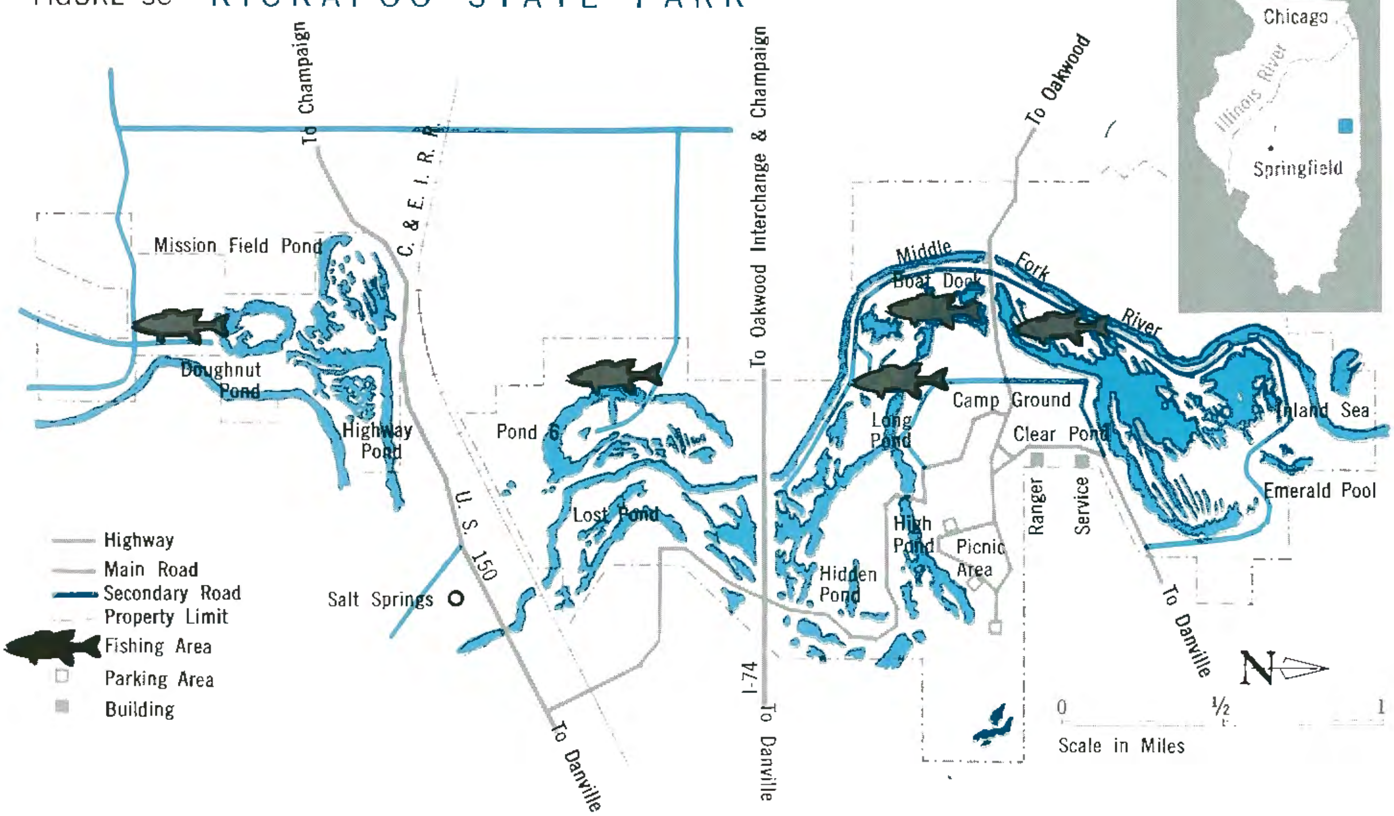
Waters created as a result of strip mining have proven to be extremely productive of fish populations and are intensively used by local fishermen.

A State fish management-stocking program gradually improved the fishing opportunities.

Launching ramps have been installed to make all of the major finger lakes accessible by boat, and areas have been cleared along the shore for bank fishing. Scenic drives, overlooks, campgrounds, picnic areas, and hiking and riding trails along the shores have been provided.

The method of developing strip mining lands used at Kickapoo State Park can be applied to any region or community located where this type of mining is practiced. Because of the time and cost involved, such reclamation is of optimum value only in areas where other lands of suitable acreage are not available, where regrading need not be too extensive, and where permanent lake sites exist or can easily be created.

FIGURE 38 KICKAPOO STATE PARK



Preservation of the Illinois Landscape

Illinois is rich in open space resources in:

— The dunes lands of Lake Michigan;

— The natural lakes and bogs of the Chain-O-Lakes region;

— The rolling, unglaciated hill country of Jo Daviess County;

— The beautiful river valleys of the Mississippi, Illinois, and Wabash systems; the rivers, the river lakes, wetlands, flood lands, and paralleling wooded slopes and limestone cliffs;

— The upland prairie and woodlands;

— The contrasting plant life in the 400-mile length of the State; and

— The wildlife inhabiting the open spaces—animals, songbirds, waterfowl, and insects.

Illinois is losing many of its best open-space resources to the advancing tide of urban and industrial growth, while the demand for open space for active and passive recreation is growing.

The Project

Increasing attention is being given, under the leadership of the Illinois Nature Preserves Commission, to acquiring outstanding examples of the Illinois landscape and establishing them as nature preserves. The map in Figure 39 shows the location of nature areas established or under consideration. The Illinois Beach Nature Preserve has been selected as a typical example of this type of open-space preservation.

The Preserve is a part of Illinois Beach State Park. It covers 768 acres and includes 2 miles of Lake Michigan shoreline. Low sand dunes near the beach support an unusual variety of plants, including bearberry, Waukegan juniper, prickly pear cactus, and other sand and prairie species. Farther inland, there are extensive areas of prairie and marsh interspersed with sand ridges covered with scrub oak. A nature center has been established near the park lodge; a park naturalist conducts nature walks through the Preserve.

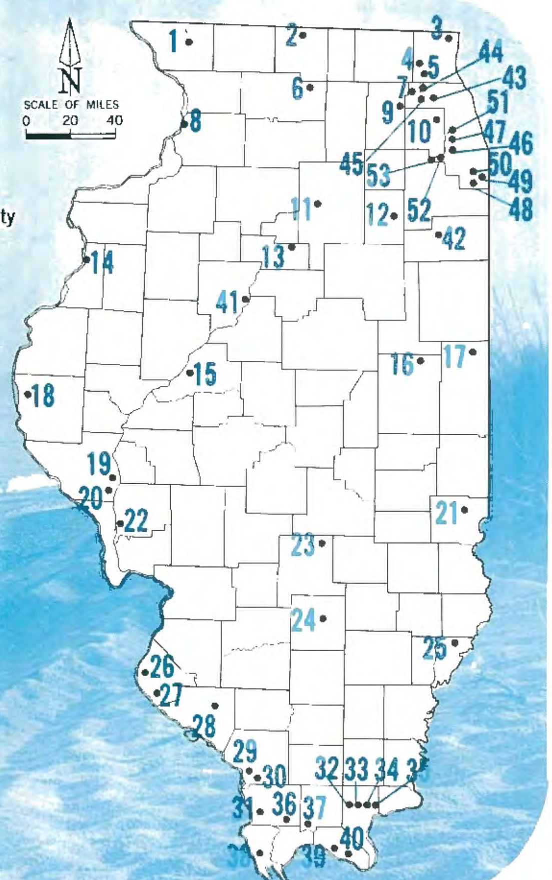
In other areas where the landscape has unique qualities or vegetation, such a project could preserve them for public use.

FIGURE 39

NATURAL AREAS

* 1. Apple River Canyon Park
2. Pasque Flower Prairie Hills
-* 3. Illinois Beach State Park
* 4. Volo Bog
* 5. Wauconda Bog
6. Pine & Castle Rock
* 7. Elgin Botannical Gardens
8. Fulton Sand Prairie
9. Prout Park
*10. Goose Island Marsh
*11. Clark Run
*12. Goose Lake
*13. Illinois River Bog
14. Oquawka Sand Banks
*15. Illinois River Sand Prairie
16. Nettie Hart Memorial Woodland
17. Vermilion County Hill
18. Vurton Cave
19. Twin Culvert Cave
20. Pearl Cave
*21. Rocky Branch
*22. Cole Creek Hill Prairie
23. Illinois Central Railroad Prairie
*24. Devil's Prop
- 25. Beall Woods
*26. Burksville Sinkholes
27. Fult's Hill Prairie
28. Piney Branch
29. Fountain Bluff
*30. Grand Canyon of Jackson County
*31. Pine Hills & Wolf Lake
*32. Jackson Hollow
*33. Bell Smith Springs
*34. Hayes Creek
*35. Lusk Creek Canyon
*36. Union County Refuge
*37. Cache River Cypress Swamps
*38. Horseshoe Lake Refuge
*39. Thornton's Ravine
*40. Fort Massac State Park
- 41. Forest Park
-*42. Kankakee River
-*43. Busse Forest
-*44. Spring Lake
- 45. Shoe Factory Road
-*46. Cranberry Slough
- 47. Paw Paw Wood
- 48. Thornton Lansing
- 49. Jurgenson Woods
-*50. Sand Ridge
-*51. Salt Creek Woods
-*52. Black Partridge Woods
-*53. Cap Sauers Holding

- Dedicated Nature Preserves
*Water-Related



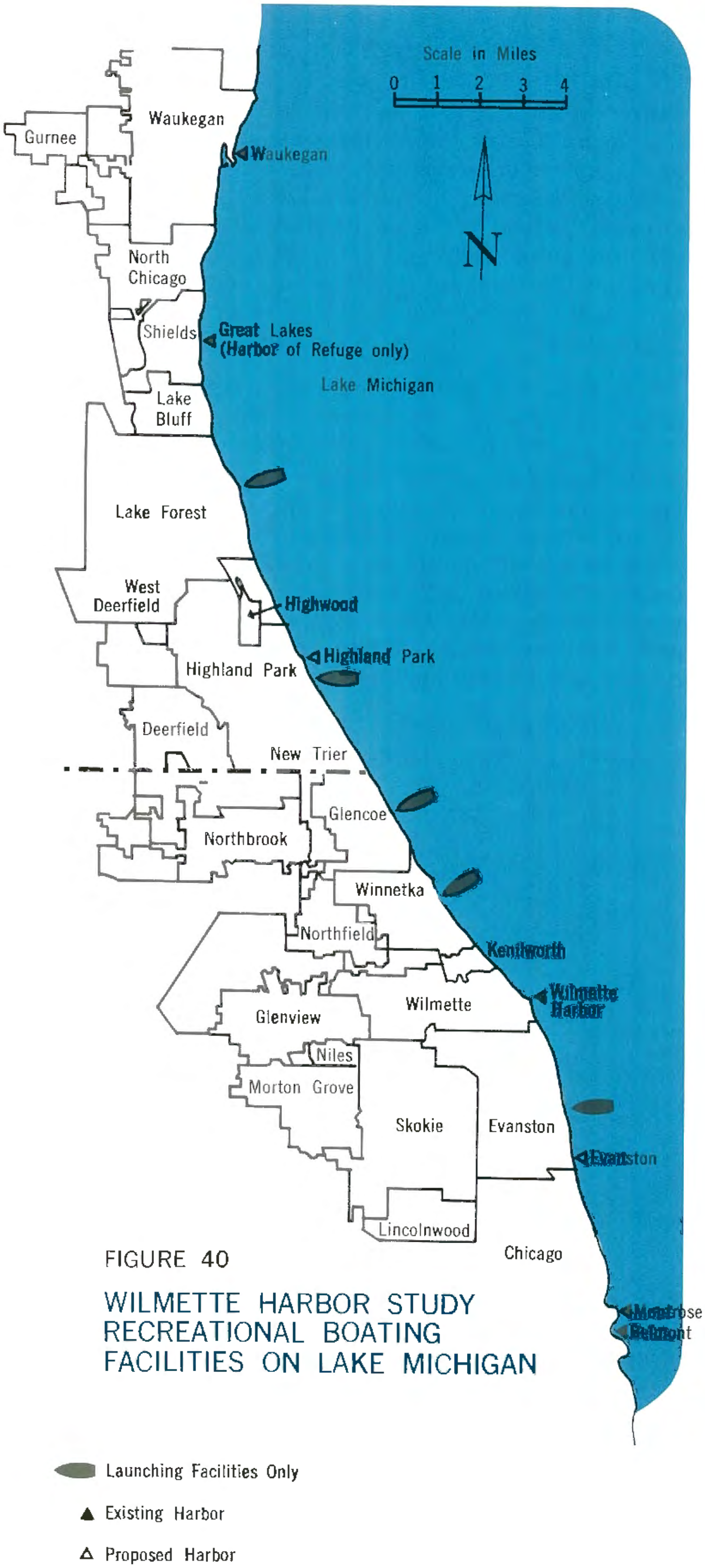


FIGURE 40

WILMETTE HARBOR STUDY
RECREATIONAL BOATING
FACILITIES ON LAKE MICHIGAN

CASE STUDY 8. WILMETTE HARBOR

Expansion of a City Harbor for Pleasure Boating

Metropolitan Chicago has a 63-mile frontage on Lake Michigan, but natural or artificial harbor space is extremely limited. The shortage in harbor facilities has severely limited the use of this valuable resource for pleasure boating.

A longer boat than can be transported by trailer is necessary for safe operation on Lake Michigan. A new boat owner must have a State registration to get a harbor slip or mooring space, and then may wait a year to be assigned harbor space.

The long distance between "harbors of refuge" also discourages pleasure boating on Lake Michigan. Harbors of refuge should be a maximum of 20 miles apart so that a small, 18-foot boat would be no more than 10 miles or one hour's travel from a safe harbor in case of a storm. Now there are no adequate harbors of refuge between Chicago and Milwaukee.

The Project

A number of planned harbor developments have been proposed. The Chicago Plan Commission Basic Policy Report recommended "the addition of a minimum of 2 square miles of lake front land to be constructed primarily by land fill in the form of peninsulas, thereby creating new recreational areas with boating and beach facilities." The Wilmette Harbor Plan has been selected as a typical example of the proposed harbor improvements being planned for the Lake Michigan waterfront (Figure 40).

The existing Wilmette Harbor was leased in 1962 from the Metropolitan Sanitary District of Greater Chicago by the Wilmette Harbor Association. It was originally designed as a settling basin for the Sanitary District water supply. The Harbor Association, as part of the lease agreement, has improved the harbor by periodic dredging and has installed sunken barges to protect the channel entrance.

The Harbor accommodates about 276 boats, with 133 slips, 109 swinging moorings, 11 moorings with bow and stern buoy ties, and 23 dry moorings. Land facilities include fuel pumps, water and electrical outlets, and parking for 50 cars.

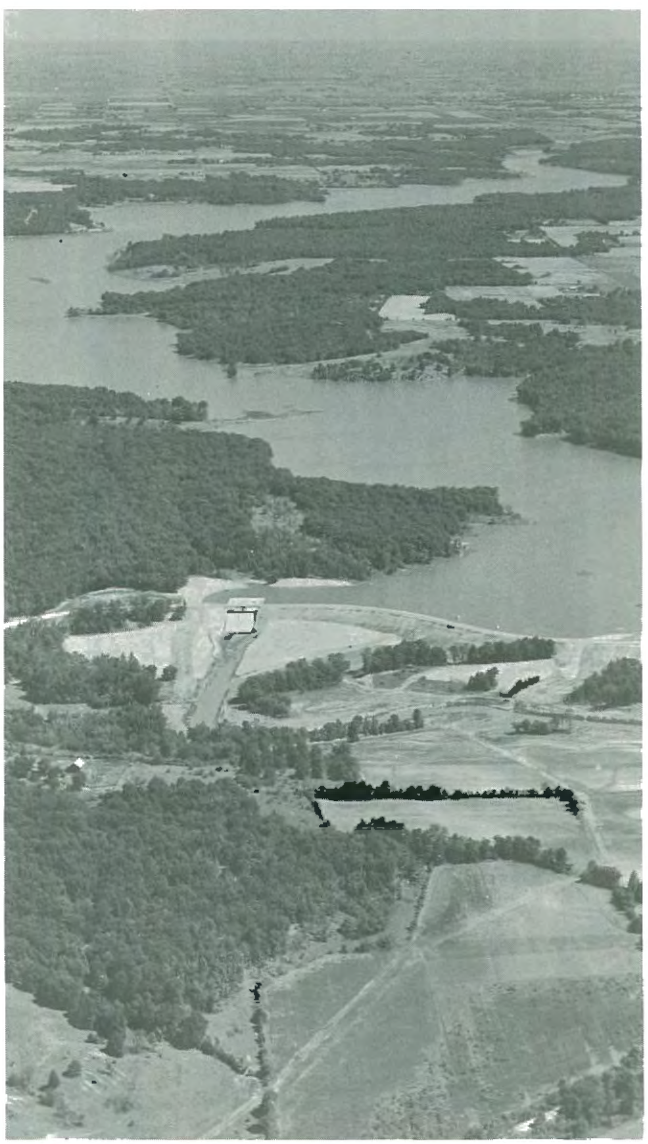
A survey showed that the types and sizes of craft which would use the harbor if it were enlarged are:

Type	Number	Average Length (Feet)
Outboard	86	18
Inboard	153	27
Sail	281	20
Total	520	24 (average)

Several active classes of sailboats operate out of Wilmette Harbor; nearly 100 races were scheduled for one class in 1965. Sailboats are expected to use 54 percent of the moorings.

Moorings needed will be proportioned with 50 percent slips, 42 percent swinging, and 8 percent dry moorings. Public restrooms and adequate parking are needed. No launching ramps are recommended in the plan.

Pollution from pleasure boating is expected to be light because of strict enforcement of regulations prohibiting disposal of sewage and debris in the water, the large number of sailboats which do not burn fuel, and the fresh water from Lake Michigan which is flushed inward by the Sanitary District's pumping operation.



An enlarged harbor will allow extra space for use as a harbor of refuge and help to complete the chain from Belmont to Waukegan.

Harbor	Distance from Belmont
Belmont	—
Montrose	1
Evanston (proposed)	5
Wilmette (limited to small boats)	9
Highland Park (proposed)	17
Great Lakes	26
Waukegan	30

This project will be of interest to other cities located on large bodies of water, particularly in a metropolitan area, where boating requirements of a special nature are to be considered. Since it involves the expansion of an existing harbor, such a program could be developed in cities whose harbor facilities have deteriorated or no longer serve the use for which they originally were intended.

CASE STUDY 9. LOU YAEGER LAKE

A P. L. 566 Multi-Purpose Lake

Lou Yaeger Lake provides recreational facilities for Litchfield and also satisfies other water requirements at a minimum local cost.

The Federal Watershed Protection and Flood Prevention Program, established under Public Law 566, has stimulated interest among local governments in developing multi-purpose lakes for flood control, water supply, and recreation.

The State Department of Conservation has worked closely with the Soil Conservation Service in developing the potential of selected areas for recreation and wildlife habitat. Chapter V describes Small Watershed projects in Illinois in more detail. About half of these projects have potential for recreational development.

The Project

Lou Yaeger Lake has been selected as an example of a multi-purpose P. L. 566 reservoir project. Litchfield needed water for domestic and industrial water supply. With the help of Federal matching funds, the City purchased the necessary land, built the 1400 acre lake, and will develop public recreational areas along its shore (Figure 41). The State, through a direct appropriation, in cooperation with the U. S. Soil Conservation Service, will help Litchfield with development costs.

The Department of Conservation has worked with Litchfield and the Soil Conservation Service in an advisory capacity in planning the areas for recreational use and will assume the responsibility of the fishery management of the Lake.

A large water-oriented park is scheduled to have launching ramps with 75 car-trailer units, a beach for 1000 visitors, a 110-unit campground, 2 group camp areas, 4 picnic areas with a total capacity of 400 units, and a lodge-motel-concession site. In another location, City park facilities are planned and will include a ball field, children's play equipment, a golf course, nature study areas, and group day camps.

Other areas with a watershed large enough to maintain the level of a body of water of useful size can apply for matching funds to develop a lake such as Lou Yaeger.

Development of a largely untapped resource—existing water supply reservoirs—can also supply water-related recreation. There are presently 114 municipal reservoirs in Illinois with a total of more than 19,000 acres of water surface. A number of these, in areas devoid of natural lakes, are multi-purpose for recreation and water supply. The largest of these man-made lakes are Lake Springfield, 4234 acres; Lake Decatur 2605 acres; and Lake Taylorville, 1286 acres. Six other lakes have areas from 500 to 1000 acres (Table 3).

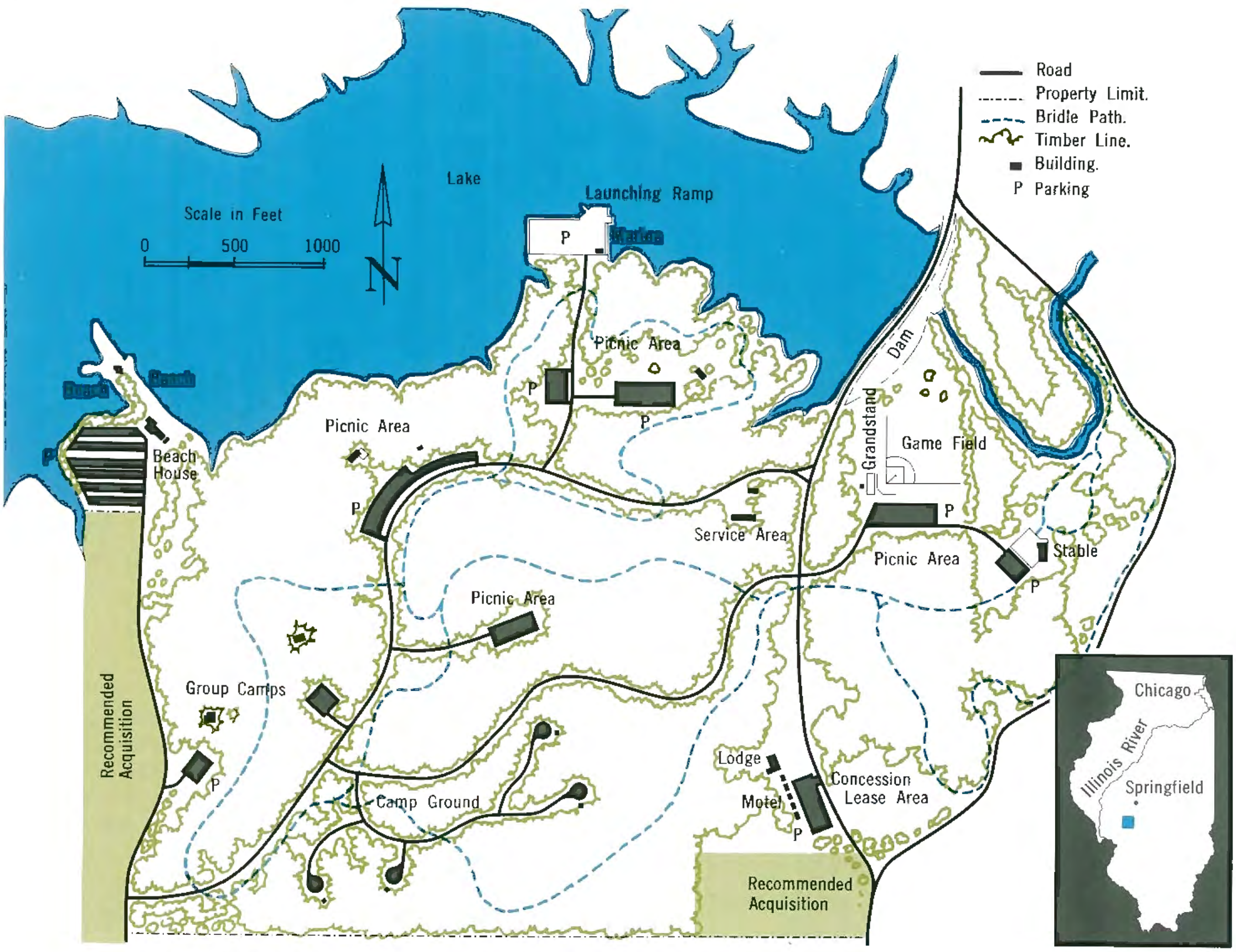
TABLE 3

WATER SUPPLY RESERVOIRS

Size	Number
Over 1000 acres	3
500 — 1000	6
100 — 500	20
50 — 100	15
10 — 50	44
.8 — 10	25

FIGURE 41

PLAN FOR LAKE LOU YAEGER PARK



From Borrow Pit to Roadside Lake

Borrow pits, dug for earth fill for highway construction, are usually left as useless, square holes which fill up with water and breed mosquitoes. Properly planned, a borrow pit can be dug to become an attractive lake. In appropriate locations, a borrow pit lake can become a valuable resource for water-related recreation, instead of a scar on the landscape. Two problems can be solved in a single operation, and in many cases, at no additional cost.

The Project

The Cook County Forest Preserve District has demonstrated that a borrow pit can be made into an attractive and useful recreational lake. Contractors in need of borrow for the In-Chicago Tollway agreed to follow the carefully prepared plans made by the Forest Preserve, in making their excavations. Locations where a natural water source would assure a year-round stable pool of water were selected. Construction specifications provided for shorelines with long sweeping curves favorable for operation of large road building equipment. The crushed stone haul roads were located on the alignment of future park roads and parking areas. In this manner, a prebuilt base for permanent roads was provided at no extra cost. Existing trees beyond the graded areas were protected from machine damage. Topsoil was removed from all grade areas, stored, and replaced over all disturbed areas.

Seven lakes, ranging in size from 5 to 35 acres for a total of 133 acres of water surface, were built in this manner. The value of these lakes, based on normal lake construction costs in Cook County, is estimated at $2.5 million. In addition to gaining such valuable recreational resources at no cost, more than $350,000 was received by the District for the earth borrow removed. The larger lakes will offer a wide variety of water-related recreation, including row-boating, canoeing, sailing, and fishing.

Axehead Lake is in the linear DesPlaines River Forest Preserve, at the intersection of the Tri-State Tollroad and Touhy Avenue northeast of O'Hare Airport. Nestled in a grove of large trees, it provides passing motorists with a natural scene of rare beauty.

The attractive kidney shaped lake has 17 acres of clear, sparkling water with an interestingly curved shoreline of about 3400 feet and a convenient parking spur. Bank fishing is the main attraction with a scientific stocking-management program to insure a continued supply of game and pan fish. At Axehead Lake a family can enjoy the out-of-doors, walk the lakeside trails, picnic under nearby trees, and listen to songbirds. The Lake offers what may be a unique experience for many urban dwellers—the opportunity to see for the first time natural aquatic plants and fish developing in unpolluted water. Axehead Lake is a striking example of true conservation.

Because of the extensive development of the Interstate Highway System and other roads in Illinois, projects such as Axehead Lake have a broad application.

CASE STUDY 11. HORSESHOE LAKE CONSERVATION AREA

A Multiple-Use Natural Area

The problem in this project was to develop an area peculiarly suited for wildlife conservation in such a way as to expand its use for various recreational activities without impairing its basic value as a waterfowl refuge. To do this, a delicate balance must be maintained between wilderness and civilization.

The Project

The Mississippi Flyway is a major migration route for waterfowl. The U. S. Fish and Wildlife Service has established a chain of refuges extending along hundreds of miles of the Mississippi River and its tributaries. Three refuge units—Crab Orchard, Chautauqua, and Mark Twain—have a total of 42,340 acres. The Illinois Department of Conservation has leased from the Federal Government 28,141 acres of associated land and water for recreational use. The Department also manages 32,137 acres of Federal land and water along the Mississippi and lower Illinois Rivers. In addition, several small State and county conservation areas serve as refuges.

The primary management objective is to develop, maintain, and manage the land and water to conserve the fish and wildlife resources. The waterfowl refuge has many of the attributes of a nature preserve. Besides being a resting and feeding area for migratory waterfowl during the spring and fall seasons, it is a natural habitat for many regional species of birds, animals, fish, and plant life throughout the year.

New refuge areas are in the long-range plan for the Illinois River and the seven Federal flood control reservoirs. These refuge areas will form important points of interest for the travelers along the Great River Road and Illinois River Parkway.

The Horseshoe Lake Conservation Area was selected as a case study to illustrate the opportunities for year-round recreation that can be developed in such an area without impairing its prime purpose as a waterfowl refuge (Figure 42).

The Horseshoe Lake Area, on the Great River Road on Illinois Route 3, is 10 miles north of Cairo in Alexander County. The 2400-acre lake was formed from an old meander of the Mississippi River; the River is now several miles to the west. The entire conservation area covers 7901 acres. The Lake has become a principal resting and wintering area for the Canadian Goose, which arrives in October and stays until March. The Department of Conservation has built a dam to maintain the water level in the Lake and cultivates grain food for the geese on several farm tracts on the site. The region has become a goose hunting center and brings nearly $1 million to Alexander County each year.

The lake scene is enhanced by a wide variety of native plants. The distinctive bald cypress and tupelo grow in the shallow water. Other aquatic plants give an unusual pattern of flowers and foliage. Oaks, maple, basswood, and pecan trees border Horseshoe Lake. Along the shore and in the

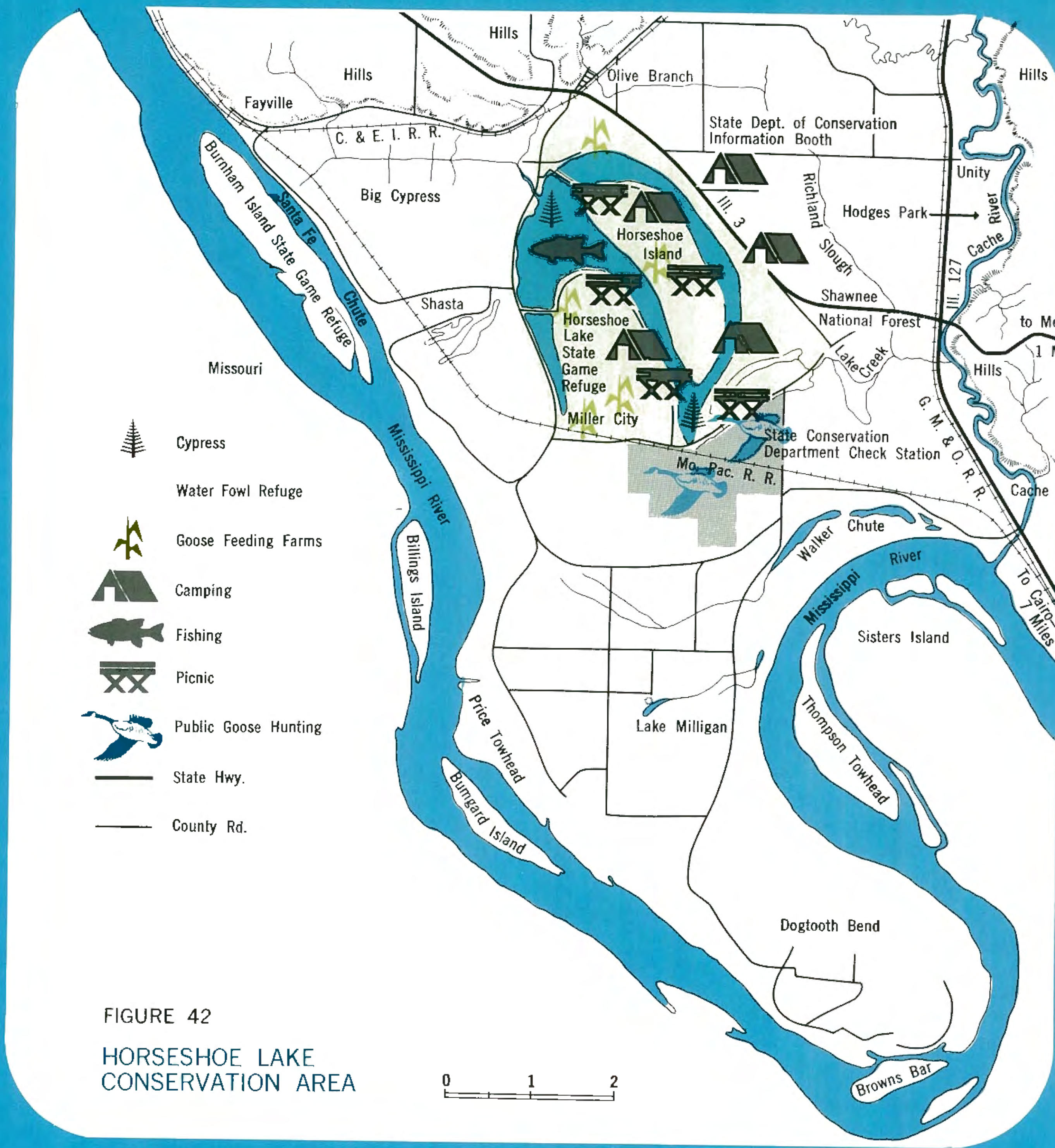


FIGURE 42

HORSESHOE LAKE CONSERVATION AREA

adjacent woods are a wide variety of songbirds and animals—muskrat, raccoon, squirrel, opossum, and deer. The Lake has an abundant supply of popular sport fishes and attracts anglers from a considerable distance.

Non-hunters are attracted to the area in increasing numbers each year. Bird watchers and naturalists far outnumber the hunters. Facilities for picnickers, campers, fishermen, and sightseers will need to be added.

It should be possible to apply the principles and practices followed at the Horseshoe Lake Conservation Area in expanding the recreational use of other conservation areas to equally good effect. However, this should be done with great care and after detailed study of the Horseshoe area.

CASE STUDY 12. COFFEEN LAKE RECREATION AREA

Public Recreational Use of A Power Company Lake

The Coffeen Lake is a private industrial lake adapted for public recreation in such a way that its original usefulness is not impaired.

Power companies have moved their plants to the coal fields in a constant search for methods to convert coal to electricity more efficiently and economically. This conversion process requires large quantities of relatively clean water for cooling purposes. To be assured of an adequate, quality-controlled, year-round water supply, the companies purchase the sites and build their own lakes.

Three such projects with a combined water surface of approximately 5600 acres are nearing completion. Negotiations are in progress to lease land and water rights on these lakes to State and Federal agencies for public water-related recreation and to sell certain shore land and water rights to a Federal agency. These projects include:

— The 2300-acre Kincaid Lake in Christian County, to the Illinois Department of Conservation;

— The 1200-acre Coffeen Lake in Montgomery County, to Illinois Department of Conservation; and

— The 2400-acre Lake of Egypt in Williamson and Johnson Counties, to the Shawnee National Forest.

The Project

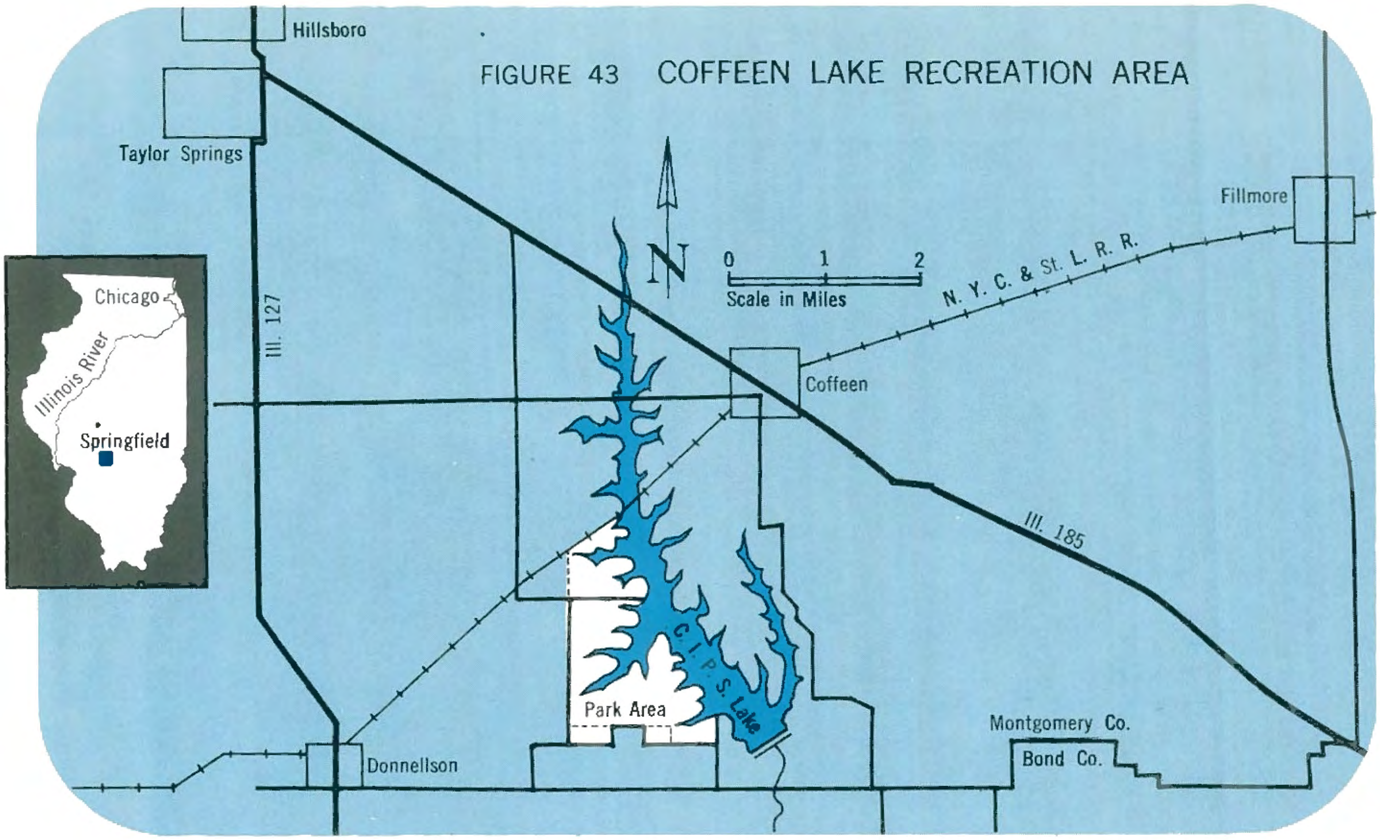
Coffeen Lake is a typical example of this new source of water-related recreation provided by private enterprise (Figure 43). Located northwest of Vandalia, the lake-park will be convenient to a large population and readily accessible by State highway. Within one hour's driving range, a 50-mile radius, there are 600,000 people. Within a two-hour range, 100 miles, there are 3,700,000 people in Metropolitan St. Louis.

The Department of Conservation, authorized by recent legislation to lease from private ownership, has negotiated a cooperative program with the Central Illinois Public Service Company for the Coffeen Lake recreation project. The water-related park will increase the State's recreational land potential by 1000 acres, and the water surface by 1200 acres.

Fishery biologists anticipate that fishing will be good. A fish management program was initiated in June 1964, when the Lake was stocked with 200,000 largemouth bass fingerlings. Samplings four months later showed these 1-inch fingerlings had grown to 7 inches. Bluegills, sunfish, bullheads, carp, and suckers were also found in the Lake.

Simple access areas—roads, parking, toilets, and lakeside trails—will be provided. A boat concession with docks, utility building, and food concession is planned. Other facilities will include well-equipped day and overnight campgrounds, picnic areas, a concession building, service buildings, an interpretive building, and nature trails.

Obviously, the application of this program is limited to industrial installations which require large quantities of water. However, such situations occur with enough frequency to make them worthy of notice in this study. Such recreational use can best be provided by planning for it from the beginning of the project.



CASE STUDY 13. VALLEY VIEW ACRES

A Private Recreational Development

The major potential recreational resources are in private ownership, including 85 percent of the streams and 94 percent of the land. There is a challenging and profitable opportunity for private enterprise to help the State and other public agencies meet the demand for regional recreation. The greatest and most immediate need is within the 80-mile driving range of major cities and along the interstate tourist routes.

The heaviest demands are for camping and similar facilities. An essential element in any private development is a body of water large enough for swimming, boating, and fishing.

The Project

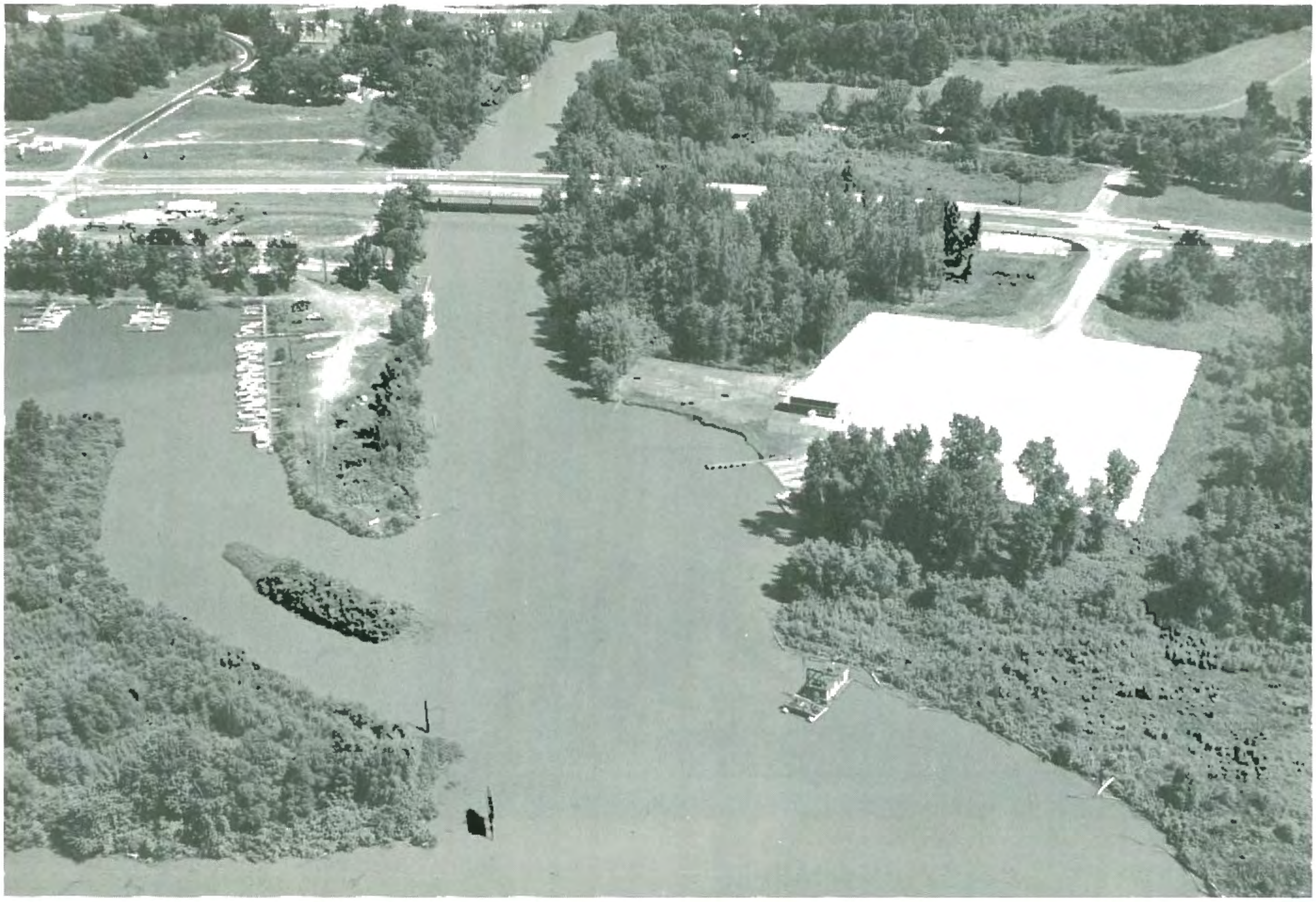
The Department of Agriculture, through the Soil Conservation Service, encourages the private farm owner to convert his marginal lands from agricultural production to recreation for profit. Farm owners may now receive professional advice and loans for development and initial operation of such a project. The Extension Service of the University of Illinois also furnishes an advisory service. The State Department of Conservation, Division of Fisheries, will assist in a fish management program. The State Department of Public Health will give advice on health and sanitation requirements.

There is a growing number of private recreational centers throughout the State. A few are larger enterprises developed by corporations, but most are smaller family operations.

Valley View Acres campground has been selected as a typical example of a private development for water-related recreation. The campground is in a grove of large oaks along the shores of the Vermilion River 12 miles north of Pontiac on Route 23. It is a family enterprise that started with a few sites and has now grown to a complete modern campground with paved roads, a pressurized water distribution system, electricity, toilets and showers, a lodge-store-restaurant, a large shelter, riding stables, and playground equipment.

The feature attraction is a 5-acre swimming lake with sand beach, bathhouse, and lifeguards. Several spring-fed fishing lakes, made from abandoned gravel quarry pits, have been well-stocked with unusual fish such as rainbow trout.

Such a project could be developed in any location where there is a proven recreational need and convenient access highways, if the owner develops and operates it to meet the standards of a public facility.



CASE STUDY 14. PIASA CREEK ACCESS AREA

Boat Access to Lakes and Rivers

More than 120,000 of the pleasure boats registered in Illinois in 1965 were 16 feet or less in length. These small craft are generally kept at the owners' homes and transported to the water by boat trailers. Thus, the owners depend upon launching ramps. Approximately 175 public ramps are now in use along the major streams and lakes in the State; they vary from the simple gravel slope to the carefully engineered multi-lane concrete ramp.

The Corps of Engineers and the Department of Conservation have built most of the public launching sites in the State. Limited funds have prevented construction of enough sites to keep pace with the growing demand.

The Department of Conservation has been able to install an average of eight sites per year to meet about 50 percent of the demand. Costs of installation, influenced by site conditions and area construction rates, vary greatly. With local governments assuming part of the costs and the responsibility for maintenance, the development program has been greatly accelerated.

The average owner has considerable investment in his car, boat, and trailer; he needs a safe, convenient ramp and level parking for his car and trailer. Other desirable facilities often supplied are toilets, water supply, picnic tables, and possibly a few convenient camp sites.

The Project

The Piasa Creek Access Area is typical of the public launching facilities being installed for boaters on Illinois rivers and lakes. It is located on Pool 26 of the Mississippi River, 6 miles west of Alton. Access is convenient on the Great River Road that borders the site on the north. Pool 26 is the most heavily used river pool in the State. Capacity use is expected most of the year.

Improvements include a four-lane, paved launching ramp built into the shore at the mouth of Piasa Creek, a parking area for 100 car-trailers and 112 cars, toilets, drinking water supply, concession for food and berevage, and picnic facilities.

Launching ramps can be installed at almost any tributary stream or pool leading to a lake or river, if there is ample room for parking and reasonably direct access to a public highway.

FUNDING

The primary problem in meeting the need for recreational areas and facilities is one of financing. Illinois lags behind all the other states in open-space acreage. The normal appropriations available from State funds have been inadequate to develop the necessary new facilities to meet the rapidly increasing demands for recreation.

Additional sources of funding will be needed to translate the 1971 to 1980 phase of the State Recreation Plan into an action program. Recommendations for such an action program are made in the next section of this chapter.

Various sources of such funds, Federal, State, and local, are available to supplement legislative appropriations. The following is a list of fiscal resources for funding:

FEDERAL SOURCES

The Department of the Interior, Bureau of Outdoor Recreation, administers the Land and Water Conservation Fund Act, which provides funds and advisory services to state and local public agencies for recreational projects.

The Department of Housing and Urban Development, Urban Renewal Administration, makes grants to state and local public agencies for acquisition and development of open-space lands and waters in urban and urbanizing areas for park, conservation, recreation, scenic, or historic purposes.

The Department of Commerce, Bureau of Public Roads, cooperates with state highway departments in developing highway systems which serve recreational areas.

The General Services Administration handles the sale of Federal surplus lands which may be acquired by state and local governments, for 50 percent of their fair market value, for parks and recreational purposes and, without monetary consideration, for historic purposes. The Department of Health, Education, and Welfare; the Corps of Engineers; the Small Business Administration; the Farmers' Home Administration; and the Department of Public Works and Economic Development also make grants and loans.

STATE SOURCES

Legislative appropriations have, in the past, played a major role in funding projects and programs for outdoor recreation in Illinois. However, increasing competition for funds from expanding educational activities, social welfare programs, public safety projects, and general governmental services has imposed new limitations upon the appropriations made from the general revenue fund for water-related recreation.

In most other states, legislative appropriations continue to be the principal source of funds. User fees, admission fees, concession rights, revenue bond financing, and general obligation bonds authorized by public referenda have also become significant in some states as major methods of financing general outdoor recreation.

The financial programs of other states for water resources development, including water-related recreation, are discussed in Chapter IX. These programs are based on various combinations of methods of supplying revenue, including general obligation bond issues and revenue bond issues.

Supplementary means of financing recreational programs in states have also been available through Federal grants, loans, direct aid, and provisions for matching funds. The extent to which the legislative appropriations for recreation vary among different states reflects, to some extent, such factors as the area of the state, population, and income.

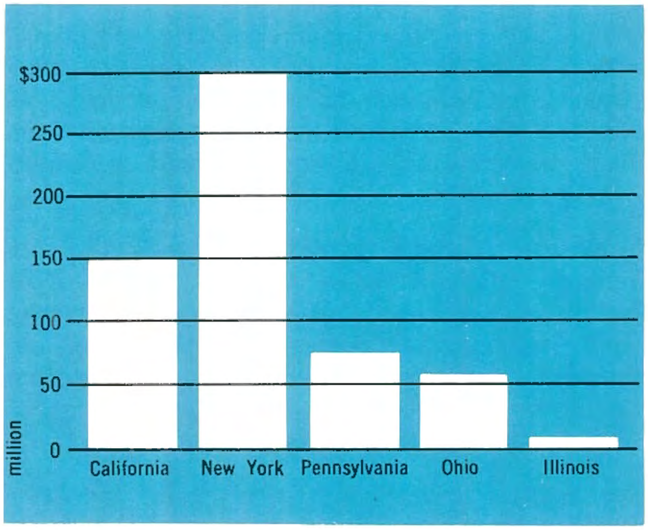
REVENUE BONDS

Raising funds through the sale of revenue bonds has been a significant means of financing state recreational programs. Revenue bond totals for recreation in California, Ohio, Pennsylvania, and New York, states, which are similar to Illinois in population and economic wealth, are compared in the Figure 44.

In Illinois, the State Park Revenue Bond Authority has authorized the sale of $9 million worth of bonds for revenue-producing improvements in state parks. These revenue bonds are to be retired from fees collected for the use of facilities provided through the bonds. Swimming beaches and pools, marinas, concessions, and lodging facilities are the kinds of projects to be financed from the proceeds of the State Park Revenue Bond Program. The Illinois Building Authority provides an additional source of funds for purchasing lands to be used for outdoor recreation. Other comparable states have greatly exceeded Illinois' effort in this direction.

FIGURE 44

RECREATION FUNDS FROM SALE OF REVENUE BONDS, 1966



STATE BOND ISSUES IN EFFECT, 1966

California	$150 million
New Jersey	60 million
New York	300 million
Pennsylvania	70 million
Pennsylvania	500 million (proposed)

The sale of revenue bonds has a number of advantages as part of a planned financial program. Revenue bond financing allows for immediate construction of needed facilities. An extended time period is necessary if appropriations are the sole source of revenue. User fees place the burden of servicing and amortizing the debt upon those who generate the demand for the facilities. After the debt has been fully amortized, the revenue derived from the use of these facilities may be applied to other recreational projects or to a general fund. There are alternative methods of providing income to service these bonds which have been quite successful in other states, i.e., cigarette and gasoline taxes.

CONCLUSIONS AND RECOMMENDATIONS

The great potential for development of water-related recreation in Illinois is clearly demonstrated in this chapter. The acute deficiency of recreational facilities in Illinois is adequately documented by one statistic—Illinois has fewer acres of public open-space in relation to its population than any other state in the nation. The deficiency is particularly acute in the Chicago Metropolitan Area. This chapter also documents the accelerating demand for water-related recreation.

The principal problems in developing adequate water-related recreational facilities are:

I. Land Acquisition

Most of the land (94.3 percent) and water (85 percent) area of the State is in private ownership and thus not open to the public.

A. It is strongly recommended that an accelerated program of public land acquisition to meet future open-space needs be initiated immediately. Illinois now as 565,178 acres of public recreation land. Open-space land acquisition should reach a minimum of:

150,000	additional acres of land by 1970
550,000	additional acres of land by 1980
1,300,000	additional acres of land by 2020
2,000,000	acres total land acquisition by 2020

B. About 75 percent of the open-space land acquired should be associated with existing or potential public water surface. The two resources, land and water, when combined, complement each other and greatly increase the value of both for recreational use. The increase in available public water surface, shore access, and associated major public parks and recreational areas on all Illinois streams and natural and artificial impoundments should have first priority in the land acquisition program. Forty percent of the State's streams and lakes should be availabe for public use by 1980. This would be accomplished by:

1. A fundamental change in the Illinois law regarding riparian rights recommended in other chapters and the principal findings section of this report.

2. Reservation and protection of valuable open-space land by zoning and land use regulations; dedication of open-space land to public use by easement; and acquisition of land to be leased until it can be developed for public recreation.

3. A major acquisition program to secure land and water in fee.

4. A major facility development program.

C. As a corollary, the conservation of large areas of the natural and scenic resources of the State to meet future open-space needs should have top priority in this land acquisition program. Roughly three-fourths of the acreage should be in the regional, natural, and scenic environmental category. The State and Federal Governments must be responsible for securing most of these regional open-space lands and waters. However, local governments can and should be encouraged to participate through representative special purpose districts—County Forest Preserve Districts, new Conservation Districts, Soil and Water Conservation Districts, and Park Districts.

II. Control and reduction of water pollution is vital to all types of water-related recreation, especially fishing, swimming, and wildlife preservation. The implementation of the recommendations for pollution control in the principal findings at the beginning of this report and in Chapter IV are vital to the development of water-related recreation in Illinois.

III. Because Illinois' recreational facilities are so acutely deficient, an immediate action program should be initiated to implement the recommendations made in **Outdoor Recreation in Illinois** and in this water resources plan. Recreational development should be planned, where practical, by resource areas designed in the two plans, but specifically to develop facilities for all the people of the State, and especially to serve the rapidly expanding needs of metropolitan areas. Additional facilities for swimming, boating, and fishing are particularly needed. Specific projects of high priority are:

A. **The Chicago Metropolitan Area:** Large major recreation centers are needed in the northern region near Chicago.

1. **Fox River** — Complete the State-Federal program to develop the River for recreational navigation, fishing, and general recreation. (See Chapter VII-Navigation)

2. **Lake Michigan** — Increase public land potential and facilities for water-related recreation through State-Federal assistance to local governments in developing public harbors, beaches, fishing piers, and small lake areas. Develop new mooring facilities and harbors of refuge. Expand Illinois Beach State Park to the Wisconsin line.

3. **Pollution** — Clean up the pollution in the Chicago harbors, the Calumet River, Cal-Sag Canal, Sanitary and Ship Canal, and the DesPlaines River. (Many boat owners refuse to use these waterways now because of the corrosive effect on boats and unpleasant odors and views. See the section on recreational waterways in Chapter VII.)

4. **Multi-purpose Reservoirs** — Develop the maximum number of multi-purpose reservoirs in the Chicago region.

5. **Fishing Waters** — The State and the counties in the Chicago area should concentrate their resources to increase the fishing waters by cleaning up polluted streams, creating more conservation lakes, and building fishing piers in Lake Michigan.

B. **Illinois-Mississippi Canal, Lake Sinnissippi, and Steel Dam Reservoir** — Encourage State and Federal cooperative efforts to complete the acquisition and development program to make the Canal a major recreational and historic resource area.

1. It is recommended that the Canal and Interstate 80 which parallels it be developed as a parkway link between the Great River Road and the proposed Illinois River Parkway. It is recommended that Interstate 80 be given parkway status between Princeton and its intersection with the Great River Road; that all land between Interstate 80 and the Canal (and the Rock River), where they closely parallel, be acquired by either purchase or easement; and that Illinois 88, which parallels the Feeder Canal from its intersection with I-80 north to its intersection with a proposed Rock River Parkway, be given status as a secondary parkway.

2. The General Development Plan for the Canal should be updated to increase the capacity of the Canal parkway complex and to give consideration to such projects as the renovation of lock structures, where they are located near villages such as Bureau and Wyanet; the development of conservation lakes on Bureau Creek tributaries; and public access areas on the Rock River.

C. **The Seven State-Federal Corps of Engineers Reservoirs:** It is recommended that special emphasis be given to the development of the seven multi-purpose reservoirs; namely, that Carlyle, Shelbyville, Rend, Oakley, Lincoln, Helm, and Louisville Reservoirs be completed and be linked by parkways to create a recreational lake region.

1. Well-equipped public swimming beaches should be developed at each of the reservoirs. In-the-lake swimming pools should be considered for the reservoirs.

D. **River Parkways:** It is recommended that river parkway systems be developed for public use, particularly for pleasure boating, motoring on scenic highways, hiking, cycling, fishing, wetlands refuges, and nature areas. Initial effort should be concentrated on the Mississippi, Illinois, Sangamon, Ohio, and Wabash Corridors.

1. **National Recreation Area:** Urge Federal participation in the cooperative development of a major resource recreation area in northwestern Illinois, the Jo Daviess-Carroll Counties area, coordinated with the development of the Mississippi River Corridor and the Great River Road and Boat Trail.

2. **Mississippi River Corridor:** The basic plan of action for the Great River Road outlined in a report published in 1958 by the U. S. Bureau of Public Roads and the National Park Service should be incorporated into a Master Plan for the total development of the Mississippi Corridor as a linear parkway for boating and motoring. It is recommended that this basic plan of action be interpreted in the immediate future into definite projects and proposals in a specific master plan for regional development of the Mississippi River Corridor.

a. Cooperation should be secured from highway authorities at various levels to create attractive parkways for those portions of the Great River Road which pass through urban areas.

b. Plans for developing the boating potential of the Mississippi River should provide for: 1) Minimum facilities (sanitation, water supply, and boat tie-ups) on islands and peninsulas; 2) Temporary mooring facilities near locks for pleasure boaters waiting to be locked through; 3) More harbors of refuge for boat tourists, with service, lodging, and restaurant facilities.

c. Counties and cities should be encouraged to help with development of the Great River Road, particularly by zoning and other regulations to facilitate its development.

3. **Illinois River Corridor:** A comprehensive River Master Plan should be made for the Illinois River for the total development of the corridor as a linear park and boatway.

a. Much of the scenic Illinois Corridor, including outstanding points of historic and archaeological interest, waterfowl habitats and natural areas, and potential park areas, are in private ownership and subject to uncontrolled development. It is recommended that the outstanding areas be acquired for the public reserve; other areas should be protected by easement.

b. The river cities within the corridor should be encouraged to develop attractive waterfront and motor parkways through urban areas.

c. Highway authorities at various levels should be urged to assist in the creation of an attractive parkway on existing highways that parallel the River.

4. **Calhoun-Jersey Counties:** This major resource area lying at the junction of the Mississippi and Illinois River Corridors should be given high priority in the comprehensive development planning of the two river corridors.

5. **Sangamon River Corridor:** It is recommended that the State cooperate with Federal agencies and local governments to develop comprehensive development plans for this river corridor, with special attention to the future recreational development of Oakley Reservoir.

E. **Southern Illinois Resource Area:** It is recommended that the Shawnee Hills, Shawnee National Forest, Ohio River, Wabash River, and Mississippi River Corridors be developed as a combined major recreational area. Not only would such development be of socio-economic value to southern Illinois, but also it would expand recreational facilities available to the St. Louis Metropolitan Area.

1. A comprehensive plan should be made for development of the Ohio and Wabash River Corridors.

2. Additional boating and fishing lakes should be included in the long-range master plan for the Shawnee Hills-George Rogers Clark Parkway development.

3. The location of the Kentucky state boundary—now the low-water mark on the Illinois shore of the Ohio River—complicates and discourages the full use and development of this valuable river frontage for recreation and for other purposes. It is recommended that legal action be taken to work out a mutual boundary location for the Ohio River similar to the centerline boundary on the Mississippi River.

F. It is recommended that the State Recreation Plan be amended to include a broad, comprehensive boating plan.

G. **Reservoirs and Conservation Lakes:** Continued development of multi-purpose reservoirs throughout the State, particularly in the western and northern regions, is recommended.

1. A study should be made as soon as possible to devise a workable program to acquire and develop attractive new borrow pit lakes in all future highway construction.

2. A more comprehensive road and trail improvement program for Federal-State reservoir perimeter zones is recommended. This should be the combined responsibility of the State Department of Highways, the U. S. Bureau

of Public Roads, and the U. S. Corps of Engineers.

3. Update the inventory and evaluate both active and abandoned strip mine areas from the viewpoint of the State Recreation Plan to determine if such areas could be reclaimed for re-use as state parks and lakes.

4. Request legislation to enable the Department of Conservation to assist political subdivisions in planning and developing multiple-use reservoirs and facilities for water-related recreation.

H. **Scenic Highways:** Cooperate with the Bureau of Public Roads and the State Department of Public Works and Buildings in the development of the scenic highway system, as proposed in the Scenic Highway Plan and as expanded in this plan, with special attention to river corridors.

IV. Finding adequate sources to finance public water-related recreational development is perhaps the State's most difficult problem. The need is urgent to secure adequate funds to acquire, develop, and operate the public conservation-recreation open-space program recommended in **Outdoor Recreation in Illinois,** this water resources plan, and in other Federal, State, and local plans. The initial amount needed far exceeds the present allotments. New sources of revenue will be needed. All possible sources of revenue should be used to meet the following estimated monetary requirements for development of water-related recreation in Illinois:

ESTIMATED MONETARY REQUIREMENTS TO 1980 FOR FUTURE ACQUISITION AND DEVELOPMENT

A. Acquisition of 10,000 acres of strip mine land and water for fishing and other water-related recreation. Cost of acquiring and developing:	$ 4,000,000
B. Acquisition of necessary lands and development of 25,000 acres of manageable lakes and a fish-rearing unit for north-central Illinois by 1980, and acquisition by 2020 of 100,000 acres of manageable lakes of less than 1000 acres in size near large centers of population and in conjunction with USDA, P. L. 566 Watershed Programs and/or local governmental agencies projects. Cost for 25,000 acres of water and development:	75,500,000
C. Purchase and development of 500 miles of various streams (at least five streams) for fishing and water-related recreational use. $6,000 per mile, cost of purchase and development:	3,000,000
D. Marsh-land, flood-plain and bottom-land lakes. Expansion of four existing areas for a total addition of 5,500 acres; Initial purchase of five areas for total of 9,500 acres; 15,000 acres. Cost of purchase and development:	6,000,000
E. Acquisition and development of additional open-space lands related to water:	60,300,000
F. Boating and Swimming Facilities Program for making shoreline available, including beaches and pools for swimming, fishing piers, jetties, breakwaters, boat launching ramps, and mooring slips; cooperative with the Corps of Engineers, park districts, the Division of Waterways, and other agencies for a total of 320 access areas and 25,200 slips. Cost of purchase and development:	51,200,000
	$200,000,000

Recommendations for methods of funding to meet these requirements are:

A. It is strongly recommended that $200 million be allocated from the Illinois Resource Development Fund to finance the program for water-related recreation, allowing 25 percent of this sum on a matching basis for funding outdoor recreation programs of political subdivisions of the State. There is no apparent other way for Illinois to catch up in meeting its recreational needs. **Outdoor Recreation in Illinois** points out that, in comparison with national standards, Illinois has a deficiency of 952,822 public acres for outdoor recreation. In 1966 dollars this means that $300 million would be needed immediately to catch up in meeting the recreational demand in land only. A complete summation of monetary needs would be staggering; $200 million to start the program is obviously needed.

B. Increased legislative appropriations should be requested in the 1967-69 biennium to help finance the program. Twenty-five percent of the total State budget request should be allocated to local governments—counties and cities—to stimulate their greater participation in the acquisition-development program, making full use of available Federal matching funds.

C. All Federal assistance should be incorporated into the State programs. A continued effort should be made to procure specific Federal developments, such as a new National Recreation Area (USDI) and additional Federal help on completion of the Illinois-Mississippi Canal, the Corps of Engineers reservoirs, and P. L. 566 reservoirs.

D. Additional funds should be raised through the sale of revenue bonds, to be repaid from fees collected for use of facilities provided from the sale of the bonds.

E. The tax on motor boat fuel, which presently produces about $2.5 million annually, should be allocated to the Department of Conservation to finance a continuing program of acquisition and development of public access areas, harbors, and boat camp and picnic areas, and to assist in matching Federal land and water funds.

V. Legislative Recommendations:

A. Enact legislation to establish a Riverfront Authority empowered to prepare and carry out comprehensive programs for the planned and orderly development of all phases of riverfront activity.

B. Encourage legislative studies concerning the possibilities of a constitutional amendment that would clarify and improve the State laws pertaining to riparian rights and navigable waters in Illinois.

C. Enact legislation to provide remuneration from the State to local governments in lieu of taxes in areas where substantial land is to be acquired for Federal-State recreational areas and taken off the tax rolls.

D. Enact legislation to authorize designation of certain streams as free flowing (left in their natural state without impoundment).

E. Study the possibility of an amended revenue article that would allow for reduced assessments to those property owners who keep their land as open space with recreational orientation.

F. Enact legislation to control pollution from boating in Federal-State reservoirs.

VI. **Planning Recommendations:**

A. Zoning and Easements: Make full use of zoning and easements as a supplement to outright acquisition in order to insure provision of outdoor recreational areas, protection of open space, pollution control, public access to reservoir developments, control of land uses adjacent to parks, and prevention of encroachment on flood plains suitable for recreation. This device is particularly applicable to the preservation of future wildlife sanctuaries and submerged lands for waterfowl and fish (rather than draining them for other uses).

B. All water supply reservoir programs administered by the State which use urban planning assistance funds should be required to include public recreational areas and facilities following an approved comprehensive plan.

C. An approved comprehensive plan, zoning ordinance, and subdivision regulations should be a requirement for any county or incorporated area that contains or adjoins a Federal-State reservoir.

VII. **Swimming:** It is recommended that swimming beaches be developed as part of water-related recreational areas on all State or other public impoundments where needed.

VIII. **Fishing:** In order to provide adequate quality fishing throughout the State and particularly in areas close to metropolitan areas the following is recommended:

A. Construct adequate fishing impoundments within 80 to 100 miles of metropolitan areas, or preferably within one hour's drive.

B. Establish more intensive fishery management and pollution control in existing waters to improve the quality of the fish population. Concentrate the effort on areas open to the public, especially those near large centers of population.

C. Assure adequate public access on streams, adequate water and habitat controls, and the necessary operational funds and authority to maintain a sustained yield.

ACKNOWLEDGMENTS

This chapter was prepared by the Department of Conservation of the State of Illinois. Scruggs and Hammond, Planning Consultants, Peoria, wrote the chapter in consultation with Department of Conservation personnel. Mr. John C. Lawrence, Associate, Scruggs and Hammond, was principal author.

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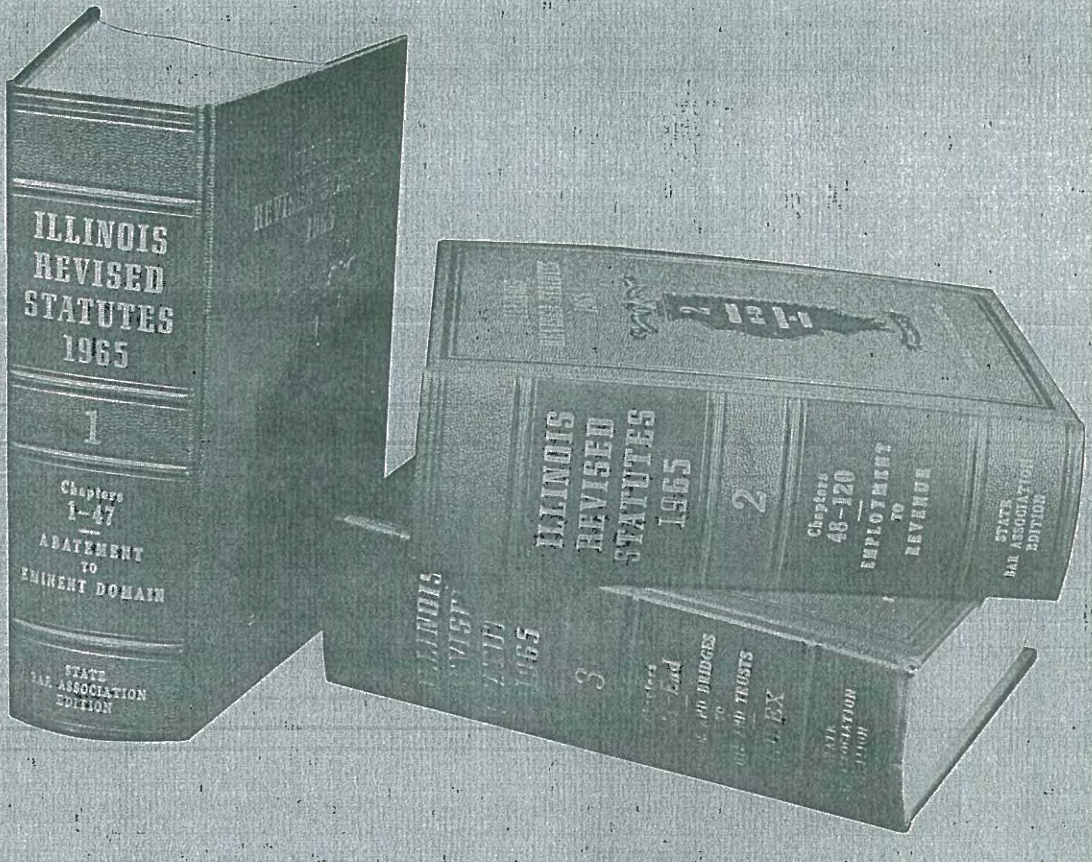


chapter nine

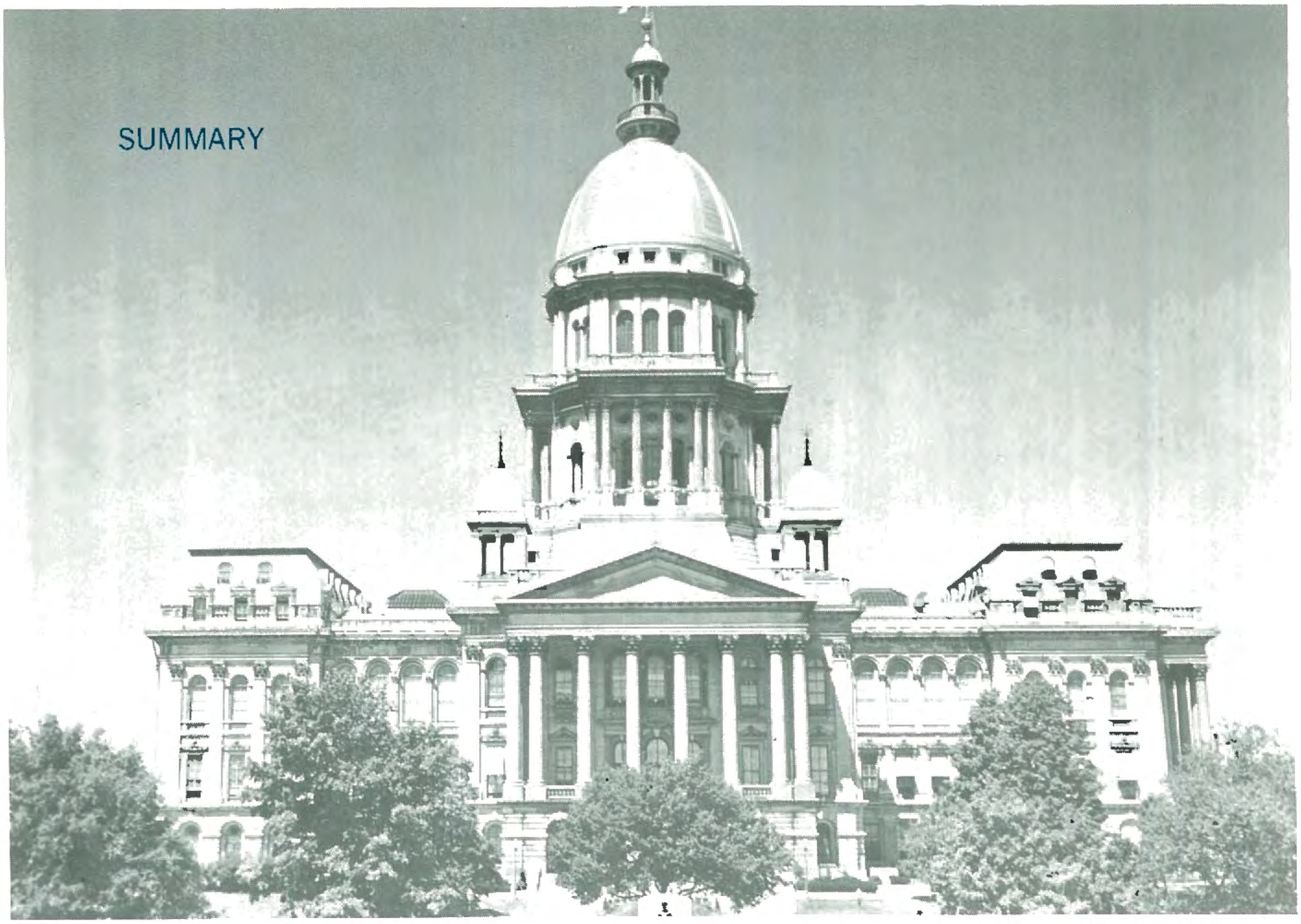
laws and government

illinois technical advisory committee on water resources

"A river is more than an amenity—it is a treasure, it offers a necessity of life that must be rationed wisely among those who have power over it."

Oliver Wendell Holmes

SUMMARY



The legal principles governing water use and the institutional mechanisms employed to furnish water services are equally as important as the physical availability of water. In Illinois, the legal framework governing water use is an amalgamation of common law, statutes, case law, opinions of the Attorney General, and regulations issued by numerous governmental units.

Water law applies different legal principles to water in different locations and also to different uses of water. Illinois law distinguishes between water in natural watercourses, diffused surface water, and percolating ground water. A distinction is also recognized between natural and artificial uses of water.

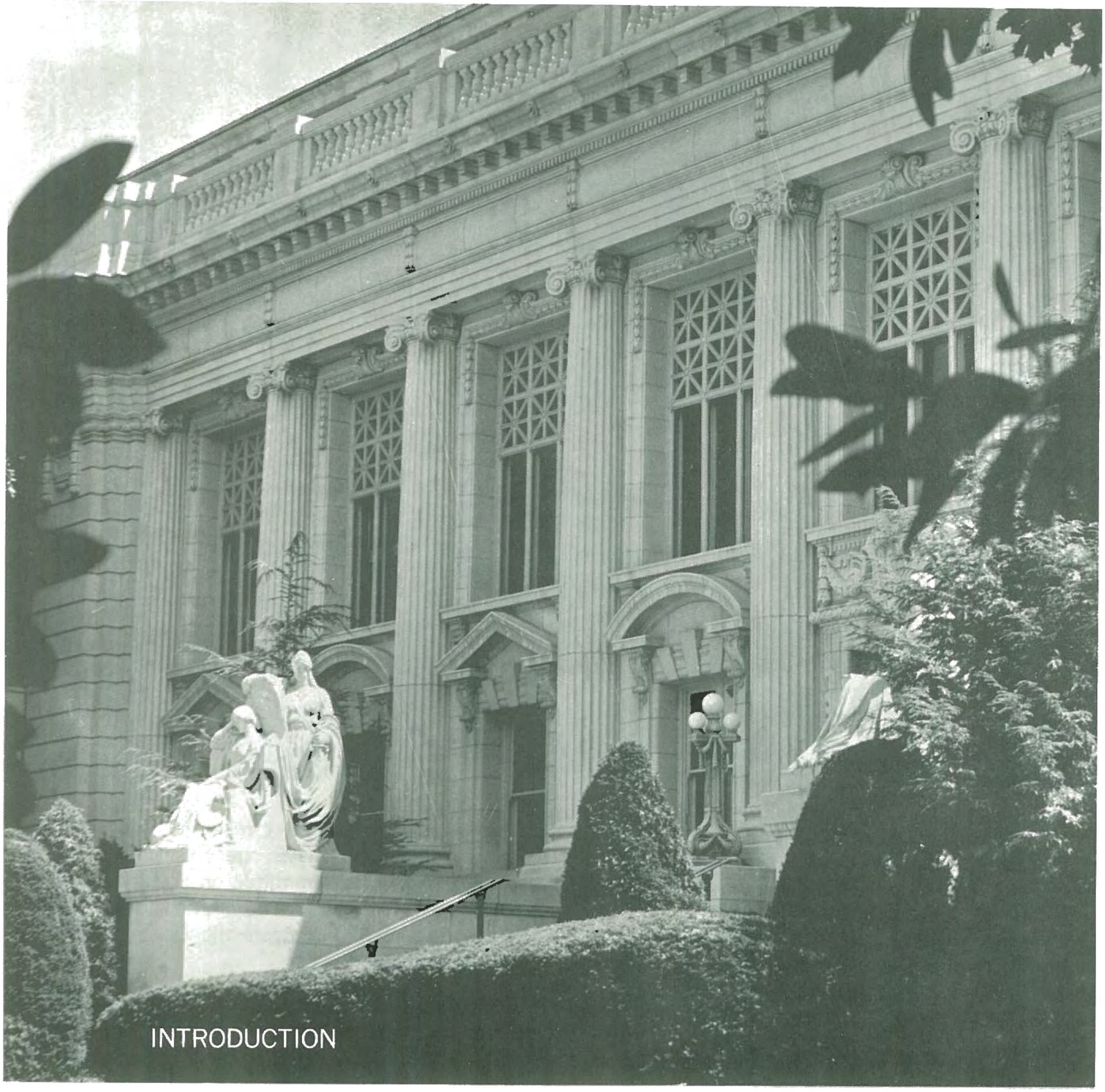
Illinois water law has been subjected to a minimum of controversy, chiefly because of the abundance of water in the State. As a result, gaps in case law present areas of legal uncertainty. As competition for available water is stimulated by increasing demands, new problem areas are beginning to emerge which will require refinement and extension of the existing legal framework.

Water resources management is truly an intergovernmental function. In Illinois, a number of State agencies have been delegated some responsibility in the broad area of water resources management. Representatives of these agencies constitute the Technical Advisory Committee on Water Resources, which acts as an advisory committee to the Department of Business and Economic Development and to the Administration.

The Federal Government administers a wide assortment of water resources programs. In recent years the Federal Government has greatly expanded the use of grants-in-aid. Such grants are designed to stimulate and assist state and local governments in increasing planning and development of water resources.

At the local level, water services are furnished by cities, villages, counties, and numerous special purpose districts. Financing remains a major problem for local governments. In addition, the present coordination of the water resources activities among the local governmental units leaves much to be desired.

To insure adequate water services in the future, through optimum water management, the State and its political subdivisions will need to implement new approaches in the organization and financing of water resources management.



This chapter is primarily concerned with the ways and means through which the State and its subdivisions, assisted by numerous Federal aids, meet their responsibilities in the broad area of water resources management. Part I presents the legal principles applying to water use in Illinois. In the aggregate, these principles circumscribe the legal framework which governs the activities of both individual citizens and public agencies.

Part II presents the present scope and role of the State agencies concerned with water resources, the Federal programs which have an impact on water resources development in Illinois, and the powers and authority granted to local governmental units pertaining to water resources management. Because financing has long been a major problem for the State and its subdivisions, emphasis has been placed on the financial powers and limitations of government. Such information, it is hoped, will be valuable for citizens and communities seeking to examine all possible alternatives and options available to meet their specific water resource needs.

This chapter cites numerous rules, requirements, and statutes. These are intended solely as guidelines. If detailed information is needed, the statutes of Illinois and professional legal counsel should be consulted.

PART I. ILLINOIS WATER LAW

Water use in Illinois has been, and still is, governed primarily by the rules of law promulgated by the State's Supreme and Appellate Courts, collectively referred to as common law rules. Water-use rights, however, also are affected by State and Federal legislation; Federal court decisions: rules, orders, and regulations of State and Federal agencies; laws and ordinances of local governmental units and special purpose districts; interstate compacts; and local court decisions regarding particular water-use rights that have not been overruled by the Supreme or Appellate Courts. In addition, the scope of various laws is regulated and limited by certain provisions of the State and Federal Constitutions.

Periodic attempts have been made to implement the common law through legislation. There have been relatively few reported court decisions regarding water use in Illinois. Some legislation dealing with certain phases of water use has been superimposed upon the common law of the State; thus, the over-all effect of the applicable laws is often difficult to determine. The Illinois statutes referred to in this chapter are found in the 1965 edition of the **Illinois Revised Statutes.**

In Illinois, court decisions are made on the basis of constitutional and statutory provisions. When there is no specific applicable provision, the courts apply the rule of application under the common-law adoption statute. The statute reads in part as follows:

> "That the common law of England, so far as the same is applicable and of a general nature . . . prior to the fourth year of James the First . . . shall be the rule of decision, and shall be considered as of full force until repealed by legislative authority."

Since the fourth year of James the First began March 24, 1606, the courts are bound to follow only the English common law that existed prior to that date, and then only when it is applicable. However, the court is free to choose a rule in harmony with the State's legal system and conditions when there is no applicable statutory or constitutional provision or pre-1606 common-law rule. In this case the court may draw upon decisions of sister states, English common-law decisions of post-1606 vintage, or analogize from its own decisions in related matters.

STATE CONSTITUTION

The Illinois State Constitution of 1870 contains two provisions relative to the use and regulation of waters within the State. The first is found in Article IV, Section 31, as follows:

> "The General Assembly may pass laws permitting the owners of land to construct drains, ditches and levees for agricultural, sanitary or mining purposes, across the lands of others and provide for the organization of drainage districts, and vest the corporate authorities thereof with power to construct and maintain levees, drains and ditches and to keep in repair all drains, ditches and levees heretofore constructed under the laws of this State, by special assessments upon the property benefited thereby."

The second provision is found following Article XIV, Amendments to the Constitution, under "Sections Separately Submitted" as follows:

> "The Illinois and Michigan canal or other canal or waterway owned by this State may be sold or leased upon such terms as may be prescribed by law. The General Assembly may appropriate for the operation and maintenance of canals and waterways owned by the State."

STATUTES

The basis for Illinois water policy is found in fragmentary form in various State statutes, rather than in a single statutory statement. The legislative attitude toward water and related natural resources is evident from several enactments.

The following declaration of policy is found in an act approved July 17, 1945, which authorizes the Department of Public Works and Buildings to carry out certain improvements for the purpose of flood relief and the conservation of low water flows in the rivers and waters of the State:

> "It is hereby recognized that the unregulated flow of the rivers and waters of the State of Illinois, resulting in periods of destructive floods upon the rivers and waters of Illinois, upsetting the orderly processes of industry, agriculture, and life in general, and causing loss of life and property, including the erosion of lands, the impairment

and obstruction of their drainage, the impairment or destruction of surface water supplies for domestic use, the impairment or destruction of navigation, highways, railroads, and other channels of commerce within the State; and periods of inadequate low water flows wherein the public water supplies of cities and villages are dangerously reduced, facilities for public recreation are rendered inadequate, and the propagation and conservation of wild life is adversely affected, constitutes a menace to the general welfare of the people of Illinois; that it is the sense of this General Assembly that regulation of the flood and low water flows of the rivers and waters of Illinois is a proper activity of the State of Illinois, independently or in cooperation with the United States or political sub-divisions and localities of the State itself; that investigations and improvements of the rivers and waters of Illinois, including the watersheds thereof, for the purpose of control of flood and low water flows, are the interest of the general welfare of the People of Illinois; that the State of Illinois should improve or participate in the improvement of the rivers and waters, including the watersheds thereof, for the purpose of regulating the flood and low water flows and the development and utilization of water, waterways and water resources if the benefits are in excess of the estimated costs, and if the lives and general welfare of the People of Illinois are adversely affected."

Also enacted in 1945 was legislation which created a State Water Resources and Flood Control Board. The first section of the act made the declaration that:

". . . the general welfare of the people of this state requires that the water resources of the state be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such water is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare. The right to water or to the use or flow of water in this state is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water."

However, the legislation including this policy statement was repealed by legislation in 1961 that created a Board of Economic Development and abolished the Water Resources and Flood Control Board. Functions of the Board were transferred to the new agency with some modifications, but it did not incorporate the policy declaration. In 1965 the Department of Business and Economic Development was created, replacing the Board of Economic Development, but maintaining its duties in the area of water resources. These include the power to determine and provide for equitable reconciliation and adjustment of conflicting claims and rights to water, to determine ways of coordinating the various water uses to attain the maximum beneficial use of water resources, and to make legislative recommendations for the most feasible methods of conserving water resources and putting them to maximum possible use.

Statements of policy appear in various statutes that include specific provisions regarding water resources. For example, the act creating the State Sanitary Water Board is introduced by a section stating:

> ". . . it is hereby declared to be the public policy of this State to maintain reasonable standards of purity of the waters of the State consistent with their use . . .; to provide that no waste be discharged into any waters of the State without first being given the degree of treatment necessary to prevent the pollution of such waters; to provide for the prevention, abatement, and control of new or existing water pollution; and to cooperate with other public or private agencies of the State and Federal Government in carrying out these objectives."

In 1957 the Legislature included a policy statement in an act relating to the planning and construction of watershed protection and flood prevention works of improvement:

> "The General Assembly of the State of Illinois finds that watershed protection offers a sound approach to flood prevention, provides proper management for surface water resources and for the maximum development of surface water storage for municipal, industrial, agricultural, and recreational uses for all citizens of the State, reduces the siltation of streams and lakes, and helps to maintain stable normal water levels in our streams for navigation and other uses."

This declaration of policy tends to recognize the importance of approaching surface-water use problems on a watershed basis.

A 1959 act concerning the licensing of water well contractors states that:

> "WHEREAS, because there is an ever increasing shortage of water supply in this State it is imperative that health and general welfare be protected by providing a means for the development of the natural resources of underground water in an orderly, sanitary, and reasonable manner without waste so that sufficient sanitary supplies for continued population growth and for future generations may be assured . . ."

The Soil and Water Conservation Districts Law embodies a policy declaration pointing out the need to conserve soil and water resources, control floods, prevent impairment of dams and reservoirs, and assist in maintaining the navigability of rivers and harbors to promote the general welfare of the people of the State.

The River Conservancy Districts Act indicates that districts may be formed when the unified control to a river system shall be conducive to the conservation and protection of water supply, development of irrigation, and other conservation and protection aspects. Found in the first section of the Surface Water Protection Districts Act is a policy statement referring specifically to the legislative determination of the need for facilities for the collection, conveyance, and disposal of surface waters in order to protect against property damage and loss of life.

CASE LAW

Illinois courts have spoken of natural watercourses with respect to riparian rights, with respect to drainage, as the term is used in a statute regulating fishing and natural watercourses, as distinguished from artificial watercourses. In 1892 the Supreme Court was called upon to interpret the meaning of "watercourse" as used in a statute regulating fishing. The Court said that a watercourse, "according to the ordinary signification of the term, . . . must be a stream usually flowing in a particular direction, and in a definite channel, and it must usually discharge itself into some other stream or body of water."

In 1896 the Court indicated that there may be at least two definitions of the term watercourse, depending on whether it is used with respect to drainage or with respect to other rights. It mentioned that a continuous ditch line could be either "a natural watercourse" or "where the water would flow in a state of nature," and that the term "well-defined watercourse" is often used to mean one that has "well-defined banks and a bed," but that this definition was not necessary where a watercourse with respect to drainage was concerned.

At a later date in St. Louis Bridge Railway Association v. Schultz, the Court said that "the term . . . has not always been given the same meaning by the courts. In its more restricted sense it is such a waterway as gives rise to riparian rights in the flow of the water. In that sense of the term a depression or natural drain which merely carries water in rainy seasons is not a watercourse."

From this, it appears that when courts attempt to distinguish between a watercourse with respect to drainage and a watercourse to which riparian rights attach, they commonly consider (for the latter purpose) whether or not it has well-defined banks and a bed.

Under the riparian doctrine, the courts have distinguished between natural uses and artifical uses

of a watercourse. In an early case, the Supreme Court said that natural wants are those needs which are considered as absolutely necessary for existence in civilization. These needs include water for drinking, for household purposes, and for watering livestock. The Court indicated that each riparian proprietor may, when necessary, use all of the water in the stream for these purposes without liability to a lower proprietor.

Artificial uses include all those that are not natural, and the designation apparently extends to use for farm irrigation and manufacturing. These are the uses that merely increase the prosperity and comfort of the user. Where these uses are involved, all riparian proprietors have an equal right to use the water that is not needed to supply natural wants or uses. They may use it only for such purposes and in such amounts as may be considered reasonable.

Illinois law concerning obstruction, detention, and diversion is somewhat vague, but certain principles can be derived from cases touching on the subject. The Court, in deciding Plumleigh v. Dawson, stated the following rule as governing the use of riparian water: ". . . all, through whose land it (the stream) naturally flows, may enjoy the privilege of using it, for culinary, agricultural and hydraulic purposes, without adulteration, diminution or alteration, except so far as it may suffer that diminution by detention for lawful uses above. Every riparian proprietor has an undoubted right to use it . . .; yet he must so use it as to do no injury to any other riparian proprietor." The Court went on to say that a riparian owner may use the stream, but he must do "no unnecessary damage" to the lower proprietor, and he must permit the water to flow to him in its accustomed channel, yet "he is allowed a reasonable use."

With respect to navigable waters, the Illinois courts have subscribed to a stricter test than have certain other states. The Court indicated that:

> "It is not enough that a stream is capable during a period, . . . when it is swollen by the spring and autumn freshets, of carrying down its rapid course whatever may have been thrown into its angry waters, to be borne at random over every impediment in the shape of dams or bridges which the hand of man has erected. To call such a stream to be navigable in any sense, is a palpable misapplication of the term."

The language of the above case was affirmed in 1909 when the Court stated: "A stream must, in its ordinary, natural condition, furnish a highway over which commerce is or may be carried on in the customary modes in which such commerce is conducted by water." The Court further stated that, if a stream could not be navigated in its natural state and was not meandered (outlined on the Federal surveyor's map as a navigable body of water), no amount of deepening, widening, or other improvement will make it navigable in the eyes of the Illinois courts.

The State of Illinois, in addition to its general police power to regulate the use of water, within certain limits, has some rather specific types of jurisdiction over natural watercourses. Various court decisions have indicated that the State has the power to 1) regulate and control fishing in all waters of the State, 2) control and protect all navigable waters of the State for purposes of navigation, 3) control and regulate the exercise of all rights incident to the ownership of beds of all watercourses to which the State holds title, and 4) control and regulate the general use of all public waters of the State.

ATTORNEY GENERAL'S OPINIONS

With regard to the dedication of watercourses to public use, the Attorney General has, in one case, expressed the opinion that an inlet constructed on private property that connected with Lake Michigan had not been dedicated to public use, because it had never been used for any length of time without a permit or lease and a payment to the landowner of a substantial rental. The Attorney General has also stated that posting "no trespass" signs or blocking the entrance to an artificial watercourse with a chain would tend to negate any intention to dedicate its use to the public.

A legislative enactment of 1911 states that the Department of Public Works and Buildings is to require that permits be obtained from it before any fill, deposit, or structure can be lawfully placed in any public bodies of water within the State. In an opinion, the Attorney General stated that a meandered lake is subject to the act, but that the act does not authorize the issuance of such permits regarding non-navigable streams, since the State has no property right or interest in them, and they are not public bodies of water within the meaning of the act. In another case, the Attorney General expressed the opinion that the act does not authorize the Department to issue permits to construct an outlet channel and divert water from public bodies of water. He stated that, although the statute relates to certain obstructions or structures in public waters, it does not authorize the construction of outlets.

However, the Attorney General expressed the opinion that the Department of Public Works and Buildings may permit the withdrawal of water from a public body of water through a pipeline for industrial and manufacturing purposes, if the Department determines that the issuance of such a permit will be in the public interest, and if riparian rights of lower riparian owners are not adversely affected by diverting the water.

WATER RIGHTS

The Illinois courts, in deciding various cases, have applied different legal rules to different types of water sources. The three general legal categories of natural water sources are 1) natural watercourses, 2) percolating ground water, and 3) diffused surface water. The courts have consistently followed this general classification, although the terms used in referring to a particular source have varied considerably. With respect to the use of water in a natural watercourse, the Illinois Supreme Court has subscribed to the doctrine of riparian rights. Although many areas of the law pertaining to percolating ground water have been left unsettled, the courts have subscribed to the rule which states that the owner of land owns all the percolating water underlying his land. For diffused surface water, the Illinois courts have not indicated what rule of law they would follow, but rather have based their decisions on the merits of each case and on statements of other state courts. Water-use doctrine is discussed in detail as it relates to each of these legal categories.

Natural Watercourses

The Illinois Supreme Court has subscribed to the doctrine of riparian rights with respect to the use of water in natural watercourses. In explaining the concept of the doctrine of riparian rights, the Court stated that: "A watercourse begins **ex jure naturae**, and, having taken a certain course naturally, cannot be diverted." The Court further stated: "The language of all authorities is that water flows in its natural course and should be permitted thus to flow so that all through whose land it naturally flows may enjoy the privilege of using it."

Enlarging upon this statement, the Supreme Court referred to the owners through whose land the water flows as "riparian proprietors," the type of ownership they held as "riparian ownership," and the rights to which the riparian proprietors were entitled as a result of the location of their land as "riparian rights." These rights are considered "usufructuary" in nature. That is, they are rights of use, not ownership, of the flowing water. In addition, the Court has subscribed to a rule of reasonable use as opposed to one of natural flow and has said that at least a certain amount of consumptive use in addition to domestic uses is permissible under the doctrine.

There are four general classifications of natural watercourses to which riparian rights apply, although the rights are not always the same with regard to all such waters. The classifications are: 1) non-navigable watercourses where there is usually a flowing current of water, such as streams and small rivers; 2) navigable watercourses where there is usually a flowing current of water, such as rivers; 3) non-navigable watercourses where the bulk of the water is usually not perceptibly flowing in any particular direction, such as ponds and small lakes; and 4) navigable watercourses of the preceding type, such as large lakes. This classification is presented for information rather than for analysis.

Underground watercourses are treated like surface watercourses so long as the channels of such streams are well known and defined, i.e., capable of being proved in court. Otherwise, they are considered as percolating ground water and are governed by the rules applicable to them.

Percolating Ground Water

Percolating ground water is defined as water found below the surface of the earth, except that water in well-defined underground watercourses. The Illinois Supreme Court has adopted the English common law rule when deciding cases involving percolating ground water. In essence, the rule states that the owner of the land owns all the percolating water underlying his land. He may use it as he sees fit for his own purposes, regardless of the effect it may have on the percolating ground-water supply of adjacent users. The Illinois Supreme Court has stated the rule thus:

> "Water which is the result of natural and ordinary percolation through the soil is part of the land itself and belongs absolutely to the owner of the land and, in the absence of any grant, he may intercept or impede such underground percolations, though the result be to interfere with the source of supply of springs or wells on adjoining premises."

As definitive as it may sound, the rule has certain exceptions. To illustrate, the rule does not necessarily mean that the owner may use the water if his sole purpose in doing so is maliciously to interfere with the use of ground water by surrounding landowners. Also, a landowner may not use his ground water, either directly or incidentally, to corrupt or make unfit for use, i.e., to pollute the well or spring of another user. The wrongdoer is considered to be maintaining a nuisance for which he may be enjoined.

A log of all wells that are drilled must be filed with the State Geological Survey to provide information on capacity of the well and thickness of water-bearing strata, as well as other information. Also, permits must be obtained from the Department of Mines and Minerals before drilling a well that penetrates the subsurface below the glacial drift.

Diffused Surface Water

From the time water falls upon the surface of the earth until it is absorbed into the ground or flows into a body of water, it is classed as diffused surface water (usually called surface water, or sometimes runoff, by the courts). In addition, overflow waters from any natural source, when thrown vagrantly upon the land, may be classified as surface waters so long as they do not become part of the percolating ground water or of a body of water to which riparian rights attach.

So few questions have been raised about the use of surface water that no Illinois courts have passed directly upon the subject, and there is little applicable legislation. However, some rules may be derived by analogy with the laws of surface drainage and of other states.

If a landowner chooses to, he may retain surface water upon his own land, apparently without incurring any liabilities with respect to surrounding landowners. There could be liability to one degree or another, however, depending upon whether damage may result from such action. Under this rule, a landowner gains absolute possession of the surface water once he stores or impounds it upon his land by any legal means. However, he may not discharge it from the impounding device in unnatural quantities or change the drainage pattern of the land so as to seriously impair a lower owner's use of his land.

Access to Lakes and Streams

Under the general rule of law in Illinois, riparian owners own the beds of rivers and streams, both navigable and non-navigable. However, where the State owns the beds, public rights are given to fish and hunt on the waters overlying the State-owned beds. A riparian proprietor along a navigable watercourse has substantially the same rights incident to his riparian proprietorship as does one who is riparian to a non-navigable body of water, except that his rights are always subject to the public easement of navigation.

A riparian proprietor has the right, as an incident to his ownership of the bed, to use the water of a watercourse while it is on his land for swimming, boating, fishing, and other similar uses that are non-consumptive. This is so at least in the absence of any local custom to the contrary.

The Court in one case held that private owners of certain portions of the submerged lands under a navigable lake, although subject to the public easement of navigation, could exclude others from fishing and hunting over their submerged lands. Although no case announcing such a rule has been located that directly concerned such rights in rivers and streams, the Court has expressly said that the rule applies to both lakes and streams.

A riparian proprietor may construct wharves and maintain docks on his land bordering on a navigable watercourse, so long as such construction does not obstruct or impede the navigation of the watercourse. If any part of the wharves or docks is to be located on a bed that is owned by someone else, other than the State, his consent generally must also be obtained.

If a lake or pond is meandered and thus navigable, as a general rule the bed is owned by the State, and the rights of hunting, fishing, and boating are held by the State in trust for the use of the people of the State. The riparian proprietor stands in a preferred position to the general public by virtue of the location of his land, since he retains an exclusive riparian right of access to the water from his land.

The Attorney General has expressed the opinion that a fishing license issued by the State gives the licensee a permit to take fish only under certain regulations and, if the stream or lake bed is privately owned and not owned by the licensee, only with the consent of the owner of the underlying bed. Also, the Attorney General has said that the fact that a stream has been stocked by the State or designated as a fish preserve does not confer upon the public the right to trespass upon waters over privately-owned stream beds.

The property line of riparian owners bordering Lake Michigan is the waterline as it usually exists when unaffected by storms, piers, or other disturbing factors, although such owners have a right of ingress and egress to their property.

Diversion Between Basins

The Illinois Supreme Court has said, concerning drainage matters and matters involving increased flow in a watercourse, that it has been decided that a landowner through whose property a watercourse runs is bound to accept only such water as comes from the natural drainage basin of the watercourse. An upper owner may not cut through a "divide" or natural barrier and cause water which would not naturally flow into that drainage basin to flow across that barrier.

Thus, from the standpoint of the landowners in the other watershed, a riparian proprietor would have no right to cause water to flow into that watershed, if it increased the burden of drainage of its watercourses. Although it has never considered such a case, the Court might reason from this that the responsibility exists to keep water within its own watershed so the riparian owners within the watershed can realize their rights of use. This seems to be the view of courts of certain other states. For example, in a Massachusetts case the court said:

> "Abstraction for use elsewhere not only diminishes the flow of the parent stream, but also increases that which drains the watershed into which the diversion is made, and may injure thereby riparian rights upon it. Damage thus may be occasioned in a double aspect . . . ."

Eminent Domain

State powers of eminent domain are set forth in the State Constitution in Article II, Section 13, as follows: "Private property shall not be taken or damaged for public use without just compensation. Such compensation, when not made by the State, shall be ascertained by a jury, as shall be prescribed by law." An act of April 10, 1872, expands upon the right of eminent domain and discusses the proper procedure for proceedings, hearings, payment of compensation, and other pertinent matters.

A review of the statutes indicates that the powers of the State in acquiring property through the power of eminent domain for purposes of water management and development of related land resources are rather broad. Several districts and governmental units have acquired, by statute, the power of eminent domain with various limitations peculiar to each. These include cities and villages, counties, townships, soil and water conservation districts, subdistricts of soil and water conservation districts, port districts, sanitary districts, river conservancy districts, surface-water protection districts, park districts, mosquito abatement districts, public water districts, water authorities, drainage districts, and the various State agencies concerned with water resources.

The primary water resource agencies at the State level with the power of eminent domain are the Department of Public Works and Buildings and the Department of Conservation. They may acquire by condemnation any and all lands, buildings, and grounds for which an appropriation may be made by the General Assembly to the respective departments.

TABLE 1 ILLINOIS STATUTE REFERENCES ON WATER (Source: Illinois Revised Statutes, 1965)

A. Pertinent Chapters

Chapter Title	Chapter Number	Chapter Title	Chapter Number
Agriculture	5	Motor Vehicles	95½
Canals and Waterways	19	Nuisances	100½
Cities and Villages	24	Oil and Gas	104
Common Law	28	Parks	105
Counties	34	Public Health	111½
Drainage	42	Public Utilities	111 2/3
Eminent Domain	47	Roads and Bridges	121
Fish	56	State Government	127
Mines and Miners	93	Townships	139
Mines	94	United States	143

B. Topical Index

Subject	Chapter Number Section or Article
Agriculture, Department of	c. 127 § 40 thru 42a7
Air Pollution Control Act and Compact	c. 111½ § 240.1 thru 240.32
Bi-State Development Agency	c. 127 § 63r-1 thru 63s-12
Boat Registration and Safety Act	c. 95½ § 311-1 thru 323-1
Bridges over Navigable Rivers	c. 121 § 192 thru 193a
Business and Economic Development, Department of	c. 127 § 46.1 thru 47.1
Common Law	c. 28 § 1
Conservation, Department of	c. 127 § 63a thru 63b2
County Jurisdiction over Drainage, Flood Control, Water Supply and Sewerage	c. 34 § 3101 thru 3123
County Planning Commissions	c. 34 § 3001 thru 3091.39
County Public Health Departments	c. 111½ § 20c thru 20c18
County Removal of Obstructions	c. 34 § 430
County Zoning	c. 34 § 3151 thru 3162
Drainage and Flood Control Plans	c. 42 § 472
Drainage Districts	c. 42 Article 1 thru 12
Drainage Rights	c. 42 Article 2
Eminent Domain	c. 47
Fish	c. 56
Floods and Conservation of Water	c. 19 § 126a thru 126h
Great Lakes Basin Compact	c. 127 § 192.1 thru 192.4
Highway Drainage	c. 121 Article 4-502; 5-501 thru 5-507
Illinois and Michigan Canal	c. 19 § 30 thru 37.24
Illinois Commerce Commission	c. 111 2/3 Article 1 thru 7
Illinois Waterway	c. 19 § 79 thru 106
Intergovernmental Cooperation Commission	c. 127 § 186 thru 191
Land Reclamation including Dams	c. 93 § 180.1 thru 180.13
Mine Drains	c. 94 § 1
Mines and Minerals, Department of	c. 127 § 45
Mosquito Abatement Districts	c. 111½ § 74 thru 85b
Municipal Flood Control and Drainage	c. 24 Article 11-110 thru 11-111
Municipal Jurisdiction over Waters	c. 24 Article 7-4-4
Municipal Public Utilities	c. 111 2/3 § 85
Municipal Removal of Obstructions	c. 24 Article 11-111.1
Municipal Water and Sewer Systems	c. 24 Article 11-124 thru 11-149
Municipal Zoning	c. 24 Article 11-13
Nuisances in Rivers, Lakes, Streams	c. 100½ § 26 thru 29
Ohio River Valley Water Sanitation Compact	c. 111½ § 117 thru 121
Oil and Gas Pollution	c. 104 § 67, 69, 69a
Park Districts	c. 105 Article 1 thru 13; § 48 thru 116
Port Districts	c. 19 § 152 thru 550
Public Health, Department of	c. 127 § 55 thru 55.35
Public or Navigable Water Obstructions	c. 19 § 47a thru 47e
Public Water Districts	c. 111 2/3 § 188 thru 212.3
Public Water Supplies	c. 111½ § 121a thru 121o; 504
Public Works and Buildings,	c. 19 § 8 thru 29.2
Department of	c. 127 § 49 thru 52
Registration and Education, Department of	c. 127 § 58 thru 63
River Conservancy Districts	c. 42 § 383 thru 410.1
Rivers, Lakes, Streams	c. 19 § 52 thru 78
Sanitary Districts	c. 42 § 247 thru 381; 412 thru 447.2
Sanitary Water Board	c. 19 § 145.1 thru 145.22
Soil Conservation and Domestic Allotment Act	c. 5 § 138a thru 138g
Soil and Water Conservation Advisory Board	c. 5 § 109 thru 111
Soil and Water Conservation Districts and Subdistricts	c. 5 § 106 thru 138.2
State Parks and Nature Preserves	c. 105 § 465 thru 468; 468g, 501
Submerged Lands	c. 19 § 150 thru 151
Surface-Water Protection Districts	c. 42 § 448 thru 471
Township Water and Sewer Systems	c. 139 § 39.14; 160.31 thru 160.54
United States Jurisdiction in State	c. 143 § 4 thru 36
Wabash Valley Interstate Compact	c. 127 § 63t-1 thru 63t-3
Water Authorities	c. 111 2/3 § 223 thru 250
Water Service Districts	c. 111 2/3 § 213 thru 222.1
Water Terminal Facilities	c. 19 § 146 thru 149
Water Well Contractor's License Act	c. 111½ § 116.76 thru 116.103
Water Well Construction Code	c. 111½ § 116.111 thru 116.117
Watershed Protection and Flood Prevention Works	c. 19 § 128.1 thru 128.3

REGULATORY AUTHORITY

Permits for Drilling Wells

In 1959 the Legislature passed an act requiring water well contractors annually to secure a license to drill or otherwise construct water wells from the Board of Water Well Driller Examiners in the Department of Registration and Education. The purpose of the act is to provide for developing natural underground waters in an orderly, sanitary, and reasonable manner. However, the act does not apply to an individual who constructs a water well on land he owns or leases and uses for farming purposes or as his place of residence, nor to one who performs labor or services under the direction of a licensed contractor. New water well legislation enacted in the 74th General Assembly (1965) strengthens control over water wells and is summarized in the following sections.

Permits must be obtained from the State Mining Board before drilling a water well that penetrates the subsurface below the glacial drift. A log of all wells that are drilled must be filed with the State Geological Survey to provide information on formations penetrated, capacity of well, thickness of water-bearing strata, and other details. Permits are issued as a matter of course and without investigating the applicant's site. The purpose of issuing permits is to apprise applicants of the statutory requirements for furnishing drillers' logs and, in some cases, drill cuttings, in order to get data for locating mineral deposits. Most permits for water wells have been granted to those concerned with the drilling of large municipal and industrial wells.

Six bills relative to private water supply systems were introduced in the 74th General Assembly and were subsequently enacted into law. Three are new acts providing for 1) an Illinois Water Well Construction Code, 2) an Illinois Pump Installation Code, and 3) an Illinois Pump Installation Contractor's Licensing Act. The other three bills amended existing legislation, i.e., the Illinois Water Well Contractor's License Act, the State Oil and Gas Act, and the Public Nuisance Act. Each of these is briefly summarized below.

The act establishing an Illinois Water Well Construction Code directs the Department of Public Health to adopt and publish rules and regulations governing the location, construction, and repair of any water well. It also authorizes the Department to institute proceedings to suspend or revoke the license of any water well contractor who fails to adhere to the rules and regulations.

The Pump Installation Contractor's License Act provides for the licensing of all persons engaged in the business of installing water pumps. Licenses are to be obtained from the Department of Registration and Education. The Act is virtually identical in form to the Water Well Contractor's License Act, enacted in 1959 and discussed previously in this section.

The newly enacted Pump Installation Code directs the Department of Public Health to adopt and publish rules and regulations governing the proper installation and repair of pumps and pump equipment. It further authorizes the Department to institute proceedings to amend or revoke the license of any pump installation contractor who fails to adhere to the rules and regulations.

The Water Well Contractor's License Act was amended to authorize the suspension or revocation of any license issued under the Act for violation of the Water Well Construction Code. The amendment further stipulates that disregard or violation of the Illinois Pump Installation Code is not grounds for suspension or revocation of a water well contractor's license.

An amendment to the Oil and Gas Act provides that the Act applies to all wells drilled for water, to abandoned water wells, and to those penetrating the subsurface below the glacial drift. The amendment requires that all abandoned water wells be properly plugged, and that notification of intent to drill any water well be filed with the Department of Mines and Minerals to secure a permit. In addition, it requires that, in the case of a water well penetrating the subsurface beneath the glacial drift, a fee permit must be secured from the Department before drilling may commence.

The Public Nuisance Act was amended to provide that it is a misdemeanor for any person to permit any water well located on property owned by him to be in an unplugged condition after use of the well ceases. In addition, it provides that improper plugging of any abandoned water well also constitutes a misdemeanor.

In general, the purpose of the water well legislation is to protect the public health and to promote the conservation of Illinois' ground-water resources. More specifically, the objectives of the drilling regulations are:

— To establish uniform minimum standards of procuring and protecting the useable ground-water resources of the State through proper location of wells, adequate construction or rehabilitation of wells, development of wells, and abandonment of wells;

— To facilitate the collection of data on the ground-water resources and other natural resources of the State by requiring the submission to the State of proper records on earth formations penetrated, water levels, manner of well construction, and pumping equipment installed in all wells and borings; and

— To assure a continuing inventory of development of the State's ground-water resources by requiring a permit or notification to drill water wells, including those finished in the drift and in the bedrock.

Permits for Impoundments

The Department of Public Works and Buildings, through the Division of Waterways, requires that a permit be obtained from the Division before any dam or like structure can be lawfully placed in any of the public bodies of water within the State. A standard form has been developed for issuing formal permits. All applicants must submit the plans, profiles, and specifications, and other such information as may be required to the Department for review and approval before a permit is issued. The applicants must also submit a statement, signed by all riparian owners whose access to the waters will be directly affected by the proposed work, approving the action of the applicants.

The permits shall expire if the work permitted is not completed within a certain time period, normally three years. When the structure authorized by the permit has been completed in the allowable time and in accordance with its provisions, the permit continues in effect indefinitely, subject to any change in the applicable laws. However, if a structure is improperly maintained, and thus interferes with navigation or other public interests, the Department may take appropriate corrective action.

Before any dam can be constructed by river conservancy districts, surface-water protection districts, or certain other districts, the plans must be submitted to, and approved by, the Department of Public Works and Buildings.

Permits for Channel Encroachments

The Department of Public Works and Buildings is charged with the responsibility for assuring that the waters of the State, wherein the State or the people of the State have any rights, are not encroached upon except as authorized by law, and then only after permission is obtained from the Department. As previously stated, a permit must be obtained from the Department before any fill, deposit, or structure may be lawfully placed in any public waters.

The Department's Division of Waterways is responsible for the investigation of all complaints as to alleged encroachments and abuses or misuses of public waters; numerous complaints are processed each year. An individual may request the Department to take appropriate action against the invasion of the following rights: 1) interference with navigation; 2) any unlawful interference with the use of docks, landings, or wharves; and 3) interference with free ingress and egress to navigable waters. Once a complaint has been registered, the Department must do what it can to see that justice is done. It also has the duty to keep watch and act on its own initiative, if it discovers a violation of rights within its jurisdicton.

The Department generally relies on discussion and persuasion to effect voluntary resolution of disputes and sometimes refers complaints to other agencies or consults with other agencies in reaching a settlement. Dumping and filling in streams is the most prevalent kind of complaint received by the Department.

Municipalities, counties, townships, and certain districts also have some powers to prevent or remove channel encroachments or obstructions. For example, counties and municipalities have the power to remove driftwood and other similar obstructions from watercourses. River conservancy districts have broad authority to clean out any ditch, river, pond, or natural stream in or out of the district. Drainage districts may also remove driftwood and rubbish from ditches either in or outside of the district. In addition, water authorities and soil and water conservation districts have some powers with respect to channel encroachments or obstructions.

Flood-Plain Regulations

Flood-plain zoning in Illinois is primarily a concern of local governmental units, whose authority comes from statutes. Municipalities and counties, under their zoning powers, are able to regulate or restrict the use of water for certain purposes by regulating the use of lands adjoining a watercourse. They may also guide land and water use through municipal and regional planning powers. For example, certain planning commissions may suggest standards for zoning to local units of government. In addition, some districts, such as surface-water protection districts, may adopt and enforce ordinances for the necessary protection from surface-water damage.

Although the State has no specific powers for zoning of flood plains, the Department of Public Works and Buildings, through its Waterways Division, ". . . shall make a survey and prepare a master plan for the drainage of and flood control of all watershed areas of this State and for lessening or avoiding hazards to persons and damage to property from flood waters. Such plan shall set out in detail the hydrography of each watershed area . . . for purposes of planning and regulation of development within and along flood water channels, frequency and degree of low flows and drainage of upland and bottom land and urban areas." As mentioned earlier, the Department also has some powers to control channel encroachments through its power to issue, deny, or revoke permits for fills, deposits, and structures.

Permit for Discharge of Wastes

As stipulated by statute, a permit must be obtained from the State Sanitary Water Board before a person many undertake the following activities: 1) construction, installation, modification, or operation of any sewerage works; 2) increase the volume or strength of any wastes; 3) construction, installation, or operation of any industrial or commercial establishment that would cause an increase in the discharge of wastes directly into the waters of the State or would otherwise alter the physical, chemical, or biological properties of any waters in any manner not already lawfully authorized; 4) construct or use any new outlet for the discharge of any wastes directly into the waters of the State.

The Board is empowered to issue, continue in effect, deny, revoke, or modify any permit when, after hearing, it determines that such action is necessary. The Board makes periodic inspections and receives operational reports regarding works for which permits have been issued. Exempt from the permit system are sewerage works that receive only domestic or sanitary sewage from a building occupied by fifteen persons or fewer.

The State Mining Board in the Department of Mines and Minerals has jurisdiction over pollution from oil and gas field development. The Board has the authority to make rules and regulations to prevent the pollution of fresh water supplies by oil, gas, or salt water. In this effort, the Board supervises the disposal of salt water, requires permits for the drilling of wells, and makes periodic inspections of oil and gas wells, among its other activities.

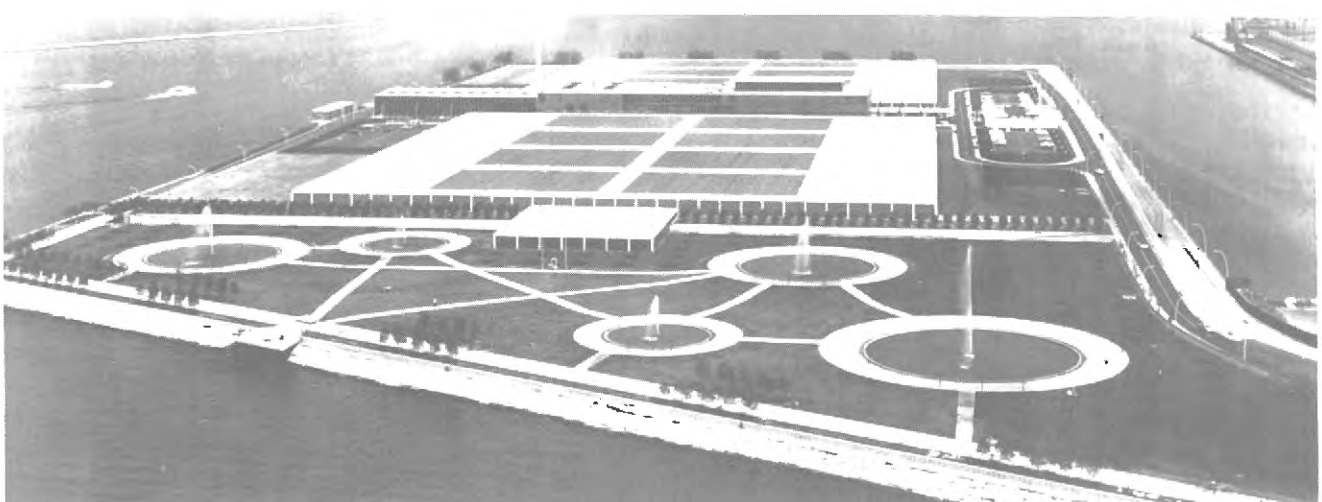
Public Water Supply Facilities

The Department of Public Health acts in a supervisory capacity relative to the sanitary quality and adequacy of proposed and existing public water supplies, water treatment and purification plants, and prepares and enforces regulations relative to the installation and operation of public water works so that public water supplies will be of satisfactory sanitary and mineral quality for drinking and general domestic use.

Public water supply owners must submit plans and specifications to the Department and obtain written approval before the construction of any proposed public water supply installations, changes, or additions is started. Waterworks operators are required to pass a qualifying examination and obtain certification of ability to operate. The Department may also request samples of water for analysis, may inspect public water supply facilities to determine adequacy of treatment, and may hold hearings and issue orders directing correction of sanitary defects.

Flow Regulation

The Department of Public Works and Buildings, through its Waterways Division, has some powers to regulate dams or to require that dams be regulated with respect to flood flows and low flows. Certain districts, such as drainage districts and surface-water protection districts, also have some powers to regulate streamflows.



PART II. Government

Water resources management is truly an intergovernmental concern. Traditionally, many water services were chiefly the responsibility of one level of government. The original concern of the Federal Government centered on navigation and reclamation, while water supply and sewage disposal services were furnished by local governments. State agencies have been largely regulatory, although Illinois is unique in its long interest in the research and investigation of its physical water resources. With the advent of new, complex problems occasioned by rapid economic and population growth, it has become increasingly difficult to demarcate the respective concerns and activities of the different levels of government.

Today, the Federal Government is deeply involved in comprehensive river basin development and has also undertaken an ever-widening program of financial assistance to state and local governments. The basic authority for Federal involvement in water resources management is derived from a number of constitutional provisions, including the commerce, property, supremacy, general welfare, war, and treaty clauses of the U. S. Constitution. Of these, the commerce clause and the general welfare clause are probably the most important.

The commerce clause, as interpreted, places responsibility for the promotion and control of international and domestic commerce on the Federal Government. Under this clause, the Federal Government retains extensive powers over all navigable waters which are superior to state water-rights law. The general welfare clause permits the Federal Government to tax and spend for the general welfare.

In recent years, state governments have begun to assume a larger responsibility in the area of water resources management. This is partially due to encouragement and financial support from the Federal Government. This trend is clearly evident in the area of comprehensive water resources planning, as demonstrated by this plan. Many states have also raised new funds to support greater state participation in water resources management.

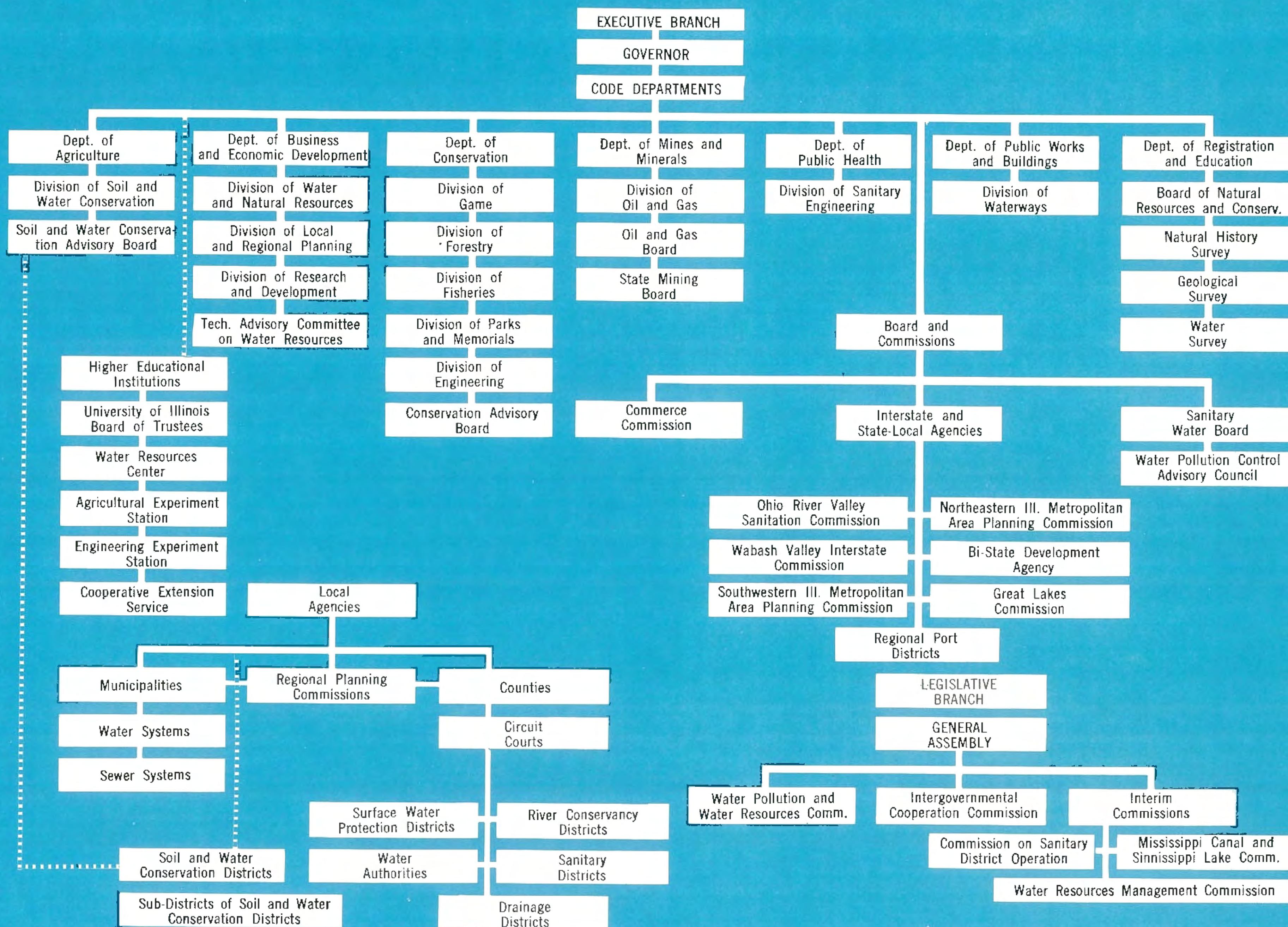
Under the Federal system, all powers not granted to the Federal Government are reserved for the states. State regulation of water use is specifically derived from their general police powers. In Illinois, the General Assembly has enacted a voluminous amount of legislation pertaining to water resources which, in summary, authorizes State agencies to engage in numerous activities, authorizes the creation of various local districts, and institutes many regulations pertaining to water use.

The political subdivisions of the State, that is, local governmental units, may exercise only those powers delegated by the General Assembly. Through legislation, municipalities, counties, and townships have received authorization to engage in varied water resources functions. In addition, the General Assembly has sanctioned the creation of a host of special purpose districts with power to furnish different water services. Indeed, Illinois is unique in the number of different special purpose districts that have been authorized.

All units of local government operate under statutory provisions which define their financial powers. These limitations have been extremely important with regard to the effectiveness of local governmental units in furnishing water services.

Part II of this chapter describes the activities of the various levels of government (Figure 1) and ends with a series of recommendations designed to enable the State and its political subdivisions to more effectively cope with the problems of the present and to adequately respond to the needs of the future.

FIGURE 1 ILLINOIS AGENCIES CONCERNED WITH WATER AND RELATED LAND RESOURCES



DEPARTMENT OF BUSINESS AND ECONOMIC DEVELOPMENT

The Department of Business and Economic Development was established by legislative action in 1965, replacing and enlarging the activities of the Board of Economic Development. The new Department is charged by law to develop programs designed to advance the State's economic growth.

Headed by a Director and Assistant Director, the Department promotes State economic growth through nine Divisions, each under the supervision of a Division Chief. The nine Divisions are: Water and Natural Resources, Export Expansion, Research and Development, Industrial and Community Development, Tourism, Local and Regional Planning, Information and Publications, State Technical Services, and Office of Economic Opportunity. The operations of the Department are supervised and administered from the central office in Springfield. In addition, offices are maintained in Chicago and Herrin, and a new office was recently established in Washington, D. C., to establish close liaison and working relationships with Federal agencies. The 1965 General Assembly also created a Commission for Economic Development to review the State's economic development activities and advise the Department on programs to further economic growth.

The enabling legislation calls for the Department to continue and expand, where necessary, industrial development, tourism, and community planning programs and to undertake new assignments in the areas of export trade expansion, research and economic analysis, and water resources planning and coordination.

Division of Water and Natural Resources

This new Division provides the State with the mechanism for coordinating its own efforts in water resources development and planning. It also acts as the compass point where State and Federal water resource development programs intersect. Studies begun under the State Plan to develop a water resources planning program will continue in conjunction with the seven State water agencies. The studies will include a broad analysis of Illinois' water resources—their current and future use.

Programs and activities include the preparation of this State water resources development plan as a guide for water management; coordination of the State's water programs through the Technical Advisory Committee on Water Resources to assure optimum water development; assisting that Committee in reviewing proposed Federal water development projects in Illinois; providing liaison and representing the State's interest in Federal water development programs; and serving in an advisory capacity to the Administration and the General Assembly.

Division of Research and Development

The Division of Research and Development, in carry-out the Department's responsibility as the official state planning agency, is responsible for the formulation of plans for the economic development of the State. This Division collects and disseminates information on power and natural resources; transportation; markets; labor; financial institutions; and industrial, recreational, and tourism potentials.

The Division is now preparing an intensive long-range study of population and economic activity, water resources, and capital facilities. The Division also has prepared an outdoor recreation plan for the State in cooperation with the Conservation Department.

Division of Local and Regional Planning

The Division gives technical assistance to eligible local governments seeking to engage in comprehensive planning programs and aids local governments which are now, or will be in the future, affected by development of large-scale projects, either public or private. The Division administers the Federal Urban Planning Assistance Program, commonly known as the "701" Program. It also develops procedural guides for cooperative planning efforts with the programs of other Federal and State agencies, such as the Farmers' Home Administration and the Illinois Division of Highways.

Technical Advisory Committee on Water Resources

The Committee (TAC) advises the Department on all technical matters where a conflict may exist or arise as to the maximum beneficial use of the water resources of the State. It reviews all proposed legislation concerning Illinois water resources and makes recommendations thereon to the Governor.

The Technical Advisory Committee on Water Resources consists of the Directors of the Department of Business and Economic Development; the Department of Conservation; the Department of Mines and Minerals; the Director of the Department of Agriculture, who is represented by the Superintendent of the Division of Soil and Water Conservation; the Chief Sanitary Engineer of the Department of Public Health; the Chief Waterway Engineer of the Department of Public Works and Buildings; the Chief of the Water Survey; the Chief of the Geological Survey; and the Director of the Water Resources Center of the University of Illinois. The Director of the Department of Business and Economic Development has been designated by the Governor as Chairman.

DEPARTMENT OF AGRICULTURE

Representing one of the leading agricultural states in the nation, the Illinois Department of Agriculture provides its services through a close relationship with the University of Illinois and United States Department of Agriculture. For the most part, the Department is a regulatory agency which enforces the many laws pertaining to agriculture. The Department has ten divisions and is administered by a Director appointed by the Governor.

Division of Soil and Water Conservation

The Division administers the Soil and Water Conservation District Law within the policies of the Illinois Department of Agriculture.

The Division prepares a biennial budget; disperses State funds allocated for district use; provides instructions and materials for election of district directors; reviews and expresses opinions on any rules, regulations, ordinances, or other action taken by district directors; seeks the cooperation of other State and Federal agencies in facilitating the work of the districts; keeps district directors informed of experiences of other districts; requires that districts file copies of minutes of meetings, rules, regulations, ordinances, and contract forms with the Division; provides information and advice on Watershed Development Programs and investigates and reports on applications to the Governor; assists the Director with program development on request; conducts administrative training programs for district directors; and has assisted in and supervised the organization of Soil and Water Conservation Districts in Illinois. (The latter job is completed.)

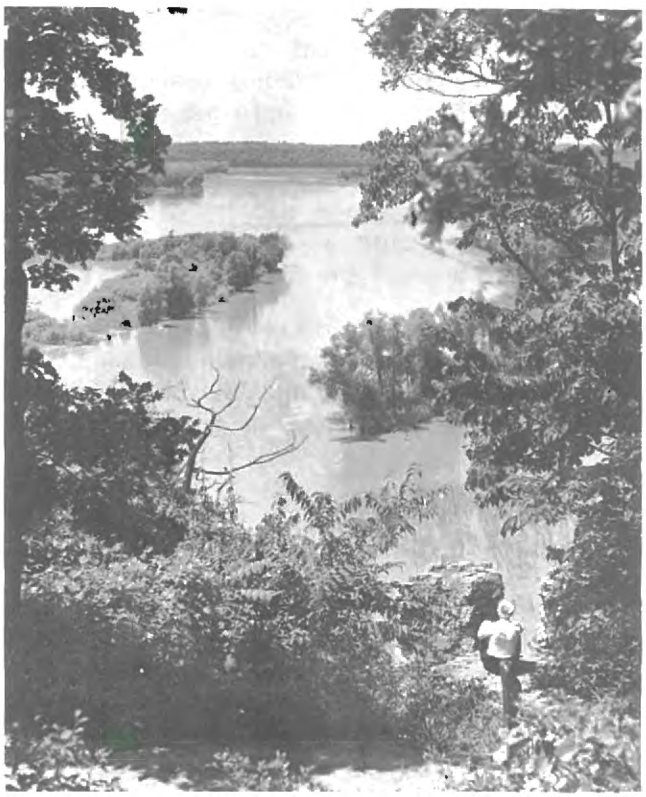
The State Soil and Water Conservation District Advisory Board acts in an advisory capacity to the Department in establishing policy under the Act and in its administration.

DEPARTMENT OF CONSERVATION

The Department of Conservation is responsible for the administration and enforcement of the game and fish codes, forestry laws, Boat Registration and Safety Act, and Open Cut Land Reclamation Act, together with the operation and maintenance of all State parks and memorials. In addition, it is the purpose of the Department to take all measures necessary, where statutory authority exists, for the conservation, preservation, distribution, introduction, propagation, and restoration of the fauna and flora of the State. The Department has also determined that an aggressive and active water development program is essential to benefit fish, wildlife, and recreation. Under a Director appointed by the Governor, the Department's activities are carried out through eight Divisions.

Division of Engineering

It is the primary responsibility of the Engineering Division to correlate all planning, engineering, construction, and land acquisition for the several Divisions of the Department of Conservation. Planning and engineering projects handled by the Division include park and recreational developments; facilities for public hunting and fishing; public access to major waterways and lake developments;



water supplies, sanitation, power, and other utilities necessary for public use of conservation properties.

A statewide lake program is part of the Division's activities. This includes studies of potential lake sites, foundation explorations, hydrologic and hydraulic studies, cost and other factors, all of which are pertinent to the creation of conservation lakes used for recreation and game management. A major portion of the Division's activities has been directed toward the continuation of the Lake Construction Program. Besides design and construction of lakes, the program includes the planning and construction of access roads and recreational developments for the surrounding shoreline areas. Specific projects include the planning of State-sponsored recreational developments for the Carlyle Reservoir and Shelbyville Reservoir projects and preliminary studies for similar participation on the Rend Lake project.

Division of Fisheries

The major objective of the Division of Fisheries is to promote the use of fishery resources of the State for the greatest good for the greatest number of people. Work toward this objective includes providing fishery management services, creating artificial sport fishing lakes, and cooperating with other agencies (Federal, State, and local) in water development projects where sport fishing is an important potential, and acquiring public access areas for fishermen on existing sport fishing waters in or near locations lacking facilities.

Each year fishery biologists complete more than 1500 separate surveys, including analyses of fish populations in State waters and creel censuses. In addition, the Division is involved in an inventory of all waters of the State, including natural and artificial lakes, ponds, and streams. A continuous field inventory of fish in streams in important watersheds throughout the State is in progress.

One of the most serious fish conservation problems is water pollution. Reports of all fish kills caused by pollution are turned over to the State Sanitary Water Board for appropriate action, as provided by law.

Division of Game

The objective of the Division of Game is to determine the best possible use of all natural resources as they affect game numbers, distribution, and harvest. Biologists on the Division staff are involved in waterfowl management, upland game, forest game, and population studies. A farm supervisor is in charge of land use practices on State lands, including the manipulation of crops and cover to the best advantage of game. In addition to various State programs, the Shawnee Forest project, in cooperation with the United States Forest Service, provides planning for forest openings, ponds, and other development within the national forest to maintain and develop suitable habitat for game.

Division of Parks and Memorials

The Department of Conservation, through the Parks and Memorials Division, is responsible for acquiring, developing, and maintaining parks, conservation areas, nature preserves, and other scenic and unusual natural areas for the enjoyment of the people of the State. In an effort to provide guidelines for recreational development, the Department of Business and Economic Development and the Department of Conservation cooperated in the preparation of a statewide recreation plan. The plan is comprehensive in scope and focuses on urban, regional, and statewide recreational needs.

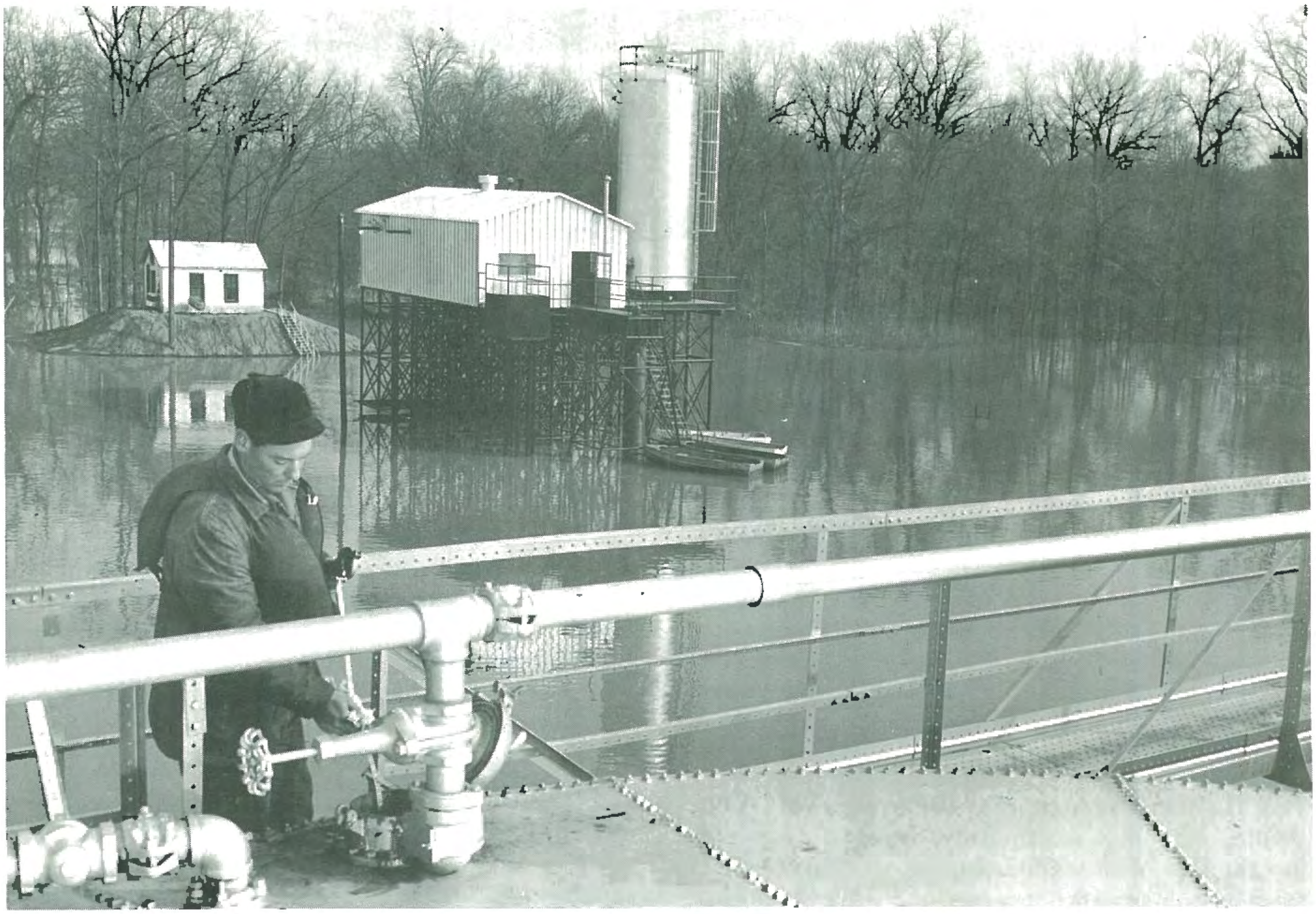
In a continuing effort to provide new recreational facilities, the Division of Parks and Memorials, in cooperation with the Corps of Engineers, has developed plans for a State park on the west shore and another area on the south shore of Carlyle Reservoir on the Kaskaskia River. Additional parks will be developed in conjunction with the Shelyville Reservoir.

Division of Forestry

The Forestry Division is responsible for the well-being of 4 million acres of existing native woodland and 3 million acres of sub-marginal and idle land throughout Illinois. Four State forests, which cover a total of 11,000 acres, are managed as public demonstrations of profitable management on lands best suited for timber production. Each year the Division grows and distributes more than 10 million forest tree seedlings and shrubs to rehabilitate idle or eroded land and to improve wildlife habitat.

Open Cut Land Reclamation

The General Office is responsible for administering basic requirements of the Open Cut Land Reclamation Act. The purpose of the Act is to require that effort be made by mine operators to reclaim lands affected by open cut or surface mining and, thereby, to encourage the conservation and use of such lands. After an operator has met various requirements for permit, bond, and fees, he may undertake reclamation of the land for forest, horticulture, pasture, or row crop production, or for recreational and wildlife development, or other useful purposes which have been approved by the General Office.



DEPARTMENT OF MINES AND MINERALS

It is the function of the Department of Mines and Minerals, among its other duties, to gather and distribute information concerning the improvement of methods, conditions, and equipment of mines with special reference to health, safety, and conservation of mineral resources; to make inquiries into the economic conditions affecting the mineral industries of the State; and to promote the technical efficiency of all persons working in mines.

Headed by a Director appointed by the Governor, the Department carries out its functions through the State Mining Board, the Division of Oil and Gas, the Miner's Examining Board, and the Oil and Gas Advisory Board.

State Mining Board

The Board administers the Coal Mining Act and makes interpretations on the provisions of the Act, sees that all mines are operated so that they comply with the provisions of the Act, and at all times sees that the health and safety of persons employed in the mines are protected to the fullest extent.

The Mining Board has the authority to make any reasonable rules and regulations necessary to prevent the pollution of fresh water supplies by oil, gas, or salt water. Permits must be obtained from the Mining Board for drilling all water wells, as well as gas and oil wells, and for plugging wells. For those water wells which penetrate the glacial drift, a $10 fee permit is required. In addition, the Board is authorized to prohibit wells which would pollute, by oil, gas, or other foreign substances, fresh water supplies.

Division of Oil and Gas

The Oil and Gas Division enforces legislation that pertains to the prevention of waste and dissipation of oil and gas resources. By strict enforcement of the spacing requirements, the Division prevents the drilling of an excessive number of wells on small tracts of land. The Division acts as arbitrator, through the medium of a public hearing, and solves many problems among the operators, landowners, and royalty owners regarding drainage claims and drilling units.

DEPARTMENT OF PUBLIC HEALTH

The Department, in fulfilling its responsibilities for protecting the health and lives of the people of the State, has definite functions relative to water supplies, sanitary investigations, swimming pools and other swimming facilities, and laboratory tests and examinations of water and sewage. Of the nine Divisions within the Department, the Division of Sanitary Engineering has main responsibility for health aspects of water.

Division of Sanitary Engineering

The Division is responsible for the promotion of the public health through the control of environmental factors. These include: a) maintaining the safety of public water supplies under the Public Water Supply Control Law; b) the proper operation of municipal, industrial, and institutional waste treatment plants to prevent stream pollution; c) the completion of stream surveys to determine the source and extent of pollution and to maintain a working knowledge of the water quality of all surface waters in Illinois under the Sanitary Water Board Law; and d) maintenance of safe swimming pools under the Swimming Pool Law. The Division also provides consulting services on environmental factors to other agencies of State government, to local governments, and to individuals.

The Division, through the Department of Public Health, acts in a supervisory capacity relative to the sanitary quality and adequacy of proposed and existing public water supplies and water treatment and purification works, administers mandatory operator certification, and prepares and enforces rules and regulations relative to the installation and operation of public water works. Besides routine checks of water supplies, sewage treatment plants, and industrial wastes, the bacteriological safety of more than 1400 public water supplies and 1100 public swimming pools is the responsibility of the Division.

State Sanitary Water Board

Regulation of water pollution is the responsibility of the State Sanitary Water Board. The Board has the power to determine whether pollution exists in any of the waters of the State.

The Board's members include the Directors of the Departments of Public Health, Agriculture, Conservation, and Public Works and Buildings, and two members appointed by the Governor to represent industrial interests and municipal governments. The Chief Sanitary Engineer of the Department of Public Health serves as Technical Secretary of the Board. The Board is an independent agency, but has its administrative offices in the Department. Also, the engineers of the Division of Sanitary Engineering provide primary technical assistance to the Sanitary Water Board.

The Board has rather broad powers for controlling water pollution. A permit must be obtained from the Board before a person may undertake certain activities which would affect the quality of the waters of the State. The board is empowered to issue, continue in effect, deny, revoke, or modify any permit when, after a hearing, it determines that such action is necessary.

In addition, the Board may order discontinuance of pollution, specifying the conditions and time within which the discontinuance is to be accomplished. The Board may institute legal proceedings to compel compliance with the statutes. It may make such investigations as it deems necessary upon receipt of information indicating a possible violation.

The Board also is responsible for preparing a general comprehensive plan for the abatement of existing pollution and prevention of new or imminent pollution, as well as for conducting research to discover economical and practical methods of preventing pollution.

DEPARTMENT OF PUBLIC WORKS AND BUILDINGS

The Department of Public Works and Buildings, on behalf of the State, has jurisdiction and supervision over all of the rivers and lakes in which the State or the people of the State have any rights or interests. The Department is headed by a Director appointed by the Governor. Water resources activities are conducted by the Division of Waterways.

Division of Waterways

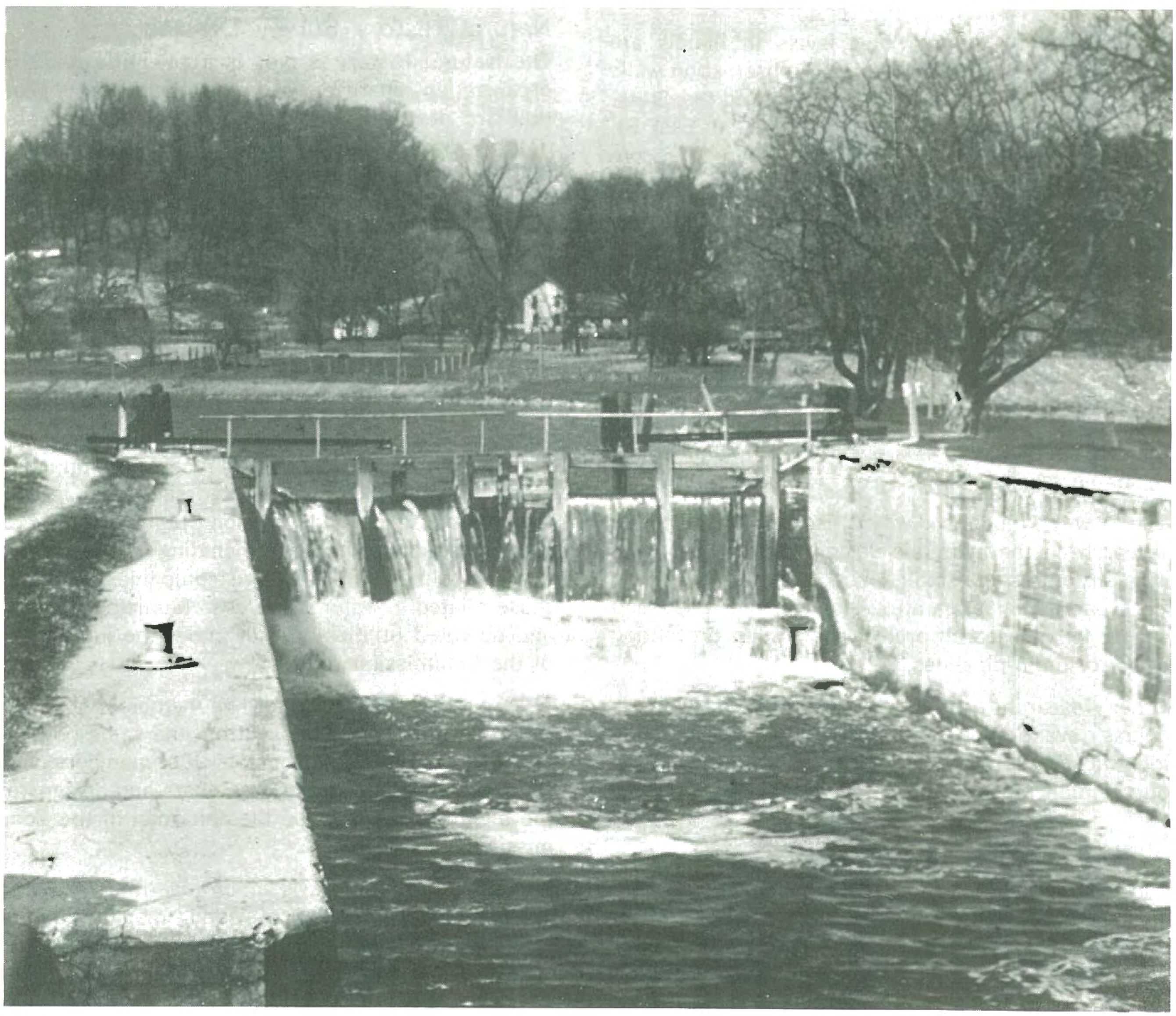
The Division has statutory duties which relate to the conservation, regulation, control, and use of the surface-water resources in Illinois. The statutory authority extends to five general areas: 1) surveys and investigations and reporting upon surface-water problems, including such phases as flood and low flow control, recreational navigation, power and erosion control; 2) the design, construction, and maintenance of such projects as may be designated by the General Assembly; 3) the issuance of permits and the regulation of construction affecting public waters; 4) the operation and maintenance of fifteen movable bridges, two ferries, one lock for recreational navigation, and maintenance of navigation lights on twenty-four fixed bridges on the Illinois Waterway; and, 5) the operation and maintenance of the Illinois and Michigan Canal.

The Division investigates any attempts to interfere with navigation and any encroachment upon public waters. Plans must be submitted to and permits issued by the Division before it is lawful to erect or make any structure, fill, or deposit in any public waters. It may require proper maintenance and modifications of existing dams to attain the proper control of water levels in the disposal of flood waters and waters at normal stages. Non-riparians must obtain permits to use water from public bodies of water for industrial, manufacturing, and public-utility purposes.

The Division maintains an inventory by county of all waters in the State and acts as a depository for data on navigability, deep waterways, and related subjects. It also gathers data on the availability of streams for water power; it furnishes, at cost, data and advice as to reclamation and drainage of lands. In cooperation with the U. S. Geological Survey, State Geological Survey, and State Water Survey, the Division maintains stream gaging stations on many State streams.

The Division makes examinations and surveys, prepares plans and estimates for, constructs, maintains, and operates or supervises all works for the control of floods, the improvement of upland and bottom-land drainage, and the conservation of low water flows in the rivers and waters of the State.

When so authorized by the General Assembly, the Division may cooperate with proper agencies of the United States Government, local governmental units, and persons and associations in planning and constructing improvements for flood control and in the conservation, regulation, development, and use of water resources. The Division has control and management of the Illinois and Michigan Canal and the locks and dams and other improvements of the navigation of the Illinois and Little Wabash Rivers.



DEPARTMENT OF REGISTRATION AND EDUCATION

The Department contains the State Scientific Surveys. The Geological, Natural History, and Water Surveys are located on the Urbana campus of the University of Illinois. The Board of Natural Resources and Conservation directs the programs of the Surveys.

State Water Survey Division

Established in 1895, the Water Survey is responsible for the scientific study of the water resources of Illinois. The Water Survey studies the available amount and chemical quality of waters. It develops methods of water use, measurement, and conservation, and when the need arises, studies ways to extend water sources that are becoming inadequate. In addition to its headquarters at Urbana, other facilities include a meteorology laboratory at the University Airport, a research laboratory at Peoria, and regional offices at Naperville and Edwardsville.

Fluctuations of ground-water levels in Illinois are studied through a network of 220 observation wells in 42 counties representing all areas of the State. This program includes special studies at East St. Louis, Peoria, and Chicago, where there are concentrations of population and industry and heavy pumpage of ground water. The entire State has been studied for possible artificial ground-water recharge sites; estimates of potential recharge amounts at various locations are in progress.

Because many sections of the State rely on surface water for supplies, a study of suitable reservoir locations throughout the State has been initiated. Sedimentation surveys, which have been conducted for the past 20 years, are an aid in planning dependable reservoirs.

The Survey's model spillway is used for experimental research on the hydraulic design of drop-inlet spillway structures on small lakes or reservoirs. Also an experimental apparatus has been designed and set up for a research project concerning prevention of corrosion in pipelines.

Other research activities are concerned with reducing evaporation and plant transpiration, the identification of organic acids in natural waters, and rainfall radioactivity.

State Geological Survey Division

The Geological Survey is responsible for research and service in the area of mineral resources, topographic mapping, and geology. The Survey collects and maintains a public file of logs of all types and cuttings of drillings; prepares monthly, quarterly, and annual reports; and carries on research on subsurface petroleum geology, water flooding problems, and ground water.

In research and public service on ground-water supplies, the Geological Survey works closely with the Water Survey. In this respect, the Geological Survey is responsible for research and information on geology and geophysics. One cooperative effort includes investigations of the ground-water resources of the Chicago region. Geophysical work includes electrical resistivity surveys to determine the location of sand and gravel aquifers.

Ground-water geologists with the Survey use basic information derived from logs and cores taken during exploratory drilling for water, gas, oil, and coal. The files of logs at the Survey contain records of more than 170,000 wells drilled in every county of the State. The Survey reports apply primarily to the occurrence, movement, quality, and quantity of water in the various aquifers of the State.

Natural History Survey Division

The Natural History Survey is a scientific research organization charged with investigating 1) pests that are destructive to crops, livestock, renewable natural resources, homes and gardens, or transmit human disease or cause human discomfort; and, 2) the various kinds of wildlife in Illinois that have a high commercial or recreational value. In addition to its activities in these areas, the Survey is concerned with pollution as it affects fish and wildlife populations throughout the State.

ILLINOIS COMMERCE COMMISSION

The primary duty of the Illinois Commerce Commission is to make certain that residents of the State who use utility services receive continuously safe, efficient, and uninterrupted service at reasonable rates. The Commission regulates several thousand utility companies, including electric, water, water pipeline, and sewerage companies, to name those related to water resources. Municipally owned and operated utilities are not under the jurisdiction of the Commission.

The Commission consists of five members, not more than three of whom may be from the same political party. The Governor appoints the members with the advice and consent of the Senate and designates the member who is to be the chairman of the Commission.

The Commission has jurisdiction regarding rates and other charges, services provided, management of property, and issuance of stocks and bonds. Before a new plant, equipment, property, or facility may be constructed, a public utility certificate must be obtained from the Commission showing that public convenience and necessity require such construction.

UNIVERSITY OF ILLINOIS

Water Resources Center

In 1963 a Water Resources Center was established by the Graduate College of the University of Illinois on the Urbana campus. Soon after passage of the Water Resources Research Act of 1964, the Center was designated by the Governor as the participating institute under Title I of the Act. The purpose of the Center is the administrative coordination of the broad range of inter-disciplinary programs relating to water which are now in operation at the University.

An Executive Committee is responsible for the development of general policies related to the activities of the Center. The Executive Committee and the Director have the assistance of a Technical Advisory Committee, which consists of technical experts from the faculty in the disciplines contributing to the water resources efforts of the University. Also, a statewide Advisory Committee consisting of representatives of other Illinois universities and officials of various State agencies involved in water resources development advises the Center on research needs.

A wide variety of colleges, departments, and other units of the University, including the Engineering Experiment Station and the Agricultural Experiment Station, are engaged in various aspects of water resources research. Current research includes the hydrologic cycle, water quality and pollution, and socio-economic aspects of water resources.

Cooperative Extension Service

The Cooperative Extension Service is the off-campus teaching arm of the College of Agriculture which disseminates useful information about agriculture, home economics, and related subjects. The educational programs of the Cooperative Extension Service are aimed at broad groups and include within the major areas of concern the production, management, and use of natural resources, and community and area resource development.

WATER POLLUTION AND WATER RESOURCES COMMISSION

Approved during the last legislative session, the Commission was created to survey and study problems pertaining to waterways, drainage, flood control, water pollution, and water resources. The Water Resources and Water Pollution Commission, organized in November 1965, is composed of nine members: three from the Senate, three from the House of Representatives, and three appointed by the Governor. The Commission's studies include the following items as they relate to waterways, drainage, flood control, water pollution, and water resources:

1) The progress and problems of the State government and of counties, municipalities, and other political subdivisions of the State;

2) The interrelationship among the various units of government in the administration of their respective programs and projects, and the necessity and feasibility of developing general comprehensive plans among such units of government to more effectively deal with the problem areas mentioned above;

3) The cost of administering the various projects and programs, and the financial structure and sources of revenue of the various units of government with such programs or projects;

4) The desirability and feasibility of the State government establishing grants-in-aid to such counties, municipalities, and other political subdivisions for such programs and projects, or of establishing State programs in regard to the problem areas mentioned above; and

5) The water laws of the State to determine the need for revision or further codification in this area.

In the course of such studies, the Commission is to consult and cooperate with the Technical Advisory Committee on Water Resources.

WATER RESOURCE MANAGEMENT COMMISSION

An Act approved by the 74th General Assembly creates a temporary commission to study the necessity for or advisability of establishing a compact with Wisconsin for the investigation and correction of problems of water pollution in areas common to the two states, including but not limited to the Fox River area.

If the Commission finds that a compact is advisable or necessary, it is to draft such a document. It is to cooperate with and solicit the cooperation of Wisconsin officials and to report its findings and recommendations to the General Assembly by February 15, 1967.

The Commission is composed of five members of the Senate, five members of the House of Representatives, and ten persons appointed by the Governor. The Commission terminates on June 30, 1967.

INTERSTATE COMPACTS

BI-STATE DEVELOPMENT AGENCY

Adopted in 1949, an interstate compact between Illinois and Missouri provided for the establishment of the Bi-State Development Agency to have jurisdiction in the St. Louis East-St. Louis Metropolitan Area. The Agency has the power to plan and establish policies for sewerage and drainage facilities and to submit plans to the communities involved for coordination of their water supply and sewage disposal works, as well as recreational and conservation facilities or projects. In 1953 an addition to the compact enlarged the powers of the Agency.

The Bi-State Agency consists of ten commissioners, five from Missouri and five from Illinois. All commissioners must reside within the Bi-State District. The Illinois commissioners are appointed by the Governor with the advice and consent of the Senate.

The Agency makes plans for the development of the district and recommends legislation to the participating states for improvement of facilities in the district. In addition, it offers advice and assistance to municipal officials in the development of projects.

GREAT LAKES COMMISSION

In 1955 the Great Lakes states, under the Great Lakes Basin Compact, established the Great Lakes Commission. The compact, which recently received Federal approval, designates the Commission as the joint instrumentality of the states on Great Lakes water resource developments, programs, and problems. In recent action, the Great Lakes River Basin Planning Commission under Title II of the Water Resources Planning Act of 1965 was approved. Organizational meetings are now being held.

The Great Lakes Commission is composed of from three to five members from each of the eight Great Lakes states (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin). They are selected in accordance with the provisions of each state's enabling legislation. Each state has three votes. The program of the Commission is carried through at least two annual meetings, five standing committees, special committees as needed, and the staff at its office in Ann Arbor, Michigan.

The Commission provides three general services to the member states. a) It serves as a clearing house for information on important developments on the Great Lakes and prepares special reports and studies to aid governmental officials and others in the use, development, and conservation of these water resources. b) It provides the states with a recognized and continuing council, under their direction and control, for joint consideration of common and regional problems on the Great Lakes. c) It coordinates state views and plans and recommends programs and policies at all levels of government which are in the interests of the states and the region.

WABASH VALLEY INTERSTATE COMMISSION

The Wabash Valley Compact of 1959 between Illinois and Indiana established the Wabash Valley Interstate Commission. The purpose of the Commission is to encourage and facilitate coordinated development of the Wabash valley as a region and to relate its agricultural, industrial, commercial, recreational, transportation, developmental, and other problems to the opportunities in the valley.

The Commission is composed of seven commissioners from each state, each appointed in accordance with the law of the state he represents. The Federal Government also may be represented, but its representative does not have voting privileges. The Commission may establish a technical advisory committee composed of representatives of such departments or agencies of the member states as have significant interest in the Commission's work.

The Commission is specifically charged with encouraging citizen organization and action to promote the Compact's objectives. In addition, it recommends integrated plans and programs for the conservation, development, and use of the resources of the Wabash valley and correlates the necessary research and development activities for doing so.

OHIO RIVER VALLEY WATER SANITATION COMMISSION

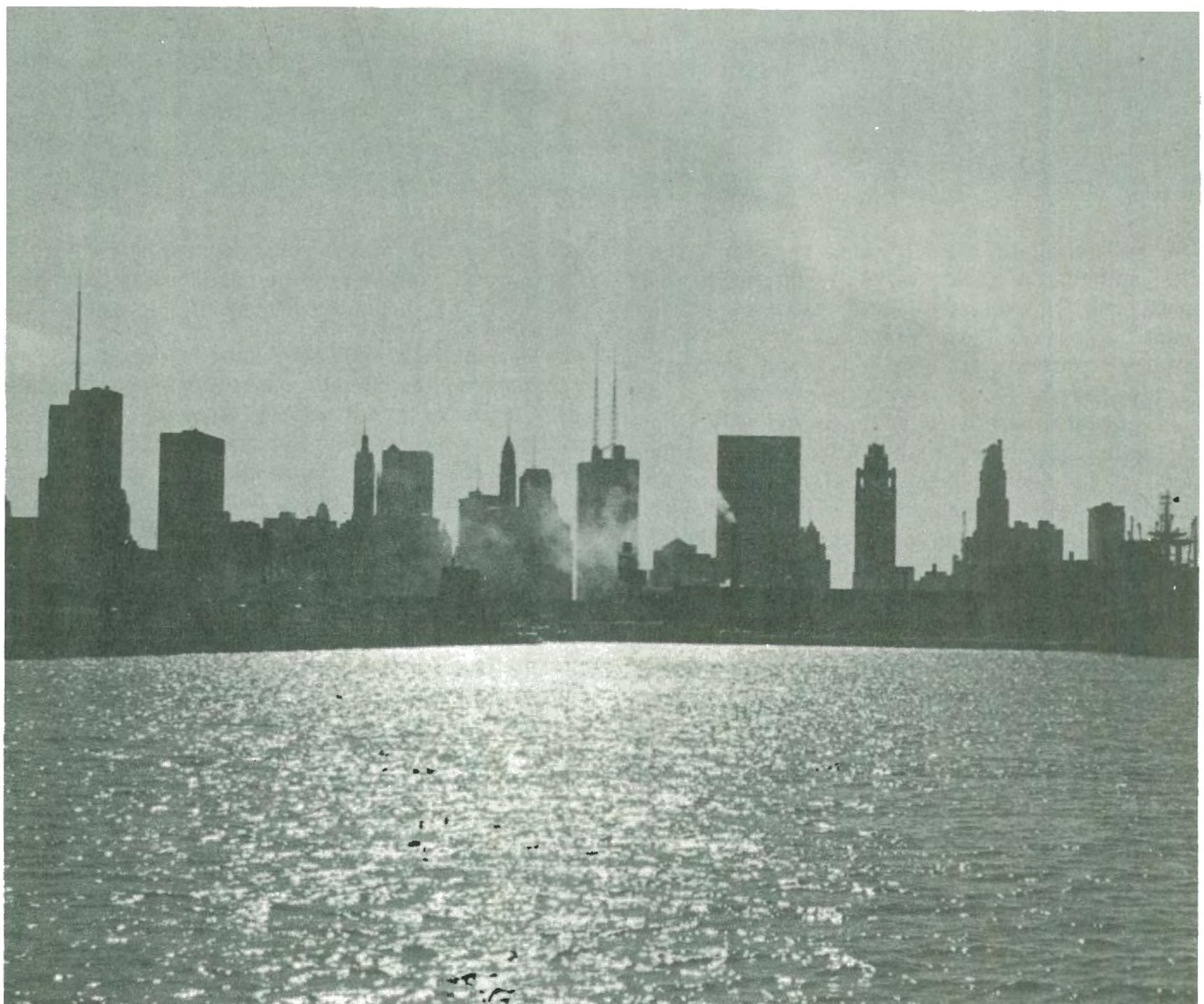
The Ohio River Valley Water Sanitation Commission, referred to as ORSANCO, was formed to implement a compact signed in 1948 by eight states—Illinois, Indiana, Kentucky, Ohio, New York, Virginia, Pennsylvania, and West Virginia—whose watersheds furnish most of the water to the Ohio River. The purpose of the Commission is to reduce pollution of the Ohio River by encouraging uniformity in regulations and their enforcement. It also attempts to bring about the cooperation of industries and municipalities in the Ohio River Basin in building and operating treatment facilities and other devices to prevent contamination from reaching the Ohio River and its tributaries.

The Commission is composed of 27 members, including three from each of the eight states who are appointed by the governors and three who are appointed by the President of the United States to represent the Army Corps of Engineers, the Public Health Service, and the Department of the Interior. A staff, headquartered at Cincinnati, Ohio, is headed by an executive director-chief engineer, who has technical and administrative assistance.

More than 40 monitoring stations provide ORSANCO with water quality data. In addition, it has developed a "robot" monitor for continuous recording and reporting of conditions in strategic locations along the Ohio River. The Commission also conducts technical studies and investigations, encourages and supports cooperation in research on industrial wastes, and carries on educational activities.

ILLINOIS COMMISSION ON INTERGOVERNMENTAL COOPERATION

It is the function of the Illinois Commission on Intergovernmental Cooperation to carry forward the participation of the State as a member of the Council of State Governments. The Commission also encourages and assists the legislative, executive, administrative, and judicial officials and employees of the State in developing and maintaining friendly contact and cooperation between Illinois and other units of government. Of particular interest is the Interstate Conference on Water Problems, an activity of the Council of State Governments in which Illinois participates.



FEDERAL AGENCIES

The Federal Government, through numerous agencies, administers a wide variety of programs which touch upon all aspects of water resources management. Recently, these programs have been increased substantially. The full scope and depth of the Federal Government's involvement in the area of water resources is much too complex to be treated fully here. Rather, this chapter centers upon those Federal water programs which offer assistance to the State and its subdivisions. These programs are sketched, not detailed. Further information may be obtained from the administering agencies which, when appropriate, have been listed.

CORPS OF ENGINEERS

As authorized by the Congress in omnibus rivers and harbors and flood control acts, the Corps of Engineers administers an extensive civil works program involving a wide assortment of projects ranging from local flood control improvements to comprehensive river basin development.

All Corps of Engineers' projects, as well as project investigations and surveys, must be specifically authorized by the Congress. Local projects are generally initiated by interested citizens' groups who bring problems and proposals to the attention of their senators and congressmen. These legislators in turn consult with the public works committee of either the Senate or House of Representatives.

In local projects for flood control or navigation improvement, the Federal Government pays almost the entire cost, but usually requires a local contribution which may be in cash or lands or right-of-way privileges. The Corps may also require guarantees from a local group or governmental unit to insure the continued maintenance and proper operation of facilities.

In larger multi-purpose developments, the Congress has required that the Federal Government must be reimbursed for the cost of certain purposes, sometimes with interest. For example, the cost assigned to flood control is non-reimbursable, but the cost assigned to municipal and industrial water supply is reimbursable with interest.

The Corps of Engineers is also coordinating a number of comprehensive river basin studies. Illinois is currently participating in four such comprehensive studies in the Ohio, upper Mississippi, Wabash, and Big Muddy River Basins. In addition, the Corps of Engineers has been delegated responsibility for providing relief and assistance during floods.

DEPARTMENT OF THE INTERIOR

Federal Water Pollution Control Administration (FWPCA)

The Water Quality Act of 1965 enlarged and extended the provisions of the Federal Water Pollution Control Act of 1956. The 1965 Act established a Federal Water Pollution Control Administration to carry out the Federal Government's pollution control programs. Formerly, the function was administered by the U. S. Public Health Service.

The FWPCA distributes grants to local communities to assist in the construction or improvement of sewage treatment plants, interceptors, and outfalls. The maximum amount of Federal aid may not exceed 30 percent of the project's total cost, or $1.2 million for a project serving a single community, or $4.8 million for a multi-community project, whichever is less.

If a state agrees to match all Federal funds, the dollar ceilings of $1.2 million and $4.8 million can be waived. In this case, the Federal share still cannot exceed 30 percent. The Secretary of the Interior can increase the grant by 10 percent for a community sewerage project that is part of a comprehensive metropolitan development plan.

Another FWPCA program offers grants to states, municipalities, and other agencies for projects that demonstrate a new or improved method of controlling the discharge of untreated or inadequately treated sewage from storm or combined sewers.

To assist states and interstate agencies in financing pollution control programs, the FWPCA provides grants for up to two-thirds of the cost of such programs. The FWPCA will also provide technical assistance to state and local agencies.

Bureau of Sport Fisheries and Wildlife

As authorized in the Fish Restoration and Management Act of 1950, as amended, and the Fish and Wildlife Act of 1956, the Bureau administers a grant program for fish and wildlife restoration. The purpose of the program is the investigation, development, and maintenance of fish and wildlife habitat, and the acquisition of land for such purposes. Grants are available for up to 75 percent of the cost of projects for the investigation, acquisition, and development of fish and wildlife habitat. These grants are distributed to state fish and game departments. Counties and other political subdivisions may cooperate in carrying out a project at the discretion of the state.

Bureau of Outdoor Recreation

The Land and Water Conservation Fund program is administered by the Bureau of Outdoor Recreation. The enabling legislation is the Land and Water Conservation Fund Act of 1965. The purpose of this program is to assist Federal, State, and local recreation units in meeting present and future demands and needs for outdoor recreation.

Financial aid is available to the states for planning and development. Grants not exceeding 50 percent of the cost of preparing statewide outdoor recreation plans or for keeping such plans up-to-date are available to the states. In addition, the states may receive grants not to exceed 50 percent of the cost of acquiring and developing land and water areas for recreation.

Governmental units which are eligible to receive Land and Water Conservation Funds include the states and certain Federal agencies. The states may allocate a portion of the money they receive to their political subdivisions. To be eligible for these funds, the political subdivisions must present project plans which are in accord with the state's comprehensive outdoor recreation plan.

Illinois has prepared a comprehensive outdoor recreation plan, **Outdoor Recreation in Illinois,** which has been approved by the Bureau of Outdoor Recreation. Funds allocated to Illinois will be distributed as follows: a minimum of 70 percent of the funds available will be used for State projects; a maximum of 30 percent may be distributed to local governmental agencies for qualified projects. Distribution of the funds is administered by the Illinois Department of Conservation. Local plans are submitted for approval to the Department of Business and Economic Development.

Office of Water Resources Research

Enabling legislation for this program of research is contained in the Water Resources Research Act of 1964. The Act provides annual grants, administered by the Office of Water Resources Research, for the operation of water resouces research institutes at the state land-grant college or at another educational institution designated by the state legislature. In addition, matching grants are available to such institutes for specific research projects. The Water Resources Center at the University of Illinois has been designated as the participating institute in Illinois. Grants, as well as other arrangements, may also be made to other organizations, both public and private, for research on water problems.

DEPARTMENT OF AGRICULTURE

Agricultural Stabilization and Conservation Service

The ASCS offers two programs designed to promote adequate land and water conservation practices. The Land Use Adjustment and Cropland Conversion Program assists farmers in converting land regularly used for the production of row crops, small grains, and hay to income-producing recreational areas, pasture, farm forests, water storage, and wildlife habitat. Farmers and ranchers, individually or in groups, may receive adjustment payments, incentive payments, cost sharing grants, and other assistance. Applications for assistance are handled by the Agricultural Stabilization and Conservation Committee of each county.

A second ASCS program, Agricultural Conservation, is intended to encourage good conservation practices by sharing with farmers the cost of carrying out soil-building and soil and water conservation practices. Farmers and ranchers, individually or in groups, are eligible for cost sharing grants. Projects are approved by the County Agricultural Stabilization and Conservation Committee.

Farmers' Home Administration (FHA)

The FHA's programs are directed to farmers and rural residents living in or near small rural communities who are unable to obtain credit from other sources at reasonable rates and terms. Authorization has been included in a number of laws, including the Consolidated Farmers' Home Administration Act of 1961, as amended, the Food and Agriculture Act of 1962, and the Rural Water and Sanitation Facilities Act of 1965.

Loans, and in some cases grants, are available to individuals for a wide variety of purposes, including farm purchase and enlargement; conservation, utilization, and development of land and water resources; establishment of income-producing recreational enterprises; improvement of water supply systems for home use, irrigation, and livestock; and refinancing of debts.

Loans, technical assistance, and grants are also available to groups, associations, local organizations, and local public agencies for water and waste disposal systems, drainage and soil conservation measures, resource conservation and development, planning in designated rural renewal areas, and other activities. Loan funds may be applied toward the applicant's share of the cost of flood control dams and reservoirs, irrigation canals, drainage projects, and recreational facilities.

Grant funds are also available to public bodies for the preparation of comprehensive plans for rural water and sewerage systems. Development projects must be consistent with any existing comprehensive plans. In 1968, a comprehensive plan will be a prerequisite for water project development grants.

FHA programs are administered through county and area offices. There are 35 local and 5 area FHA offices in Illinois. The area offices are in Oregon, Rushville, Effingham, Fairfield, and Harrisburg; the state office is in Champaign.

Soil Conservation Service

The SCS administers three programs concerned with the management of water and land resources.

The Resource Conservation and Development Program, authorized by the Food and Agriculture Act of 1962, aids soil and water conservation districts, local governmental units, and non-profit private associations in planning and designing improvements involving erosion and sediment control, flood prevention, irrigation, and drainage. The SCS supplies technical assistance, while financial assistance in the form of 30-year loans can be obtained from the Farmers' Home Administration. Loans exceeding $250,000 require specific Congressional approval. Projects must be consistent with an overall economic development plan, if one exists, and priority is given to projects of considerable size, i.e., in two contiguous counties.

The P. L. 46 Program provides funds for the salaries, maintenance, and necessary equipment to be used by technicians who directly assist Soil and Water Conservation Districts in the application of land treatment measures.

For water management in Illinois, the Small Watershed and Flood Prevention Program (Public Law 566) has proved very important. Under this program, the SCS provides technical assistance for planning and will bear the total cost of engineering and other services allocated to flood prevention, agricultural water management, and public recreation or fish and wildlife development. SCS grants can cover the following portion of the construction costs: a) the total amount allocated to flood prevention; b) up to 50 percent of the amount allocated to agricultural water management, public recreation, fish and wildlife development; and c) up to 50 percent of the cost of land rights required for public recreation or fish and wildlife development. Loans are available from the Farmers' Home Administration to pay the local sponsoring organization's share of the cost. Eligible organizations include state agencies, counties, municipalities, soil and water conservation districts and subdistricts, special purpose districts, water users' organizations, and similar non-profit groups. In Illinois, the SCS programs are administered through seven area offices at Sterling, Kankakee, Macomb, Pekin, Effingham, Edwardsville, and Carbondale. The state office is in Champaign.

DEPARTMENT OF COMMERCE

Economic Development Administration (EDA)

Created by the Public Works and Economic Development Act of 1965, the EDA, which supercedes the Area Redevelopment Administration, offers technical assistance, grants, and loans for public works and development facilities to prevent substantial and persistent unemployment and under-employment in economically distressed regions. Eligible projects include watersheds and waterlines, sanitary and storm sewers, waste treatment works, watershed protection, flood prevention directly related to economic development, and residential water and sewerage facilities that contribute indirectly to economic development.

Any state, political subdivision, Indian tribe, or private or public non-profit organization representing a redevelopment area or part of one can apply for a grant or loan. Grants are made for up to 50 percent of the total cost of needed public works and public services or facilities. The Secretary of Labor certifies areas to be eligible on the basis of substantial unemployment.

In addition to direct grants, supplementary grants are designed for areas of greatest economic distress which lack the required matching share necessary to take advantage of this and other Federal grant programs. However, combined direct and supplemental Federal grants cannot total more than 80 percent of the cost of a project. The Herrin Office of the Department of Business and Economic Development administers the EDA program in Illinois.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Community Facilities Administration (CFA)

The Community Facilities Administration offers four assistance programs which are related to water resources management. To assist communities in financing architectural surveys, designs, plans, and specifications, the CFA distributes interest-free advances for the planning of specific public works projects. As provided in Section 702 of the Housing Act of 1954, state and local agencies who plan to undertake construction within five years are eligible.

Secondly, to encourage and assist in the timely acquisition of land to be used in future public works construction, the CFA offers grants to cover reasonable interest charges on loans incurred to finance the acquisition of such land. To be eligible, a local government must plan to begin construction within five years.

Through a third program, the Public Facilities Loan Program, the CFA issues long-term loans covering up to 100 percent of the cost of needed public works in small communities and in underdeveloped areas. These loans are limited to communities which are unable to market bonds on reasonable terms, and which have a population less than 50,000, or less than 150,000 in designated redevelopment areas. The program also excludes projects which are eligible for aid from other Federal agencies.

Another CFA program provides grants to assist local public bodies in constructing basic water and sewerage facilities which are needed to promote efficient and orderly community development. Basic water facilities include water storage, treatment, purification, and distribution works. Grants may cover up to 50 percent of the development cost of a project, including land acquisition, site improvement, and construction costs. Under certain conditions, the grant may be increased up to 90 percent of the total development cost.

Urban Renewal Administration (URA)

Two programs of the URA pertain to water resources management. Under Section 701 of the Housing Act of 1954, the URA is authorized to distribute grants for comprehensive state, regional, and local planning activities. Grants may be issued for up to two-thirds of the preparation cost of comprehensive plans. Eligible units include official state, regional, and metropolitan planning agencies; counties, cities, and other municipalities with less than 50,000 population; and cities of more than 50,000, when located in federally impacted areas, disaster areas, areas with unemployment because of a decline in Federal purchases, or officially designated redevelopment areas. This program is administered through the Department of Business and Economic Development.

The URA's Open-Space Land Preservation and Improvement Program provides grants to states and local public bodies for the acquisition, beautification, and other improvement of open space and other public urban lands. "Open-space uses" is defined as use of open-space land for parks and recreation, conservation of land and other natural resources, and historic or scenic purposes. Grants may be obtained to pay up to 50 percent of the cost of acquiring and developing land for open-space uses. In addition, grants are available for up to 50 percent of the cost of extra activities aimed at beautification, and up to 50 percent of the cost of demolishing and removing structures in built-up portions of urban areas. For projects demonstrating new and improved methods and materials for beautification, a grant may be increased to 90 percent of the project's cost. Most programs of the Department of Housing and Urban Development are administered through the Department's regional office in Chicago.

WATER RESOURCES COUNCIL

The Water Resources Council was established by the Water Resources Planning Act of 1965. Its responsibilities include: a) administration of a program of grants to states to assist them in developing comprehensive water and related land resources plans, b) recommendations on the creation of river basin commissions, c) approval of requests for appropriation of Federal funds submitted by river basin commissions, and d) review of plans prepared by river basin commissions and the formulation of recommendations for the President and the Congress.

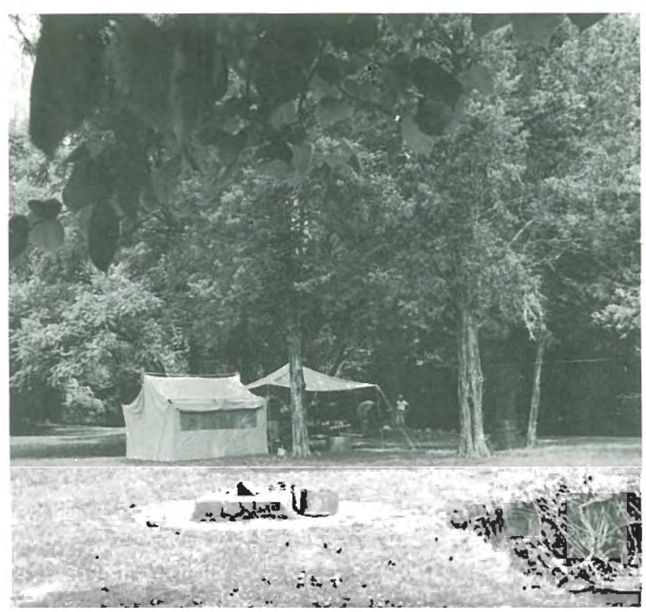
Title III of the Act provides for financial assistance to the states for comprehensive water resources planning. Grants are available for up to 50 percent of the cost of carrying out a state program.

Title II of the Water Resources Planning Act authorizes the creation of river basin commissions for an area, river basin, or group of river basins. Such commissions are empowered to: 1) serve as the principal agency for the coordination of Federal, state, interstate, local and nongovernmental plans for water and related land resources development; 2) prepare and keep up to date a comprehensive development plan; 3) foster and undertake such studies as are necessary for the preparation of comprehensive plans; and 4) recommend long-range schedules of priorities for the investigation, planning, and construction of projects.

Each river basin commission is composed of a chairman appointed by the President; one representative of each Federal department or independent agency which has a substantial interest in the work to be undertaken by the Commission; one representative from each state within the river basin or basins; one representative of any interstate agency whose jurisdiction extends to the waters of the basin; and, where appropriate, one representative of any international commission whose jurisdiction extends to the waters of the basin area.

Each commission shall recommend what share of its expense shall be borne by the Federal Government, but such share is subject to Council approval. Estimates of proposed appropriations from the Federal Government shall be included in the budget estimates by the Water Resources Council. No more than $750,000 can be allotted annually to any single river basin commission.

Commissions are created by the President, with the written concurrence of the Water Resources Council and of not less than half of the states within the basin concerned. Currently, Illinois is participating in the formation of the Great Lakes River Basin Planning Commission. This kind of organization is also being considered for other interstate river basins affecting Illinois.



MUNICIPALITIES

In Illinois, municipalities may exercise only those powers specifically authorized by the statutes or implied by the statutes, subject to strict interpretation by the courts. The multitude of statutes authorizing the various functions of municipalities are often similar and overlapping. Later statutes may be but a slight revision of an older statute to provide for new conditions or changed circumstances. The basic laws pertaining to municipalities take up more than 300 pages in the Illinois Revised Statutes. Although the legal powers granted to municipalities are comprehensive in terms of functions, the ability of the municipalities to render services often depends on their financial capabilities and the fiscal constraints imposed through statutory and constitutional taxing and debt limitations.

MUNICIPAL FINANCING

Debt Limitations

The Illinois Constitution prohibits municipalities and municipal corporations from incurring any indebtedness which in the aggregate exceeds 5 percent of the value of the taxable property in the community. For municipalities with a population of less than 500,000, the Municipal Code further limits the total permissible indebtedness to 2.5 percent of the value of the taxable property. However, the Code excludes certain functions from this limitation, including indebtedness for construction of impounding dams and artificial lakes for water supply purposes; for constructing, altering, improving, or repairing a waterworks or sewerage system, including a plant for the treatment and disposal of sewage, or a surface-water drainage system; for the acquisition of rights of way and borrow pits; for the construction of levees; and for the construction and repair of sea walls, riverbank retaining walls, and riverbank bulkheads.

Issuance of Bonds and Taxing Limitations

Under the provisions of the Municipal Code, bonds cannot be issued by a corporate authority until such bonds have been approved by the electorate through a referendum. Certain bonds, however, may be issued without a referendum, including most revenue bonds.

A municipality with less than 500,000 population may not levy a total tax greater than 0.333 percent of the total value of all taxable property in the community. However, certain taxes contain specific provisions excluding them from this limitation.

In addition, the corporate authorities may submit a proposal to the electorate for approval to levy a tax in excess of 0.333 percent, but not exceeding 0.4375 percent. Such a tax can be levied for up to five years.

Municipalities incorporated under special acts have the power to levy taxes at whichever of the following rates is higher: the rate specified in or allowed under its special act; or a rate which will not exceed 1 percent of the total assessed property valuation. Again, certain taxes, by the terms of their act, are excluded from this limitation.

HARBORS

A city or village may institute proceedings in any court of record to condemn any land or right of way needed for widening, deepening, or otherwise improving a river or harbor.

The city may finance such acquisition by special assessment upon the property benefited by these improvements, or upon the general public, or both.

Harbors for Recreation

Any city or village of less than 500,000 population bordering upon any public waters has the power to acquire, construct, enlarge, improve, and operate a harbor for recreational use, subject to the approval of the Department of Public Works and Buildings and the proper officials of the U. S. Government.

To finance improvements, a city has power to issue revenue bonds; however, such bonds are payable solely from revenue derived from the harbor facilities, cannot bear a rate of interest greater than 6 percent, and must mature within 40 years.

Special Tax for Harbor Development

Each city or village may levy in each of four consecutive years a tax of .0125 percent of the taxable property for the express purpose of financing harbor development programs. This tax is in addition to all taxes authorized by law to be levied in that municipality and is not subject to the general tax rate limitation specified in the Municipal Code.

Use of Acquired and Reclaimed Land

A municipality may occupy, hold, and use any submerged land of the State filled in or reclaimed by the municipality for harbor and terminal facilities. This includes: a) harbors, canals, levees, wharves, docks, and all appropriate harbor structures, facilities, and improvements; b) elevators, vaults, and warehouses; and c) all other necessary terminal facilities.

The municipality may lease any of this land for periods of not longer than 50 years with the written approval of the Department of Public Works and Buildings. All money received from the lease of such land is credited to a special harbor fund to be used for harbor purposes only.

LEVEES

In a municipality protected by levees or embankments or a municipality that may deem it necessary to be protected, a majority of the voters, through a referendum, may authorize a tax to build, raise, strengthen, or repair levees around the municipality. The tax rate cannot exceed 0.1666 percent annually on the taxable property of the municipality and cannot be levied consecutively for more than seven years. The Seven Year Levee tax is not subject to the general tax rate limitation stipulated in the Municipal Code.

Every municipality which is subject to overflow or inundation from a river or other sources may levy a tax not exceeding 0.1666 percent of the value of all taxable property in the community to construct, raise, improve, and maintain levees, protective embankments, and other structures. This tax must be approved by a referendum held in each year in which it is to be levied and is not subject to the general municipal tax rate limitation.

Levee Improvement Commission

The corporate authorities of a municipality with a population of less than 500,000 which is bounded by a river, or is contiguous to or contains within its corporate limits a portion of a navigable lake, or through which a river flows, may provide by ordinance for the creation of a levee improvement commission.

The Commission consists of four members appointed by the Mayor or President, with the mayor serving as ex officio chairman. The Commission exercises full control and supervision over all improvements, docks, levees, industrial developments and facilities. These include terminals and parks on the river front or lake shore and the land, whether developed or undeveloped, near the river front or lake shore located within the corporate limits of the municipality.

To finance the construction, maintenance, or improvement of facilities, the corporate authorities may issue bonds with an interest rate of not more than 5 percent annually which will mature within 20 years. An annual tax may be levied to pay the principal and interest on these bonds.

DRAINAGE

Municipal authorities may construct and maintain drainage systems for any land within the corporate limits of the municipality. They may finance this function by special assessment upon property specially benefited, or by general taxation, or both. When it is necessary or advantageous for the proper construction of such drainage systems, the city may acquire rights of way outside its corporate limits by the power of eminent domain, if necessary, and can assess all landowners outside the corporate limits who will benefit from such improvements.

The corporate authorities of any municipality with a population of less than 500,000 may levy an annual tax not to exceed 0.15 percent of the value of all taxable property to provide for the expense of pumping to remove surface water and sewage due to flood conditions. However, this tax must first be submitted to the voters for approval and is not subject to the general municipal tax rate limit set forth in the Municipal Code.

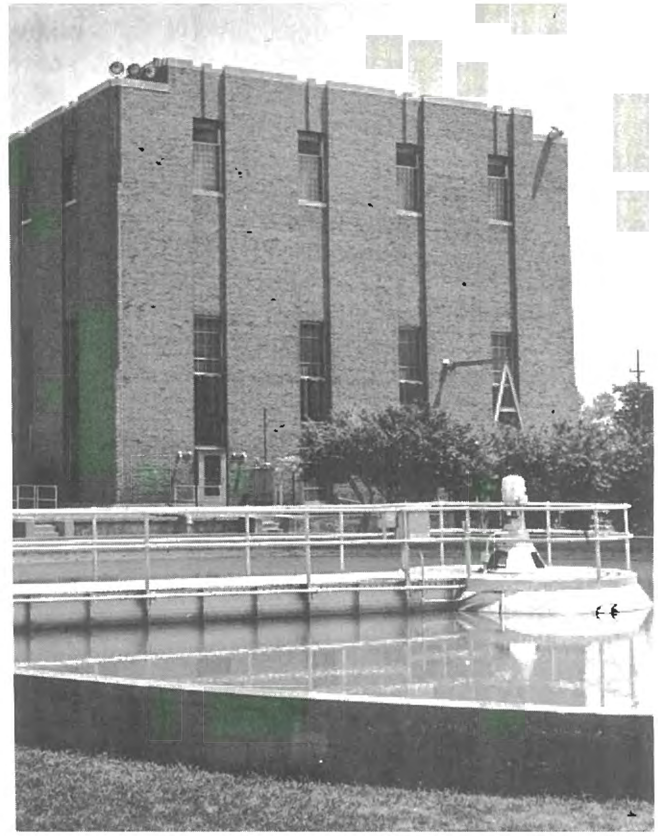
Every city or village whose site is wholly or partially subject to overflow and wholly or partially surrounded by levees, dikes, or embankments to prevent overflow, may: a) divide the municipality, or any portion of it, into improvement districts; b) fix the grade of the streets, avenues, alleys, or public grounds within the improvement districts at any height necessary to give surface drainage from each improvement district to the river or rivers which cause the overflow; and c) may require low lots, blocks, or parts thereof within an improvement district to be filled to prevent standing water. Improvements such as walls and other structures may be financed through special assessment or special taxation on contiguous property.

WATER SUPPLY AND WATERWORKS

The corporate authorities of each municipality are authorized to contract with any person, corporation, political subdivision, or public agency for a supply of water. However, payments for this service shall be solely from the revenues derived from the operation of the municipality's waterworks system. Such contracts cannot be made for a period exceeding 40 years and are not to be considered a debt within the meaning of any constitutional limitation.

The corporate authorities of each city and village may provide for a supply of water by digging, constructing, or regulating wells, pumps, cisterns, reservoirs, or waterworks; borrow money for such purposes; and authorize any person to construct and operate such facilities.

The municipalities may make all needful rules and regulations concerning the use of water supplied by the city's waterworks and for the collection of such water rates or rents as may be deemed necessary. The municipality is further authorized to levy a general tax for the construction and maintenance of the waterworks system.



Municipalities with a population of less than 500,000 are authorized to pay the cost of purchasing, constructing, improving, or extending a waterworks or water supply system through the sale of revenue bonds payable from the receipts of the waterworks or water supply system. Such bonds cannot exceed 6 percent interest and must mature within the period of usefulness of the project, but in no event in more than 40 years.

Any municipality issuing such revenue bonds may establish a municipal water board consisting of not less than three nor more than seven members to administer the actions and functions of the municipality in managing, maintaining, and operating the waterworks.

Any city with a population of more than 25,000 but less than 500,000 which owns or operates its waterworks system may contract with any person for the filtration and treatment of its water supply. The contract may include an option for the city to acquire the filtration and treatment facilities. The charges or payment for such filtration services are payable from the revenue received by the city from the operation of its waterworks system.

To be used solely for purchasing or financing the construction and enlargement of waterworks, each city and village may levy a direct annual tax of not more than 0.1666 percent of the full cash value upon all the taxable property within its corporate limits. This tax is payable yearly for a period of not more than 30 years; is not subject to any statutory tax rate limitation; and, in a referendum, must receive approval from three-fourths of the electors voting on the proposition.

For the above purposes, any two or more adjacent cities or villages may create a water district by an ordinance adopted by each. This water district is governed by a board of trustees jointly composed of the corporate authorities of the cities and villages creating the district. Any proposal submitted by the district to the electors must be approved by three-fourths of the electors voting on the proposition in each city and village constituting the district.

Water Fund Tax in Cities

The city council of any city, whether incorporated under a special charter or the general law, which has established or leased a waterworks system for the supply of water to its inhabitants, has the power to levy and collect annually a tax not to exceed 0.0166 percent of the full, fair cash value of the taxable property in the city. This tax may be used for the extension of watermains or pipes in the city, for the maintenance of its waterworks system, or for the creation of a sinking fund to be applied to the establishment of a waterworks system. However, the city's board of public works or the head of the city's water department must first certify to the city council the amount that will be necessary for the specified purposes and must further certify that the revenue from the waterworks system will be insufficient in itself to finance the proposed actions. This tax is known as the Water Fund Tax.

A two-thirds majority of all the aldermen or commissioners elected to the city council may authorize a tax not to exceed 0.05 percent of the value of all taxable property for the purposes specified above.

In addition to all other taxes now authorized by law, a further tax not to exceed 0.033 percent may be authorized with the concurrence of two-thirds of the aldermen or commissioners for the purpose of supplying water to the city. All of these water fund taxes must be levied within the tax rate limitation specified in the Municipal Code.

Joint Construction of Water Supply

A municipality may construct and maintain a system of waterworks, unite with any adjacent municipality to do so, and procure a supply of water from any adjacent municipality which already has a waterworks.

A municipality may borrow money and levy a general tax for the construction and maintenance of joint waterworks, may levy special assessments for property that is benefited by improvements, and may levy special assessments upon property that is benefited by improvements and lies up to one mile outside the corporate limits.

Water Commission

Any two or more municipalities, except cities of 500,000 or more inhabitants, may acquire, either by purchase or construction, a waterworks system or common source of supply, or both, and may jointly operate such facilities. To operate such facilities, the municipalities may provide for the establishment of a public corporation to be known as the Water Commission.

The Commission consists of three or more members, with one appointed by the corporate authorities of each participating municipality and one appointed by the judges of the circuit court.

The Commission has complete supervision, management, and control of the waterworks system or the common source of supply, or both. The Commission is authorized to contract to provide a supply of water for a period of up to 50 years.

To acquire the necessary facilities and equipment or make improvements and extensions to existing facilities, the Commission may issue revenue bonds payable solely from the revenue to be derived from the operation of the waterworks system. These bonds do not constitute an indebtedness of any of the municipalities represented on the Commission. The bonds shall bear interest at a rate not exceeding 6 percent annually and must mature within the period of usefulness of the facility, not to exceed 50 years.

The Commission establishes rates and charges for its services which are sufficient to provide an adequate depreciation fund, to pay operating and maintenance costs, and to pay the principal of and interest upon all revenue bonds.

In addition to the municipalities which have formed the Commission, the Commission has the right to supply water to any municipality, political subdivision, private person, or corporation, provided the water is delivered to such parties at the corporate limits of the municipalities which have created the Commission, or from such waterworks properties of the Commission located outside the primary municipalities that have been acquired as necessary or incidental to the furnishing of water to the primary municipalities.

CASE STUDY 1.

SPRINGFIELD'S MUNICIPAL WATER OPERATION

The City Water, Light, and Power Department of Springfield is an example of an effective municipally-owned water utility. Springfield has the commission form of city government with a mayor and four elected commissioners. Each commissioner directs the operations of one or more of the City departments. The water utility is one component of the City's Water, Light, and Power Department, which is administered by the Commissioner of Public Property.

Springfield entered the water utility field in 1860 with the purchase of the Springfield Water Works Company. At that time, Springfield had a rudimentary water system. Four wells located around the Court House Square furnished water to the City. Today, Springfield operates a complex, modern water system which includes an 18.5 billion gallon water supply reservoir, Lake Springfield.

To help finance the expansion of its water system over the past 106 years, Springfield has issued nearly $8 million worth of municipal bonds. These bonds are retired solely from the revenue from the operation of the waterworks. Tax revenues have never been used to support the system.

Nevertheless, Springfield has the lowest water rates in Illinois. For the first 3000 cubic feet, residents are charged $0.21 per 100 cubic feet. Individual customers who live outside the corporate limits are billed directly and are charged approximately double the resident rate.

In addition to supplying the needs of its own residents, Springfield is a major water supplier for many residents of the metropolitan area. Springfield supplies water directly to the residents of Leland Grove, Southern View, and the Lake Springfield area. It sells water to the villages of Jerome, Grandview, Rochester, and Auburn. Auburn acts as the agent for Chatham, Divernon, Pawnee, Virden, and Girard. These towns share a jointly-owned transmission system, but each operates its own distribution system.

The Auburn, Divernon, Girard, Pawnee, Thayer, and Virden Water Commission has been organized to construct and operate an independent source of supply. It is anticipated that an emergency connection will be maintained with the Springfield system.

The City created a Utility Advisory Board in 1960. Composed of four local citizens, the Board serves the Commission in an advisory capacity. The Board members are appointed by the Commission for four-year staggered terms.

Through its waterworks facilities, the City Water, Light, and Power Department also provides other services. Fire hydrants and water for fire-fighting and street flushing are furnished to the City without charge. This service has been estimated to be worth at least $15,000 annually. The Department also subsidizes the operation of recreational areas at Lake Springfield. Although some revenue is derived from admission charges, property leases, and boat licenses, this subsidy for recreation was estimated at $145,000 for fiscal 1966.

The City Water, Light, and Power Department has demonstrated an effective approach to satisfying the needs of the people of Springfield. Recently, the Department was cited as the outstanding municipally-owned utility in the United States by the American Power Producers Association.

SEWERAGE SYSTEMS

Any municipality may construct, acquire, improve, extend, and operate a sewerage system, either within or without its corporate limits. A municipality may issue revenue bonds to finance sewerage systems, payable solely from the income received from the operation of the sewerage facilities. Such bonds must mature within 40 years and must not exceed 6 percent interest annually.

A municipality is further empowered to contract with industrial establishments for the provision and operation by the municipality of sewerage facilities to abate or reduce the pollution of waters caused by discharges of industrial wastes.

Whenever a municipality which is not in a sanitary district has constructed a sewage treatment or disposal plant or plants, the municipality may, after the question has been submitted to and approved by the voters in a referendum, levy an annual tax not to exceed 0.075 percent of the full, fair cash value of all taxable property in the municipality for the operation and maintenance of the plant or plants. This tax is in addition to all the taxes authorized by law and is not subject to the general tax rate limitation stated in the Municipal Code.

The city council of any city may levy a tax not to exceed 0.01666 percent of the value of all taxable property in the city for the extension and laying of sewers in the city and for the maintenance of those sewers. The board of public works must first certify the amount necessary for such purposes.

A two-thirds majority of all the aldermen elected to the city council may levy a tax not to exceed 0.10 percent of the value of all taxable real and personal property. These taxes must remain within the aggregate tax limitation stipulated in the Municipal Code.

Upon approval by the voters in a referendum, the city council of any city with a population of less than 100,000 which operates a sewage disposal plant may levy an annual tax not to exceed 0.075 percent of the assessed taxable property. The board of public works must first certify the amount necessary for the operation and maintenance of a sewage disposal plant. This tax is not subject to the statutory tax limitation for municipalities.

COMBINED WATERWORKS AND SEWERAGE SYSTEMS

A combined waterworks and sewerage system is a system which the municipality determines by ordinance to operate in combination. Any municipality is authorized to acquire, operate, maintain, or construct a combined system and to issue revenue bonds to finance the construction of or improvements to such a combined system.

Any two or more municipalities, except cities of 500,000 or more inhabitants, may acquire, either by purchase or construction, a waterworks system or source of supply of water, or a sewerage system, or any combination thereof, and may jointly operate, improve, and extend such facilities.

To operate and manage such facilities, the municipalities may establish a public corporation to be known as the Water Commission or the Water and Sewer Commission. One commissioner is appointed by each participating municipality and one by the judges of the circuit court.

The Commission has full and complete supervision, management, and control of the operation, maintenance, and extension of the joint facilities. The Commission is authorized to issue revenue bonds payable solely from the revenue received from its operations and may contract, in addition to the founding municipalities, with any person, firm, corporation, or political subdivision.

Any bonds issued by the Commission will not constitute an indebtedness of any of the municipalities represented by the Commission, and such bonds shall bear interest at a rate not exceeding 6 percent annually and must mature within 50 years.

The Commission may operate in a contiguous territory not more than 3 miles beyond the corporate limits of the participating municipalities. It can also operate in the territory necessary to interconnect any of the municipalities involved.

CASE STUDY 2.

THE MECHANICSBURG-BUFFALO WATER COMMISSION

In August 1960 Mechanicsburg and Buffalo created the Mechanicsburg-Buffalo Water Commission by ordinance. These villages are farming communities in Sangamon County; their combined population in 1960 was about 800.

The villages had previously relied on individual homesite wells for a supply of water. Each village had drilled test wells to investigate the possibility of developing a community water supply, but an independent supply was found to be unfeasible. The Water Commission was formed to construct and operate a waterworks system to serve both communities.

The system constructed by the Commission consisted of a 10-inch well on the banks of the Sangamon River, a pump house and treatment plant, an elevated storage tank with 100,000-gallon capacity, and a water distribution system with 300 service connections and 35 fire hydrants. The total cost of the system was about $300,000.

To pay part of the construction cost of the waterworks system, Mechanicsburg and Buffalo issued a total of $62,000 in general obligation bonds in late 1960. These bonds are payable from **ad valorem** taxes levied on the taxable property in the villages.

The Water Commission issued waterworks revenue bonds for $238,000 in January 1961. These revenue bonds do not constitute an indebtedness of the member villages. The bonds are due in 40 years, carry an annual interest charge of 5 percent, and are payable solely from the revenues of the system.

The estimated population of the area served is 1500; the Commission has 300 customers. The service area includes the two member communities and certain territory adjacent to the villages and along the supply lines.

Monthly water charges are based on a graduated scale ranging from a minimum of $4 for the first 2000 gallons to approximately $64 for 100,000 gallons. The villages pay $100 per year for each fire hydrant.

The water commission form of organization appears to be well suited to enable these two communities to satisfy their water needs.

COUNTIES

COUNTY FINANCE

No county, according to both constitutional and statutory provisions, may incur any indebtedness exceeding an aggregate of 5 percent of the value of all taxable property in the county. The Constitution further directs that before or at the time a debt is incurred the county board is to provide means for repayment within 20 years.

County boards are empowered to issue general obligation bonds, within the specified debt limits, to finance county functions and programs after such bonds have been approved by the voters in a referendum. These bonds may pay not more than 8 percent interest annually.

The Illinois Constitution prohibits county authorities from assessing taxes at a rate greater than 75 cents per $100 valuation, unless specifically authorized by a referendum.

The statutes also contain further taxing limitations. For counties with a population of less than 500,000, the maximum permissible tax rate is 0.125 percent. For counties with 500,000 or more inhabitants, the maximum tax rate in even-numbered years is 0.26 percent; in odd-numbered years it is 0.22 percent. In counties with less than 15,000 inhabitants, the county board may levy taxes up to 0.20 percent of the assessed valuation by simply enacting a resolution to that effect.

By statute, whenever a tax is levied for payment of a specific debt, the revenue produced by that tax is to be placed in a separate fund and may be expended only for the liquidation of such indebtedness. However, any surplus remaining in the treasury after full repayment of the debt may be transferred to the common fund of the county.

COUNTY POWERS AND FUNCTIONS

Water Supply, Drainage, and Flood Control

County boards may acquire, construct, maintain, and operate waterworks systems, sewerage systems, wells, canals, levees, and other related works and facilities. A county board is authorized to establish a Department of Public Works to exercise complete supervision over all such works and facilities.

Counties may contract to sell water or to supply sewerage services to incorporated cities and villages, corporations, firms, and individuals residing in unincorporated areas. However, this authority can only be exercised in areas which do not have similar service provided by another governmental unit, unless that governmental unit requests county service.

To finance the construction and operation of waterworks and sewerage facilities, the county authorities may levy, after receiving the approval of the people through a referendum, an annual tax not to exceed 0.02 percent of the value of all taxable property. This tax may be in excess of any tax rate limit prescribed by law.

The county authorities may also issue revenue bonds and general obligation bonds to finance these functions. Revenue bonds are payable solely from the income derived from the operation of the water and sewerage systems, must mature within 40 years, and may not exceed 6 percent interest annually. Revenue bonds do not constitute an indebtedness of the county within the meaning of the constitutional limitation. General obligation bonds must be approved by the voters through a referendum, may not exceed 8 percent interest annually, and must mature within 20 years.

Counties are further empowered to prevent pollution of any stream or other body of water, to cause any party to cease such pollution, and to cooperate with Federal agencies, municipal corporations, political subdivisions, individuals, and associations in the formulation of plans, in the construction of improvements for flood control, and in the conservation and development of water and related resources. Any county may contract with a sanitary district for sewerage service, provided that the sanitary district lies wholly or partially within the county limits.

Counties exercise numerous additional regulatory and other functions pertaining to water and related resources. They may establish regional planning commissions to provide for comprehensive development plans. They may exercise their zoning powers to lessen or avoid hazards to persons and damage to property from floodwaters. They may also appropriate funds for the use of soil and crop improvement associations.

TOWNSHIPS

Any township with a population of less than 500,000 is authorized to construct or purchase and operate a waterworks system or a sewerage system and to improve or extend such systems. To exercise these powers, the Board of Town Auditors may create a township utility board.

The township, in addition to furnishing water or sewerage service to township residents, may contract with a) any city, village or incorporated town located within the boundaries of the township for township water or sewer services, when the incorporated unit requests such service; b) any area surrounding the township limits desiring to purchase water from the township, provided that such service is merely incidental to the operation of the system for the benefit of the township's residents; and, c) any industrial establishment to provide sewerage facilities to abate or reduce pollution resulting from the operation of the establishment.

To finance such systems, the township's Board of Town Auditors has the power to issue revenue bonds, which are repayable solely from the income derived from the operation of such systems. These bonds must mature within 40 years and may not exceed 6 percent interest annually. Such revenue bonds are not to be considered an indebtedness of the township within the meaning of any constitutional or statutory limitations.

SPECIAL PURPOSE DISTRICTS

Special or special purpose districts constitute one of the more important types of local governmental units in Illinois. A special district is a governmental body legally organized under the laws of the State and existing for a special purpose. Special districts comprise about 33 percent of the total number of governmental units in Illinois, with drainage districts accounting for approximately 40 percent of the special districts.

Although the total number of Illinois governmental units declined between 1952 and 1957, the number of special districts grew significantly. Most of the special districts furnish only one service.

A special district generally has two unique characteristics. It retains a large degree of independence, with a governing board that usually exercises both legislative and executive powers; the special district usually has an independent source of funds and may have considerable freedom in formulating and executing its own budget.

The growth and importance of special districts has been attributed to two factors: other local governmental units have been severely restricted by statutory and constitutional limitations on their taxing and borrowing powers; in many cases the jurisdiction of local governmental units does not conform to the optimum size service area. In Illinois, special purpose districts have been created to furnish vastly different services having to do with health, recreation, wildlife, and many water management functions.

Special purpose districts created under permissive legislation are authorized but not specifically created by the General Assembly. The Legislature provides the framework and specifies certain powers and limitations for such districts, but leaves the initiative of organizing them to the local interests.

SOIL AND WATER CONSERVATION DISTRICTS

Illinois has 98 soil and water conservation districts which blanket the State. Such districts may perform a variety of functions pertaining to soil and water conservation, flood prevention and control, and soil erosion control. A district's board of directors is composed of five elected directors who own or occupy land within the district.

The district is authorized to cooperate and effectuate agreements with individuals or agencies of government to plan, construct, operate, and maintain programs and projects relating to the conservation of renewable natural resources, including the provision of domestic, industrial, and agricultural water supplies; recreational project developments; and air pollution control.

Soil and water conservation districts have no formal authority to raise revenue; they receive certain funds distributed annually by the Division of Soil and Water Conservation of the Department of Agriculture. Additional income may be obtained by contributions from county governments, from charges collected for services rendered to landowners, and from bake sales and similar fund-raising events.

SOIL AND WATER CONSERVATION SUBDISTRICTS

A portion of a soil and water conservation district or districts may be organized as a subdistrict, if the area is contiguous and located in the same watershed. A subdistrict has the power to develop and execute plans, programs, and projects relating to any phase of flood prevention, flood control; erosion control; and control of erosion, floodwater and sediment damages; to cooperate and enter into agreements with the U. S. Secretary of Agriculture; and to carry out, maintain, and operate works of improvement pursuant to the Watershed Protection and Flood Prevention Act of August 4, 1954, as amended.

The activities of the subdistrict are administered by a board of directors composed of five members (seven directors if the subdistrict lies in more than one district) who own or occupy land within the subdistrict. To organize a subdistrict, a majority of the landowners in the proposed subdistrict who also own a majority of the land may present a petition to the directors of the parent soil and water conservation district. The district directors hold a public hearing on the petition. Afterwards, they conduct a referendum in which all the legal voters residing in the proposed subdistrict vote to determine whether the territory should be organized as a subdistrict.

The subdistricts have the power to levy and collect an annual tax not to exceed 0.125 percent of the total property valuation in the subdistrict for general corporate purposes. In addition, the board of directors may finance works of improvement by special assessment.

DRAINAGE DISTRICTS

The function of a drainage district is to improve and supplement the natural drainage of areas in the State. Specifically, drainage districts may be formed to construct, maintain, or repair drains or levees or to engage in other drainage or levee work for agricultural, sanitary, or mining purposes.

Drainage districts are governed by commissioners who are appointed by the circuit court for three-year terms. However, the statutes contain a provision allowing a majority of the landowners to designate, by petition, who shall be appointed. Furthermore, after the initial work of the district has been completed, two of the commissioners may be dismissed by petition.

The commissioners are responsible for implementing the drainage system for which the district was organized; for maintenance and repair of the works of the district; and, when authorized by the court, for additional projects. If the commissioners wish to exercise additional powers or to levy or increase an assessment, they must petition the county court for permission. The court, after conducting a public hearing, may approve or reject the commissioners' petition.

To organize a drainage district, a majority of the landowners holding at least one-third of the land, or at least one-third of the landowners holding the major portion of the land, submit a petition to the county court. The court conducts a public hearing and then may appoint three landowners to serve as temporary commissioners to study the feasibility of creating the proposed district.

The temporary commissioners examine the proposed district and, if feasible, submit a report which includes a description of the proposed system of drainage. The court conducts a second public hearing and may declare the drainage district legally organized.

An alternate method may also be used to organize a drainage district. This method begins with a petition signed by one-tenth of the owners of at least one-fifth of the land. This is followed by a public hearing and then by a referendum. If a majority of the landowners voting on the question approve the district, it is declared legally organized.

The activities of a drainage district are financed by assessments; three kinds of assessments may be levied by a drainage district. An original assessment is levied to finance the original work of the district. An annual maintenance assessment may be levied to pay for maintenance work. Finally, an additional assessment may be employed to finance original, additional, or repair work. The commissioners may borrow money only in anticipation of the collection of outstanding assessments.

In districts whose drainage facilities, through long, continued and common usage, collect and convey sewage and other wastes, the commissioners may construct and operate sewerage works. Such services may be financed through assessments or through revenue bonds. To provide for more complete drainage, outlet drainage districts, drainage subdistricts, and minor subdistricts may be organized.

WATER SERVICE DISTRICTS

A water service district provides water service to unincorporated areas. The district is not empowered to maintain its own water supply system, but rather is authorized to contract with any adjacent city, village, or incorporated town, or with a public utility, to furnish water to the inhabitants of the district. The district may also contract for the installation, rental, or use of water service mains within its boundaries. The district is governed by a board of three trustees who are appointed for three-year terms by the county judge.

A water service district may be organized in any contiguous area which is not included within the corporate limits of a city, village, or town and which is not already part of an existing water service district.

The procedure for organizing a water service district is initiated by a petition requesting the county judge to organize a referendum on the proposed district. The petition must be signed by 50 voters or a majority of the voters in the proposed district, whichever is less. The petition is followed by a public hearing to hear objections and to determine the boundaries of the proposed district, and finally by an election. If a majority of the votes cast is favorable, the district is declared legally organized.

The district has authority to borrow money and issue bonds to pay for the installation of water service mains, but the board of trustees must secure the approval of the voters through a referendum before any bonds are issued. The maximum amount of indebtedness is fixed at 5 percent of the total property valuation.

At the time of incurring any indebtedness, the board of trustees must provide for the collection of a direct annual tax sufficient to repay the principal of and interest on the bonds within at least twenty years. The tax levied for this purpose may not exceed .075 percent of the assessed property value of the district.

The board of trustees has further authority to levy taxes for general corporate purposes. The sum of this tax and all other taxes, including those levied for the payment of the bonds, cannot exceed 0.125 percent of the total property valuation.

PUBLIC WATER DISTRICTS

In any contiguous area in the State with a population of less than 500,000 and so situated that the construction or purchase, maintenance, and operation of waterworks properties will be of public benefit, a public water district may be organized with the authority to provide water services. The district may operate sewerage properties in combination with its waterworks properties.

Upon request, the district may supply water to any city, village, or incorporated town within the district and may maintain and operate its waterworks properties within the corporate limits of such city, village, or town.

The public water district may supply water to any municipality, political subdivision, private person, or corporation outside the limits of the district, provided the water is delivered at the corporate limits of the district or from waterworks properties located outside the district that are operated primarily to furnish water to the inhabitants of the district.

Waterworks properties are defined as wells, dams, reservoirs, treatment or purification plants, distribution mains, pumping equipment, and other equipment, lands, easements, and rights of way as may be appropriate.

The board of trustees, which is responsible for the government and management of the affairs and business of the district, is composed of seven members appointed for five years by the county judge.

The procedure to establish a public water district involves a petition, a public hearing, and a referendum on the question of whether such a district should be organized. The petition must contain the signatures of 100 resident voters. The steps which follow are similar to those described for establishing a water service district.

The board of trustees may levy annually, for a period of not more than 10 years, a tax not be exceed 0.02 percent of the total assessed property valuation in the district to be used for corporate purposes. However, such tax may be levied only after approval of the voters.

To finance the acquisition, improvement, or extension of any waterworks properties or sewerage properties, the board of trustees may issue revenue bonds. These bonds are payable solely from the income derived from the operation of such waterworks or sewerage properties, must mature within 40 years, cannot bear more than 5 percent interest annually, and do not constitute an indebtedness of such a district within the meaning of the constitutional limitations.

WATER AUTHORITIES

In addition to its major objectives of supplementing the existing water supply or providing additional water supply, a water authority exercises numerous regulatory powers over wells, recreational water activities, water use, and pollution.

The powers granted to a water authority are exercised by a board of trustees consisting of one trustee for each county within the boundaries of the authority or three trustees, whichever is greater. Trustees are appointed by the circuit judge or judges for a three-year term.

The board is authorized to: a) supplement the existing water supply or provide additional water supply by such means as may be practical or feasible (construct and operate wells, reservoirs, purification plants, and other necessary facilities); b) sell water to municipalities or public utilities operating water distribution systems; c) reasonably regulate the use of water and establish limits upon or priorities to water during periods of shortages; d) regulate wells and other withdrawal facilities; e) regulate and provide recreational water activities; f) abate pollution of its water supply sources; and g) consult and cooperate with State and Federal agencies.

Five-hundred voters may petition the county court of the county in which the proposed authority, or the major part thereof, is located to request that the question of whether the proposed territory should be organized as a water authority be submitted to the voters. After a public hearing and the determination of the boundaries of the proposed authority, a referendum is held. If a majority of the votes cast is favorable, the district is legally organized.

For the purpose of acquiring necessary property or facilities, the board of trustees may issue general obligation bonds bearing interest at a rate not to exceed 5 percent annually and payable within twenty years. However, the aggregate permissible amount of indebtedness is limited to 0.5 percent of the value of all taxable property located in the authority. The board may levy a direct annual tax on property to meet the principal of and interest on such bonds.

To finance the acquisition, construction, improvement, or extension of any water supply or other water properties of the authority, and for the expenses associated with the creation of the authority, the board of trustees may issue revenue bonds payable solely from the income derived from the operation of such properties. The board of trustees may levy a general tax on all taxable property within the corporate limits of the authority, but the aggregate amount of such taxes, exclusive of taxes levied for the payment of bonded indebtedness, may not exceed 0.08 percent of the assessed property valuation.

CASE STUDY 3.

THE EFFINGHAM WATER AUTHORITY

In 1955, after previous attempts to create a river conservancy district and a public water district had failed, a water authority was created to help ease the water supply problems of Effingham. The City had previously issued revenue bonds to purchase the local water utility and could not issue additional bonds until earnings from the sale of water for a period of one year were equal to 1.33 times the annual requirements on its outstanding $1.1 million issue. It was impossible to increase water sales, because the City's water supply was insufficient to meet the then current demands. The City was forced to develop some other unit of local government to deal with the problems, and the water authority was organized.

The Effingham Water Authority's boundaries include Effingham and an area extending about a mile around the City. Effingham and the Authority have passed ordinances to authorize a contract under which the City could purchase water from the Authority. The Authority contracted to deliver to the City sufficient water for full operation of its waterworks system and agreed not to sell water to any other customer without the City's consent.

The Authority has built a dam and reservoir about 2 miles outside the boundaries of both the City and the Authority. The project was financed primarily through the sale of revenue bonds amounting to $1.2 million. The project was financed without Federal or State assistance. The reservoir has been used as a supplemental supply in late summer when the river flow has been inadequate.

By July 1961, about one-third of the land around the lake had been subdivided and was being leased for residences. A development plan and a zoning ordinance were enacted; all leases are subject to the ordinance. The Authority also established a commercial area with a public beach and amusements and has entered into contracts for use of the area for swimming, recreation, motel, and related purposes. Thus, Effingham, by creating a water authority not only satisfied increased demands for water, but also provided additional recreational facilities for area residents.

RIVER CONSERVANCY DISTRICTS

A river or lake conservancy district serves as a legal entity for the purpose of exercising unified control over a lake or river, or any portion thereof, where such unified control will promote the conservation and development of water and related resources. Conservancy districts have been delegated authority to engage in a wide variety of functions involving: a) stream pollution prevention and abatement; b) water supply development, conservation, and protection; c) preservation of water levels; d) flood prevention and control; e) reclamation of wet and overflow lands; f) development of irrigation; g) soil conservation; h) collection and disposal of sewage; i) provision of forest, wildlife, and park areas and recreation facilities; and j) promotion of public health, comfort, and convenience. An appointed board of trustees, usually about five in number, governs the affairs of the district.

One percent of the voters of a proposed conservancy district may initiate the organization process by submitting a petition to the circuit judge of the county that contains all or the largest portion of the proposed district. The circuit judge, together with the circuit judges of all the counties involved, acts as a board of commissioners with power, after conducting a public hearing, to determine the boundaries of the proposed conservancy district. The question is then submitted to the voters. If a majority of the votes cast is favorable, the district is declared legally organized. Six conservancy districts have been organized in Illinois.

A conservancy district may borrow money and issue general obligation bonds for corporate purposes. Such bond issues require the prior approval of the district's voters. The total indebtedness of a district may not exceed 5 percent of the value of all taxable property in the district. A conservancy district may also issue revenue bonds to finance water supply distribution and sewage disposal facilities. Such revenue bonds are repayable solely from the income received from the operation of such facilities. In addition, improvements which benefit specific property may be financed by special assessment. However, special assessments can only be levied on property within the district.

The board of trustees is also authorized to levy taxes upon property for corporate purposes. The aggregate amount of such taxes is limited to 0.083 percent of the total property valuation. The permissible tax levy can be increased up to 0.75 percent in districts with a population of less than 25,000 and up to 0.375 percent in districts of more than 25,000, provided that such increases have been authorized by the legal voters in an election.

CASE STUDY 4.

THE REND LAKE RIVER CONSERVANCY DISTRICT

In March 1954, following two years of serious water shortage, a group of civic leaders in the Big Muddy River Watershed met to discuss the possibility of building a reservoir near the deserted town of Rend City. Impressed by the success of the conservancy districts in Ohio, the group turned to the Illinois Conservancy Law, an act passed in 1925. This legislation enables citizens of a river basin to create a conservancy district to solve their particular water problems.

As a result of an election held on January 8, 1955, the Rend Lake Conservancy District was created. The District includes all of Franklin County and six townships in Jefferson County. In accordance with the legislation governing the creation of conservancy districts, six trustees were appointed. Three of the trustees were appointed by the circuit judges of Jefferson and Franklin Counties, and one trustee was appointed by each of the mayors of the three larger urban areas included within the District—Mt. Vernon, Benton, and West Frankfort.

In order to help initiate development plans, the trustees requested assistance from the Governor and the Legislature. Specifically, such assistance was to be used to study the Big Muddy River in the vicinity of Rend City and to determine the feasibility of a multi-purpose reservoir in that area.

The Legislature appropriated $40,000 to the Illinois Division of Waterways for a preliminary engineering study, which was completed in March 1957. After carefully examining the preliminary engineering survey, the Board of Trustees authorized the purchase of land in the area proposed for the lake. Financed through local funds, the first land was purchased in January 1958.

In June 1959 a bill was passed by the Legislature which appropriated $150,000 to the District for land acquisition in the Rend Lake area. In March 1961 the Conservancy District contracted with the Illinois Division of Highways and the Federal Bureau of Public Roads to protect the lake site from invasion by proposed roadways. In June 1961 the Legislature appropriated an additional $1 million to the District for land acquisition.

The passage of the Federal Area Redevelopment Act in May 1961 made Federal financial participation in the project possible. Almost immediately the District applied by letter for assistance; a formal application was submitted concurrently with the Board of Economic Development's Overall Economic Development Plan for Southern Illinois.

In October 1961 the Area Redevelopment Administration provided $45,000 to the Corps of Engineers for a feasibility study of the proposed lake. In the summer of 1962, the ARA made available $550,000 to the Bureau of Public Roads to defray the additional expense of raising a highway above the elevation of the proposed lake. The Area Redevelopment Administration also provided $450,000 to the Corps of Engineers for preliminary engineering investigations on Rend Lake.

In November 1962 Congress authorized the Rend Lake project, as proposed by the Corps of Engineers, and $501,000 was appropriated for preconstruction engineering studies in December 1963. Congress appropriated $1 million to the Corps of Engineers for construction of Rend Lake in August 1964.

In 1961 the District engaged a private planning consultant to prepare a development program for the lake area. In 1963 the Conservancy District, the State of Illinois, and the Area Redevelopment Administration entered into a joint contract with a consulting engineering firm to study the feasibility of the Rend Lake Intercity Water System. The planning and the engineering studies were completed in 1964 and were reviewed and approved by appropriate local, State, and Federal agencies. The Intercity Water System will serve more than 30 towns in the Rend Lake area.

A $12,383,000 Federal loan to be used to finance the construction of the intercity water project was approved by Congress on April 14, 1965. The financing was jointly undertaken by two Federal agencies, the Area Redevelopment Administration and the Community Facilities Administration. In February 1966 the Federal Department of Housing and Urban Development approved a local assistance 701 planning program for Franklin and Jefferson Counties. This program was designed to help coordinate and implement the expected development in the Rend Lake area.

Construction of the Rend Lake Dam and Reservoir was initiated during the summer of 1965. In March 1966 the Secretary of the Army approved a water contract between the Corps of Engineers, the State, and the Rend Lake Conservancy District. Through this contract the District has complete authority to manage the Intercity Water System and other water resources before and after completion of the Rend Lake Reservoir.

The history of the Rend Lake Reservoir and Intercity Water Supply System is one of effective coordination and cooperation at all levels of government. It is a successful project of which the citizens of the basin can be proud.

SANITARY DISTRICTS

With the exception of districts created by specific statutes, sanitary districts in Illinois have been formed under authorization in two acts. The 1917 Sanitary Districts Act, under which 72 districts had been organized through July 1965, relates to districts within incorporated areas. The 1936 Act, under which 30 districts have been formed, authorizes sanitary districts in unincorporated areas.

In recent years, there has been a jump in the number of sanitary districts. Forty of the 102 districts created by the end of 1965 were formed in the period from 1958 through 1964. One district was dissolved during that time.

Sanitary Districts in Incorporated Areas

Sanitary districts are directed to: a) provide for the disposal of sewage within the district, b) save and preserve the water supplied to the inhabitants of the district, and c) provide for drainage within the district. Under the 1917 Act, a sanitary district may be organized for any contiguous area within the limits of, and up to 6 miles outside the limits of, any city, village, or incorporated town that would benefit from the operation of sewage purification and treatment facilities and from the operation of one or more drainage outlets. The district is specifically prohibited from operating a water supply system. The district is governed by three trustees who are appointed by the circuit court for three-year terms.

To fulfill its purposes, the district is empowered to construct sewers, treatment plants, and other necessary works; to require any sewage disposal works constructed in or within 3 miles of the district to conform to the standards and specifications of the district; to build dams for the regulation or control of streamflow; and to maintain a police force to carry out pollution prevention activities.

To form a sanitary district, at least 100 voters petition the circuit court. A public hearing and a referendum follow. If a majority of the votes cast in the referendum is favorable, the district is declared organized.

For general corporate purposes, the board of trustees may levy taxes upon property within the district, but the aggregate amount for any year is limited to 0.083 percent of the total property valuation. After approval of the voters in a referendum, the board may increase the tax levy by an additional 0.083 percent to a maximum of 0.166 percent. In addition to the taxes already authorized, the board may levy a tax of not more than 0.05 percent, which is to be used solely for the purpose of paying amounts assessed for public benefits. In addition to these taxes, the district may collect a connection charge and may also collect extra charges for the disposal of industrial wastes.

The board of trustees may borrow money and issue bonds for corporate purposes. However, the district may not become indebted to an amount which in the aggregate exceeds 5 percent of the total assessed property valuation. Bond issues must receive the prior approval of the public through a referendum, although a referendum is unnecessary if the district has been ordered by a court or a State administrative agency to abate its discharge of untreated or inadequately treated sewage, and if such borrowing is deemed necessary by the board to comply with the order.

Sanitary districts with less than 500,000 population may issue revenue bonds to finance the construction or purchase, improvement, and extension of a sewerage system. Such revenue bonds are payable solely from the income derived from the operation of the system. The board of trustees has the power to construct drains, sewers, laterals, and other necessary adjuncts and to defray the expenses of such construction by special assessment.

Sanitary Districts in Unincorporated Areas

The 1936 Sanitary District Act authorizes the organization as a sanitary district of any area of contiguous territory within the limits of a single county and outside the limits of any city, village, or incorporated town. The district is administered by a board of three trustees who are appointed by the circuit court for three years. The district is directed to perform the same functions as a sanitary district in an incorporated area. In addition, this sanitary district may operate a waterworks system.

The process of organizing a sanitary district in unincorporated areas is identical to that for an incorporated area, with one exception. The petition requesting a referendum on the question of the proposed sanitary district must be signed by 20 percent of the voters residing in the area to be included in the district.

The board may levy taxes upon property within the district for corporate purposes, but the aggregate amount of such taxes may not exceed 0.25 percent of the assessed property valuation. This rate may be increased by an additional 0.25 percent to a maximum of 0.50 percent, if such an increase is authorized by the voters in a referendum.

The district may also collect charges for construction, maintenance, and operating costs over and above those covered by normal taxes from producers of industrial wastes. In addition, the district may defray the cost of constructing drains, sewers, laterals, and other necessary adjuncts by special assessment, by general taxation, or by a combination of the two.

The district may borrow money for corporate purposes and issue bonds payable from taxes, but the total permissible indebtedness is limited to 5 percent of the district's assessed property valuation. All general obligation bonds must receive prior approval from the district's voters before they may be issued. However, such bonds may be issued without holding a referendum, if the district has been ordered by a court or administrative agency to abate the discharge of untreated or inadequately treated sewage, and if borrowing is necessary to comply with the order.

To finance the acquisition or construction, improvement, extension, and operation of either a drainage system or a waterworks system, the district may issue revenue bonds payable solely from the income derived from the operation of such systems. However, only the voters may authorize such revenue bonds through a referendum.

CASE STUDY 5.

THE SPRINGFIELD SANITARY DISTRICT

Prior to creation of the Springfield Sanitary District in 1924, raw sewage was discharged into fifteen open ditches which surrounded the City. This sewage eventually reached the Sangamon River, which was then the main source for the City's water supply. Local residents sought to remedy the obnoxious conditions created by the situation.

Residents felt that an organization to serve Springfield and several outlying municipalities was more desirable and less costly than individual systems. For this reason, the people of the Springfield area turned to the State Sanitary District Act of 1917.

On February 20, 1924, 150 legal voters petitioned to organize a sanitary district. A referendum was held shortly afterwards, and the District was declared legally organized on April 18, 1924.

Within the next year, almost $2.5 million in general obligation bonds was approved by referendum to finance the original sewerage system. When this system began operation in 1929, Springfield became one of the first communities in central Illinois to be served by sewage treatment facilities.

General obligation bonds were not issued again until 1956, when a referendum vote approved $3.2 million for emergency construction and $1.2 million for deferred work by the District. In 1956 the District initiated a sewer service charge, which has been used to retire the general obligation bonds. Bonds in the amount of $800,000 were also approved in 1960 and are being retired in the same manner.

For general corporate purposes, the District collected a corporation tax of 0.083 percent of the assessed property valuation, as authorized by the 1917 Sanitary District Act. In addition, the District also levies a public benefit tax when necessary. By law, this tax cannot exceed 0.05 percent of the assessed property valuation.

On June 27, 1960, the District passed a connection fee ordinance. Annexed areas or areas which wish to tie into the Sanitary District lines are charged a connection fee. Fees thus collected are deposited in a fund to be used exclusively for capital improvements in the District.

The District has also applied for and received Federal grants. In 1957 the District received a grant of $250,000 from the U.S. Public Health Service to cover part of the cost of additions to the sewage treatment works.

The District recently received a grant of $86,570 under the Water Quality Control Act of 1965 to investigate a method of treating the combined flow of storm and sanitary overflow waters which occur during times of heavy rain. The total project cost has been estimated at $199,140.

In addition, the District has applied to the Department of Housing and Urban Development for a grant of $278,900 under the Water and Sewer Facilities Program to aid in the construction of needed sewer lines. The total project is estimated at $625,000.

Since its inception in 1924, the Springfield Sanitary District has spent more than $2 million for treatment plant construction and more than $4 million for sanitary sewers, interceptors, and pumping stations. Through the creation and proper operation of a sanitary district, the people of the Springfield area are meeting one of the important needs of the community.

PARK DISTRICTS

Illinois has about 200 park districts, ranging in size from 1 to 8000 acres. The park district has become a popular means of providing public recreational facilities and programs. Any territory which forms one connected area may be incorporated as a park district.

Five elected commissioners act as the corporate authorities of the park district with authority to offer a variety of recreational services. The commissioners may operate swimming pools, bathing beaches, boating, and other facilities for water-related recreation. A park district may take possession of and reclaim submerged public lands which are not fit for navigation, and may operate recreational harbors. A park district is organized by the standard petition-hearing-referendum process. The petition must be signed by 100 residents of the proposed district.

To finance the activities of the district, the commissioners may levy a tax of up to 0.10 percent of the value of all taxable property in the district for general purposes and 0.05 percent for recreation. Additional taxes may be authorized by public referendum for certain purposes. The district may issue bonds, but the total amount of bonds issued cannot exceed 2.5 percent of the total assessed property valuation. Revenue bonds may be issued for certain purposes, such as swimming pools and recreational harbors.

OTHER DISTRICTS

A number of other special purpose districts are involved in one or more aspects of water resources management.

Forest Preserve Districts

For the education, pleasure, and recreation of the public, forest preserve districts are directed to: a) acquire and hold lands containing or capable of containing natural forests; b) protect the flora, fauna, and scenic beauty of such forests; and, c) restock, restore, and preserve such forests. Forest preserve districts are specifically empowered to acquire lands along watercourses, lakes, ponds, and planned impoundments or lands which are required to store floodwaters, to control other drainage and water conditions, and to preserve ground water.

Mosquito Abatement Districts

Mosquito abatement districts are responsible for the extermination of mosquitoes, flies, and other insects. Specifically, the districts are authorized to treat all stagnant pools of water and other breeding places; to build and maintain levees, cuts, canals, and channels; and to cooperate with the State Department of Public Health.

Surface-Water Protection Districts

Surface-water protection districts are established to provide facilities for the prevention and control of surface-water damage. At least four districts have been organized in Illinois.

The executive body of the district, a board of five trustees, has the power and legal duty to provide adequate protection from surface-water damage for all persons and property within the district. The board is authorized to prescribe all necessary regulations and may acquire, establish, maintain, and operate ditches, channels, sewers, pumping stations, retention basins, dams, levees, or any other necessary structure within the limits of the district.

SPECIAL ORGANIZATIONS CREATED BY STATUTE

In addition to districts organized under permissive legislation, the General Assembly has created a number of special organizations tailored to meet the specific requirements of certain areas.

Special Sanitary Districts

Three sanitary districts have been created by special acts. Although these acts are couched in general terms, they obviously are applicable only to certain areas.

The Metropolitan Sanitary District of Greater Chicago covers 858 square miles and includes the City of Chicago, 115 other municipalities, and 25 other sanitary districts. Authorized under an 1889 act, the District was organized primarily to protect the water supply of Chicago from contamination by preventing the discharge of sewage into Lake Michigan. In addition to the original act creating the District, at least 50 subsequent acts have extended the boundaries of the District.

The District treats more than 1 billion gallons of sewage a day at four treatment plants. The District also constructed the Chicago Sanitary and Ship Canal to divert sewage from Lake Michigan and to promote navigation. The Canal reversed the natural flow of the Chicago River and the South Branch, causing them to discharge into the DesPlaines River, rather than into Lake Michigan.

To finance construction, improvement, and operation of its facilities, the District may obtain funds through taxation, special assessment, leases, contracts for services, general obligation bonds, revenue bonds, and permits and penalties.

East Side Levee and Sanitary District

The East Side Levee and Sanitary District serves about 140,000 inhabitants in thirteen incorporated and several unincorporated municipalities in Madison and St. Clair Counties. Because the District is situated primarily in river bottom land, drainage is a major concern. Greater emphasis has been placed on drainage than on sewage treatment.

North Shore Sanitary District

Created to protect the waters of Lake Michigan from pollution, the North Shore Sanitary District extends from the Wisconsin state line to the boundary of Cook County. Before the District was formed, the serious pollution was reflected in the high incidence of water-borne diseases in the North Shore municipalities. Eleven sewage treatment plants were built by 1958, two with complete treatment, one with chemical treatment, and the other with treatment by sedimentation.

PORT DISTRICTS

Illinois has eight port districts—the Chicago, Waukegan, Joliet, Tri-City, Seneca, Shawneetown, Southwestern, and Little Egypt Regional Port Districts.

The Little Egypt Regional Port District, created in 1965, has authority to: a) require permits to build any structure or deposit any material in, or within 40 feet of, any navigable water; b) regulate the anchorage, moorage, and speed of vessels; c) acquire, operate, maintain, and lease port and terminal facilities; d) prevent or remove obstructions in navigable waters; e) locate and establish dock lines and shore or harbor lines; f) locate, establish, operate, and improve public airports and facilities; and g) collect rentals, fees, and charges for the use of airports, terminals, and other facilities.

Revenue to finance the activities and projects of the Port District can be obtained through revenue bond issues, and from fees, charges, and fines. The Little Egypt Regional Port District has no authority to levy taxes or special assessments. The District may accept grants, loans, or appropriations from any Federal agency. The other port districts have similar powers and duties with some variations tailored to meet the needs of the areas they serve.

REGIONAL PLANNING COMMISSIONS

Specific legislation directly created the Northeastern Illinois Metropolitan Area Planning Commission in 1957 and the Southwestern Illinois Metropolitan Area Planning Commission in 1963.

The Northeastern Illinois Metropolitan Area Planning Commission serves an area encompassing all or part of Cook, DuPage, Kane, Lake, McHenry, and Will Counties and has authority to: a) assist local governments in preparing plans, policies, and proposals and advise local governments of the relationship of their plans and policies to those of other local governments in the area; b) prepare and recommend to local governmental units, generalized comprehensive plans and policies which may cover such topics as land use, transportation, water supply and distribution, drainage, flood control, sewage disposal, and recreation; and c) conduct research required for planning, including the collection of data on population trends and the social, economic, physical, and governmental factors affecting the development of the area.

The Northeastern Illinois Planning Commission has no formal revenue-raising powers. The Commission may solicit and accept appropriations from any governmental unit within its jurisdiction. The Commission is further authorized to accept funds from the State and the Federal Governments. For the 1965-67 biennium, the State appropriated $100,000 to the Commission.

The Southwestern Illinois Metropolitan Area Planning Commission serves an area encompassing all of Madison, Monroe, and St. Clair Counties. Its powers and duties are similar to those of the Northeastern Commission.

COOPERATION, COORDINATION, AND COST SHARING

Recent State administrations have fostered a policy of cooperation and coordination with Federal programs which affect Illinois. The Governor has designated the Director of the Department of Business and Economic Development as his representative in matters of mutual interest to the State and the U. S. Corps of Engineers. The Director, with the assistance of the members of the Technical Advisory Committee on Water Resources (TAC) of which he is chairman, reviews Corps of Engineers' proposals, coordinates these with other entities, and provides active liaison between State agencies, local governments, and the Corps of Engineers.

In addition, the Director, in cooperation with the TAC and the State Division of Soil and Water Conservation, reviews and recommends approval or disapproval of local applications for assistance under the P. L. 566 program. These applications and recommendations are then forwarded to the Governor for final action.

When necessary, the General Assembly makes appropriations for cooperation in Corps of Engineers' projects in the State which may require non-Federal cost sharing, or more extensive development to comply with State requirements. Such projects include the Carlyle, Shelbyville, Rend Lake, and proposed Lincoln Reservoirs.

In addition, the Illinois Division of Waterways maintains an active cooperative relationship with the Corps of Engineers. By memorandum dated April 23, 1965, from the Governor's office, the Division was designated as the State agency responsible for liaison with the Corps of Engineers with regard to the accumulation and dissemination of flood data. The Governor also designated the Division, prior to July 1, 1961, as the coordinating agency for the State in connection with flood-plain information studies conducted under the provisions of Section 206, P. L. 86-645. The Division is also responsible for disseminating public notices released by the Corps of Engineers.

Legislation passed in the 74th General Assembly designated the Department of Public Works and Buildings as the cooperating agency to act with the Corps of Engineers in connection with the construction of the Carlyle and Shelbyville Reservoir projects and the Kaskaskia River navigation program. Agreements concerning the water supply aspects of the Reservoirs, which enable the State to recover some of its investments, have been made with the Corps of Engineers.

The State participates financially in the programs of the Great Lakes Basin Commission, the Wabash Valley Interstate Commission, and the Ohio River Valley Water Sanitation Commission. It is also a member of the Bi-State Development Agency and cooperates with the Council of State Governments through the Illinois Intergovernmental Cooperation Commission. The functions of these interstate agencies are discussed in an earlier section on interstate compacts.

State financing of cooperative programs with local governments has been very limited. In special cases, this may be done on a contractual basis with municipalities and counties. However, special appropriations must be made by the Legislature before this kind of arrangement is possible. Most of these cases have dealt primarily with flood control projects. The Department of Public Works and Buildings may cooperate with local political units in studying certain projects, but before they can initiate such studies, authorization and appropriations must be approved by the General Assembly. The Department of Conservation, subject in many cases to the legislative restrictions mentioned above, cooperates with local political units in the development of recreational areas.

In recent years, the State has followed the policy of seeking the greatest degree of overall development of each reservoir project in Illinois. The Technical Advisory Committee on Water Resources reviews all aspects of proposed Corps of Engineers' reservoir projects in Illinois and coordinates the State agencies and interested local groups in these matters. The Rend Lake project, described previously, is a good example of a multi-purpose project in which the State, the Federal Government, and a local unit, the Rend Lake Conservancy District, cooperated.

While the Department of Business and Economic Development and the TAC are responsible for preparing this water resources plan, three other State agencies are involved in planning for substantive elements, i.e., the actual projects to be constructed. These agencies are the Division of Soil and Water Conservation in the Department of Agriculture, the Division of Engineering in the Department of Conservation, and the Division of Waterways in the Department of Public Works and Buildings. Each of these divisions is concerned with developing plans for projects within its areas of responsibility. Program and activity responsibilities of these divisions are discussed in the section on state departments and agencies.

As indicated previously, the Division of Waterways in the Department of Public Works and Buildings supervises the planning and construction of State flood control works. In addition, it cooperates closely with other State, local, and Federal agencies which have flood control projects and studies in the State. Division personnel are continuously involved in the general investigations and analyses required in the development of plans of improvement for flood control and other water-related projects. However, before final plans and actual construction can begin, the Illinois General Assembly must authorize the project and appropriate funds for completion of the proposed improvement.

In addition to State activities, many local organizations are concerned with flood control and related programs. These include soil and water conservation districts and subdistricts, surface-water protection districts, river conservancy districts, and municipalities.

Water supply is considered as primarily a local responsibility. Initiative for water supply projects comes from the local people, as in the case of the Rend Lake Conservancy District water supply system, and may be supported by State funds in some instances. The State has not initiated and financed a project specifically for water supply, although water supply storage has been included in some projects in which the State has participated. As mentioned previously, the Illinois Department of Public Works and Buildings has been cooperating with the Corps of Engineers in connection with the Carlyle, Shelbyville, and Rend Lake Reservoirs for water supply storage in these projects.

Local units, such as municipalities, river conservancy districts, soil and water conservation districts and subdistricts, and water authorities, also have programs and responsibilities with respect to water supply projects.

Water quality control is primarily the responsibility of the State Sanitary Water Board. The Board has rather broad regulatory powers for controlling pollution of the waters of the State. These regulatory functions have been discussed in prior sections of the chapter on state departments and agencies.

Although the Sanitary Water Board is not directly involved in the construction of projects for water quality control, except to issue permits for such construction and associated works, it may recommend, in cooperation with the Divisions of Waterways and Sanitary Engineering, that certain standards with respect to dilution and low-flow augmentation for water quality control be considered in the development of water resources projects in the State.

ORGANIZATION AND FUNDING IN OTHER STATES

Previous sections of this chapter have described the governmental organization and the methods of financing of water resources development in Illinois. This review indicates the fragmented and overlapping responsibilities of the various agencies of the State Government in the management and development of water resources.

For comparison, it may be useful to describe the organization for water resources management and development and the various financial programs of other states.

ORGANIZATIONAL STRUCTURES

The administrative structures through which six other states plan, manage, and develop water resources are:

California: The California Department of Water Resources is responsible for water resources planning, management, and development in that state.

Kansas: The Kansas Water Resources Board formulated a state water plan which was enacted by the state legislature in 1965. The Board has been directed to submit revisions or additions to the plan from time to time for enactment by the legislature. The Kansas WRB has authority, whenever any person proposes any action that may conflict with the plan, to review and approve, or prohibit, such action.

The WRB has also been empowered to contract with any public corporation or with the Federal Government for the inclusion of water supply storage space in any proposed water development project. In addition, the WRB may provide financial assistance to certain public corporations for part of the cost of water development projects.

Kentucky: A Kentucky Water Resources Authority was created in 1966. It is composed of the Governor, the Attorney General, and the Commissioners of Natural Resources, Finance, Health, Commerce, and Agriculture. The Act also created a Division of Water in the Department of Natural Resources which is responsible for water use and management in Kentucky.

New York: A Water Resource Commission was established in 1962 to coordinate water resources planning and to establish a state policy for water resources development in New York. The Commission is composed of the Commissioners of Conservation, Health, Commerce, Agriculture, and Markets; the Superintendent of Public Works; the Attorney General, the Commissioner for Local Government; and four advisory members representing agriculture, industry, the cities, and fish and wildlife interests. The Division of Water Resources in the Conservation Department provides staff services to the Commission.

Texas: Created in 1957, a Water Development Board is responsible for all water resources activities in Texas. It is composed of six members appointed by the Governor and serves as an independent agency under the Governor.

Wisconsin: In 1966, all water resources responsibilities were centralized in a reconstituted Wisconsin Department of Resource Development. The act that authorized the Department also provides for the appointment of an advisory policy board by the Governor.

FINANCIAL PROGRAMS

Brief examples of the financial programs of other states for providing water resources development and services are given below.

California: The California State Water Project, recommended in 1957 by the California Water Plan, is financed by the California Water Resources Development Bond Act, which authorizes $1.75 billion in state general obligation bonds. The bonds are marketed under the direction of the Water Resources Development Committee. The Department of Water Resources is also authorized to issue revenue bonds to finance the project. The Water Project provides water for municipal, industrial, and irrigation use, as well as other incidental benefits.

The state provides direct financial assistance to local governments for the construction of water projects; $25 million has been distributed since 1957. The program is financed from the Burns-Porter Act, which provides $130 million in general obligation bonds for this purpose. Another program provides assistance for the construction of flood control projects. Also financed from general obligation bonds, the program has provided $100 million since 1956.

New York: In November 1965, New York voters approved a $1 billion bond issue to finance part of the New York Pure Waters Program. The cost of the Pure Waters Program, including the portion to be borne by local governments, is estimated at $1.7 billion. A community may receive 60 percent of the construction costs of sewage treatment works. The cost of a project is divided: 30 percent state, 30 percent Federal, and 40 percent local. The program permits the state to pre-finance the Federal share, with arrangement for recovery when the Federal grant program is amended. (This is now before Congress.)

One hundred percent state aid is available for the preparation of local sewerage studies and cooperative water supply studies. New York also allows the creation of regional water resources planning and development boards; 75 percent of the financial support for these boards comes from state funds.

Kentucky: The Water Resources Act of 1966 established a special revolving trust and agency fund entitled the Water Resources Fund. All loans and expenditures for the development and construction of water resources projects are to be paid out of the Fund. The Fund is administered by the Kentucky Water Resources Authority and consists of all funds paid to the Authority, including fees, deposits, and repayments.

The Authority is also authorized to issue revenue bonds to finance water resources projects. The Authority may construct and operate state projects, contract with the Federal Government for water supply storage space in existing or proposed projects, and provide financial assistance to political subdivisions.

Texas: In 1962, Texas passed a constitutional amendment authorizing a $200 million bond issue to finance storage facilities and works necessary for the treatment and transportation of water. In November 1966, another constitutional amendment to authorize an additional $100 million bond issue to finance similar works was voted upon.

The Texas Development Board makes interest-bearing loans to local governments for the development of water supply projects. This program is financed by general obligation bonds.

Wisconsin: Wisconsin provides financial assistance to local governments for the construction of pollution abatement and prevention facilities. For cities using their own bonding power, the state provides up to one-third of the total project cost. If cities have reached the limit of their bonded indebtedness or if they face extreme financial hardship, they may enter into a leasing agreement with a non-profit corporation. The corporation is authorized to obtain the necessary bonds to construct the project. Facilities are leased to the state water agency, which sub-leases them to the municipality. The state will pay for one-third of the city's annual lease rental payments.

Carlyle Reservoir, Kaskaskia River

CONCLUSIONS AND RECOMMENDATIONS

I. WATER LAW

The present legal framework of water law has been developed incrementally over a long period. Many legal principles have ancient foundations. The Riparian Doctrine, for example, was originally a part of Roman Law. As a result, much of the existing water law does not reflect the current level of understanding of water resources. From the scientific viewpoint, all units of water are interrelated in a pattern or system. This pattern is called the hydrologic cycle. Existing water law, however, does not take cognizance of this inter-relationship. Rather, Illinois water law applies different legal doctrines to water in different locations. Illinois water law, therefore, is not necessarily based on scientific fact. Consequently, the existing legal framework is not adequate to cope with some emerging problems.

Compared to some other states and other countries, water law in Illinois, with the exception of drainage law, has not received much attention. Water has generally been available in sufficient quantity to satisfy most demands. Water use conflicts have been relatively few in number, as demonstrated by the dearth of court decisions regarding water use. However, water demands in Illinois have grown steadily. In certain areas, the difference between supply and demand has shown a marked reduction. Population expansion and concentration, coupled with industrial growth, will undoubtedly continue the upward trend in water demands. Consequently, water law will assume greater importance in the future. Although water law in Illinois does not appear to have acted as a constraint on economic growth in the past, this is no guarantee of its adequacy for the future in light of the shifting relationship between supply and demand.

Today, some new problems have already emerged. The transfer of water between river basins has been suggested as a solution for certain problems, but Illinois water law does not authorize inter-basin transfer. Secondly, inter-basin transfers may involve complex legal questions regarding the rights of riparian owners.

Another problem area centers on the fact that the right to use surface water is determined by the ownership of the lands bordering a watercourse. In the Kaskaskia River canalization project, for example, the State had to guarantee the Federal Government that surplus floodwaters captured by the Carlyle Reservoir and allocated to navigation would not be withdrawn from the River for any other purpose. Under existing law, the State, to insure such control, was required to purchase the bed and banks of the River in order to have the riparian rights to the water. This was an expensive solution.

Future developments and mounting water demands will undoubtedly produce new legal complexities, especially where legal uncertainties are involved. To adequately satisfy future water demands occasioned by economic and population growth, the legal framework governing water use must be designed so as to create a legal environment which will promote, not restrain, optimum water management. Otherwise, the future legal framework will be the result of discontinuous, piecemeal development based on short-range considerations and crisis planning.

A. It is strongly recommended that such a framework be developed through a comprehensive, in-depth study of Illinois water law and of the relationship between the legal framework and the goals of water resources management. The State should initiate such a study as a part of its continuous water planning program.

This study should build on past research, and extend it to apply to emerging Illinois water problems. Among the significant studies now available upon which future research should be based are **Illinois Water Rights Law and What Should Be Done About It** by John E. Cribbet, published by the Illinois State Chamber of Commerce and **Water Use Law in Illinois** by Fred L. Mann, Harold E. Ellis, and N. G. P. Krausz, published by the University of Illinois.

B. As a first step, information on water law should be made available in a convenient and useful form. In preparing material for this chapter, it was evident that the legal details of water resources management are scattered throughout numerous references. It is recommended that the pertinent statutes, decisions, and opinions be systematically cataloged and cross-referenced in a recodification of the water laws of Illinois.

C. In the immediate future, attention should be directed at two major current problem areas. Legislation should be enacted clarifying the present uncertainty involved in the use of surplus waters impounded in reservoirs during flood periods. Secondly, legislation permitting the inter-basin transfer of water should be proposed.

II. STATE-LEVEL ORGANIZATION

Organization at the State level to meet Illinois' responsibility for the proper management and development of its water resources should be a major consideration in the immediate future. Optimum management of the water resources through intelligent planning for its use rather than piecemeal development should be the goal of the State's activities in the water field. Good management will result in needed development when and where it will yield the best services to the people of Illinois.

An objective appraisal of the current status of the State's water resources development has resulted in the following general conclusions. The Technical Advisory Committee on Water Resources, by statute, serves the Department of Business and Economic Development in an advisory capacity only. Because the Technical Advisory Committee does not have more definitive and more extensive authority, the potential effectiveness of both the Committee and the Department is limited. Further, this situation makes less effective any attempt to integrate agency programs into a viable, responsive and responsible State program for water and related resources. The experience of the Federal Government and other state governments described in this chapter indicates that the integration of all agency programs is becoming increasingly important.

Each of the water resources programs in California, Kansas, Kentucky, New York, Texas, and Wisconsin described in this chapter was obviously structured to meet the particular political and resource needs of the state. Although not wholly adaptable to Illinois, they are characteristic of the kinds of changes in water resources policy which should be considered in Illinois.

A second and related observation is that a lack of definitive agency responsibilities tends to leave gaps between State and local water resources programs in Illinois. Although Illinois statutes enable the creation of several local entities to deal with water resource problems, no single State agency is overtly concerned with local problems and programs. An integrated State program, guided by a clearly defined statewide policy for water resources, would enhance the State-Federal-local relationships in this important area.

Another pertinent observation is that certain aspects of planning and research are dispersed among the State water agencies. Because planning is highly dependent upon collecting data and making it available, it would be desirable to integrate these functions to provide a better State water resources planning program.

Based upon the preceding observations, several alternative organizational arrangements were studied as to their potential for improving the management and development of Illinois' water resources. Each alternative was analyzed as to its potential effecttiveness in overcoming the problems mentioned above, and one alternative was determined to be most effective for Illinois:

A. It is strongly recommended that the present Technical Advisory Committee on Water Resources be transformed into a State Water Resources Board with broad powers for guiding and controlling water resources development and use. The existing technical functions of the various State departments and boards would be retained, while a significant increase would be realized in the integration of all State water resources management programs. The proposed Board, would be administratively attached to the Department of Business and Economic Development.

To be effective, the Board should be given powers and responsibilities (among others) to:

1. Determine State water resources policy within the framework established by the Governor;

2. Integrate and coordinate water programs of the State agencies, and have legislative authority for resolving water use conflicts;

3. Administer a program of financial and technical assistance to local governmental units for planning and resource development;

4. Review and approve comprehensive plans of local governmental units as they relate to State plans and policies;

5. Represent the State in all Federal studies and act on behalf of the State in contracting with the Federal Government; and,

6. Otherwise fulfill the functions of the existing Technical Advisory Committee.

The staff of the Division of Water and Natural Resources of the Department of Business and Economic Development would be increased to:

1. Serve as staff to the Water Resources Board;

2. Provide technical planning assistance to local governmental units; and

3. Carry out continuing State water resources planning functions.

In this regard, an effort should be made to integrate the water resources planning function at the State level. The Illinois Division of Waterways is the State agency with specific engineering and technical responsibility for project design and related activities. These particular responsibilities should be retained by the Division, which has technical capability in this area. The general river basin planning functions presently assumed by the Division of Waterways should be undertaken by the Department of Business and Economic Development to centralize the comprehensive water resources planning responsibilities in the State agency with statewide planning capabilities. This move to centralize the planning functions would, in essence, integrate the planning functions. The integration would lessen or avoid completely the conflicts which often lead to arbitrary decisions on issues concerning water use.

Facing similar needs in 1963, the State of Kansas was prompted to transform its Water Resources Board from an advisory group to a water development organization by extensively broadening its powers. Since that time, Kansas has moved from a situation of chaotic development to an orderly, integrated water resources program.

For Illinois, this alternative would retain most of the present structure, yet result in making the functions of the various agencies more specific. Further, it would result in more effective coordination of water agency programs and provide definite procedures in the State's relationship with Federal and local governments. Also, the State would be better able to determine the feasibility of participation in Federal projects as opposed to State and/or local development of specific projects. Finally, the State would have a central voice in a Water Resources Board with authority to make decisions concerning the development and use of the water resources of Illinois.

At present, any attempt to reorganize the State agencies concerned with water and other natural resources would create organizational problems and affect so many departments that invaluable time would be lost in placing Illinois in a favorable position to carry out an effective, responsible water resources management program. In this era of progressive Federal and State activity in the resources field, Illinois cannot afford to allow organizational chaos. For this reason, elevation of the Technical Advisory Committee to a State Water Resources Board with extensive authority to regulate water use and development, to provide Illinois with definite policy guidelines, and to oversee State water programs represents the most desirable approach for an effective water resources management program in Illinois.

III. REGIONAL ORGANIZATION

The existing arrangements for coordination of water resources development and management at the local level in Illinois need to be critically reexamined. The majority of local governmental units participate in the provision of water services. In any area of the State, the responsibility for water resources management is finely dispersed among counties, cities, villages, and a variety of special purpose districts. This environment of fragmented responsibility fosters a number of problems, such as uneconomical development of water utilities, inadequate investment in facilities, and uncoordinated water resources development. These problems are of increasing significance.

There is a growing need for a mechanism to promote the integrated management of regional water resources. Each local organization generally is concerned only with the water resources within its territorial jurisdiction. The interdependency of the water resources within a hydrologic unit, such as a river basin, has received only minimum attention. To promote the optimum use of all its water resources for all purposes, the State should initiate an integrated and intergovernmental approach to the management of the water resources of each region. Such an approach will be increasingly important as a system in the future, as it becomes necessary to intensify water resources management practices.

A. To achieve such an integrated approach, it is recommended that the State establish and support regional water resources commissions. A commission would encompass a complete river basin, but its boundaries would be modified where hydrologic and economic considerations make such modification desirable. Each commission would be given responsibility for integrating all aspects of water resources management within its area. The commissions could prepare comprehensive regional water resources plans, consistent with the State water resources plan.

Through financial incentives, the State and the commissions would be in a position to encourage local governments to cooperate in implementing regional water plans and in developing the most economical water facilities. Financial assistance, administered through the proposed State Water Resources Board, would be necessary to support the activities of the regional commissions.

These commissions would function as a means of creating a more effective State-local partnership. Although they would be allied to the proposed State Water Resources Board, the commissions would be directed by local representatives. This procedure would stimulate local cooperation and participation and, at the same time, would couple such local participation with the technical capability and financial resources of the State.

IV. FINANCING WATER RESOURCES ACTIVITIES

Financing water resources development in Illinois is closely related to organizational considerations. To adequately meet its responsibilities in the management of water and natural resources, it is a conclusion of this study that the State must appropriate, or provide in some manner, more funds than have been available in the past. Increased funds are needed to plan for the use of our water resources, to combat water pollution, and to provide for recreational and other development. This need is apparent at both the State and local level.

The Federal Government, by requiring water quality standards, has placed a significant burden upon states and local governments to spend millions of dollars to treat waste water adequately before it is released into streams. If the State Government does not provide the funds to accomplish this task, the Federal Government is ready to assume the role. Although financial assistance from the Federal Government is required in certain cases, water pollution control is still primarily a responsibility of the State Government.

Illinois' recreational needs, particularly for water-related recreation, are also great. Millions of dollars must be expended to provide a minimum amount of recreational land and water-related recreational facilities.

The need for increased appropriations to certain State agencies is apparent. The Division of Sanitary Engineering in the Department of Public Health, for example, is understaffed, underbudgeted, and in its present circumstance, cannot carry out the responsibility of overseeing the proper treatment of waste as assigned by the State and demanded by the Federal Water Pollution Control Act. Other agencies are in a similar circumstance.

Perhaps the greatest demand for additional financial resources is at the local government level. Local governments are required by State and Federal law to provide a proper level of treatment of waste water before it is released into the streams. However,

in many cases these local governments are prohibited by constitutional and statutory debt limitations from issuing general obligation bonds to pay for the needed treatment facilities. In many cases, even if the constitutional and statutory debt limitations were removed, sufficient funds would not be available to provide these services because of competing local demands for education, hospitals, streets, highways, and other facilities.

The Federal Government does provide, and will continue to provide in increasing amounts, financial assistance to local governments. However, there will always be a gap between the amount of Federal assistance available and the amount that is required by local governments. This gap must be filled by another source—the State Government.

In Illinois, appropriations from the General Revenue Fund have been used to support the water agencies and to finance major water resources projects and improvements.

On the basis of the magnitude of the need for both recreational facilities and for meeting the State's responsibility in the water resources area, Illinois must seek additional sources of revenue. The provision of adequate technical services by most State agencies can probably be met by increased appropriations from the General Revenue Fund. However, the great need for adequate water resources planning and development, for financial assistance to local governmental units for waste treatment facilities, and for the acquisition and development of lands for recreational and other water-related uses appears to be possible only through some source other than general appropriations.

A. For these reasons, it is strongly recommended that the people of the State be asked to approve in a public referendum the issue of general obligation bonds to support an expanded program to manage and develop the water resources of the State as outlined in this report.

As illustrated in this chapter, other states with active, progressive water resources programs have utilized such bond issues to provide these services. In the majority of cases, approval was granted on the first referendum.

This bond issue would form the basis for the Illinois Resource Development Fund. As presently conceived, this Fund would be composed of two major programs: (a) the State Projects Program, and (b) the Local Government Assistance Program. The proposed State Water Resources Board should be given the responsibility for the overall administration of the Fund.

The purpose of the State Projects Program would be to finance major State water and related land resources projects. Such projects would include recreational land acquisition and development and the construction of water resources facilities. In addition, this Fund would be used to finance State participation in Federal projects where such participation is deemed desirable. In the event that any of the water resources facilities financed by this program are of a revenue-producing nature, provisions will stipulate that the Resource Development Fund would be reimbursed from the revenues of the facilities.

The second program, the Local Government Assistance Program, would provide financial assistance to local governmental units for recreation, sewage treatment, and water supply purposes. This program would administer both grants and loans. Grants would be used chiefly where matching State grants are necessary to obtain the maximum benefit from Federal programs.

In addition, grants would also be used to encourage and assist local governmental units in undertaking comprehensive water supply and sewage treatment studies. To qualify for these planning grants, the comprehensive study would be required to consider area or regional needs and the possibility of intermunicipal or area systems to satisfy these needs.

The Local Assistance Program would also offer loans to assist local governmental units in developing needed water supply, sewage treatment, and recreational facilities. Particular attention would be given to those units which are unable, because of bonding limits or high interest rates, to reasonably finance needed facilities. All loans would be repayed with nominal interest to the Fund. Therefore, the loan portion of the Illinois Resource Development Fund would be a self-perpetuating revolving fund.

The Illinois Resource Development Fund with its component programs has only been presented in outline form. The specific provisions of this Fund should be developed after detailed consideration and evaluation.

V. LOCAL GOVERNMENT DEBT AND TAX RATE RESTRICTION

The following discussion on local financial restrictions is necessarily limited. To adequately appraise the problem, a major in-depth study should be made in this area of governmental operations. The point to be made here is that this particular problem affects in many ways the financial capability of local governmental units adequately to provide the numerous water services for which they have been given responsibility.

All local governments in Illinois operate under constitutional and statutory restrictions on their taxing and borrowing powers. These restrictions are specified in terms of the assessed valuation of locally taxable property. A referendum is generally required to approve bond issues and many tax levies. Instead of enhancing good government, such restrictions seriously impede local self-government, handicap the self-reliance of communities, and increase financial dependence on the State and Federal Governments.

These debt and taxing limitations are a reaction to abuses of county and municipal financial powers which date back as much as a century. The competence of the administrators of local government has increased greatly since that time.

Debt limitations as presently specified do not take cognizance of the total revenue raising capability of local governments. The level of permissible debt is related solely to the property tax. Today, local governments tap other sources of funds; revenue from parking meters is one such additional source. In Illinois, the overwhelming majority of cities collect a one-half-cent sales tax.

Statutory and constitutional financial restrictions often channel local governments into uneconomical financial practices. Local governments often resort to financing by revenue bonds to circumvent debt limits. In general, the cost of borrowed money is about 0.5 percent higher on revenue bonds than on general obligation bonds. The use of revenue bonds, therefore, may unnecessarily add to the cost of government.

Local governments have been granted extensive authority to provide numerous water services, but frequently this authority has been rendered meaningless because of ineffective funding authority. To enable local governments to fulfill their role in providing water and sewerage services, local authorities should be allowed maximum flexibility in financial management. In essence, this means that the current financial restrictions on local governments should be liberalized.

New York has recently taken a first step in this direction. In the fall of 1963, the people of New York State voted to exclude construction of sewerage works from the constitutional limitation on municipal borrowing. However, if local authorities are to maintain all their functions (including health, safety, water, education, and other services) in proper perspective, it is not desirable to remove only water and sewerage functions from the prevailing financial restrictions. Rather, the overall effectiveness of local governments should be strengthened by establishing a more effective framework for local government finance. The State should consider granting increased responsibility and power to local governments to allow them to establish debt ceilings and maximum tax rates. This fundamental change in the laws regarding local taxing authority would require a revision of the Illinois Constitution—a difficult and time-consuming process. Nevertheless, such a change should be given serious consideration as a long-range step toward improving local government finance.

Because of the magnitude of the present problems, the proposed State bond issue can be used to meet the immediate needs of local governmental units in Illinois. Both the short-range and long-range steps proposed here should be given serious consideration as the means to solving financial inadequacies in the State's water and natural resources program.

VI. INFORMATION NEEDS AND OTHER RECOMMENDATIONS

Effective water and natural resources planning depends upon sufficient information and data. It has been recognized that gaps exist in our present information. For example, no one agency is responsible for maintaining information on the organizational and financial methods which are used by local governmental units in providing water services. In addition, data should be centrally collected and maintained on water use and pricing practices, on sewerage service charges, and on other economic data affecting water resources activities of local units.

As previously stated, the foregoing types of information and data, ideally, should be collected and maintained by one State agency. Under our present organization, however, the data should be collected by the appropriate technical agencies and made readily available to the planning agency for its purposes.

Just as the State is not fully informed of local activities, so the local units are not adequately aware of the many water and related resource programs of the State agencies. An interchange of information could establish a base for cooperative planning.

As this State Water Plan is being implemented and as goals, policies, and programs are formulated, consideration should be given to the following general areas:

A. Flood-plain zoning in cooperation with local governmental units;

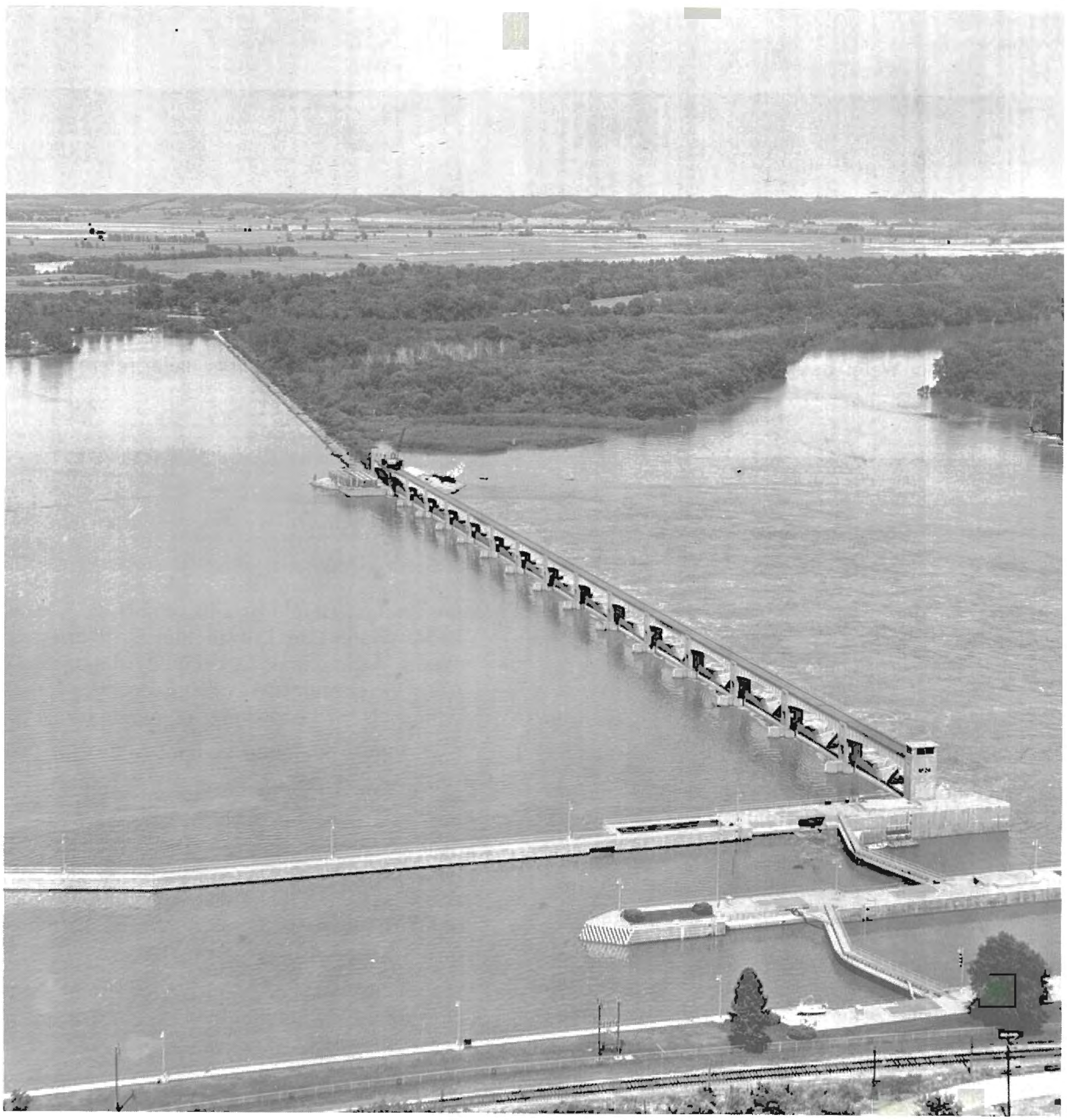
B. Reserving, or setting aside in some manner, sites for future reservoir or park development in known strategic areas;

C. Increased research by State agencies and the Water Resources Center in areas of need;

D. Integration of information and recommendations resulting from studies of the various legislative commissions, i.e., the Commission on State Government or the Water Pollution and Water Resources Commission; and

E. Gather economic information on alternative measures of water resources management so that recommendations for future development reflect economic justification.

As a state rich in water resources, Illinois has for too long neglected to plan for the proper management of this vital resource. This water resources plan represents the first comprehensive statewide study of water resources management in Illinois. Implementation of the important conclusions and recommendations presented in this plan will allow the State to significantly increase its role in water and natural resources development.



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