KANKAKEE RIVER BASIN STUDY

a comprehensive plan for water resource development

State of Illinois
The Honorable Otto Kerner, Governor

Department of Public Works and Buildings
Francis S. Lorenz, Director

Division of Waterways
John C. Guillou, Chief Waterway Engineer

State of Illinois
Department of Public Works and Buildings
Bureau of Water Resources
1967

State of Illinois
The Honorable Otto Kerner, Governor

Department of Public Works and Buildings
Francis S. Lorenz, Director

Division of Waterways
John C. Guillou, Chief Waterway Engineer

Springfield
1967

KANKAKEE RIVER BASIN STUDY

a comprehensive plan for water resource development

By Bruce Barker • John B. Carlisle • Raymond Nyberg

State of Illinois
Department of Public Works and Buildings
Bureau of Water Resources
1967

AUTHORITY

The 74th General Assembly through House Bill 2227 signed into law by Governor Kerner on July 21, 1965 authorized a survey, study, and report on the Kankakee-Iroquois River Basin.

water resources planning

Objectives of Water Resources Planning

The problems associated with water resources tend to appear larger and more pressing in the eyes of the general public with the passage of time. The magnitude of the problem may appear larger than it really is due to the increased awareness generated by the various news media, civic organizations, conservation groups, politicians, and to complete the cycle, a more aware public. There is no denying that the problems associated with the utilization of the water resource are increasing in magnitude and complexity. The increasing population and increasing uses of water require, more than ever before, that optimum beneficial use be derived from the water resource. It is axiomatic that the affluent society in which we live requires more and better utilization of all our natural resources.

It is the people—the general public—who must, in the end, make the determination as to how the water resources are to be developed and used. It is the people who vote for bond issues, conservancy districts, sanitary districts, and representatives to the General Assembly that make the decisions about how their water resources will be developed.

In order to make a knowledgeable decision, the citizen as well as the public official must know and understand the alternatives or choices he has in development of the resource. It is for this end that this plan has been prepared. An inventory of the resource has been made, past and present uses and problems have been analyzed, and estimates of future uses and problems have been prepared. Where problems have been recognized, solutions have been formulated. The utilization of engineering principles and judgment coupled with economic analysis has led to the formulation of programs for water resource development which, it is thought, will obtain the optimum beneficial use. The programs and alternatives are presented in order to better inform the decision maker—you.

Water Resources Planning in the Kankakee Basin

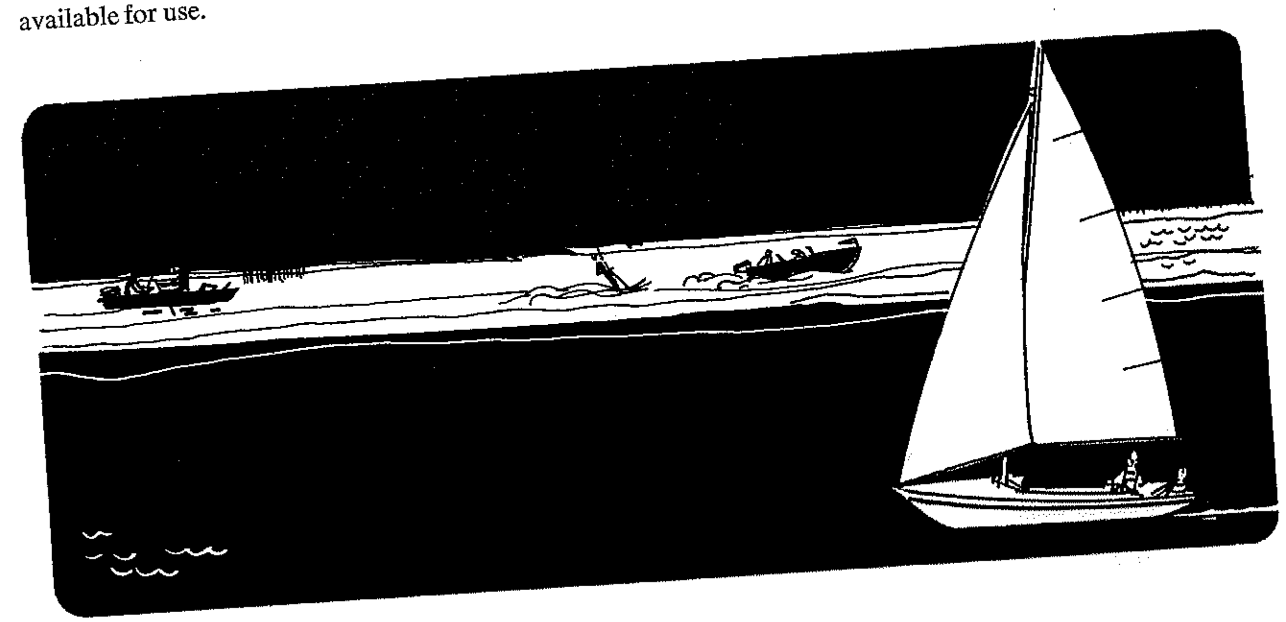
It is not entirely practical to draw an arbitrary boundary, ... watershed divide, around an area and consider ... boundary. A further constraint is that the basin study has been terminated at the Illinois-Indiana State Line. Yet, in the development of a water resources plan, all the discernible influences on the utilization of the resource must be considered whether they originate within or outside of the basin.

Most data, conclusions, and programs presented herein are for that portion of the Kankakee Basin within Illinois. In determining the demands placed upon the water resources of the Kankakee Basin both now and in the future, it was necessary to consider the much larger area encompassing northeastern Illinois and northwestern Indiana. Specific consideration has been given to the six-county area in northeastern Illinois: Cook, Du Page, Kane, Lake, McHenry, and Will Counties. It appears that by the year 2020 some of the growth of the Chicago Metropolitan Area will have taken place well within the Kankakee Basin. Numerous problems concerning sewage disposal, municipal water supply, recreation lands, flood damage, and drainage may be anticipated due to the spread of urbanization into the basin. Hopefully, solutions will be implemented to meet anticipated problems. It remains, then, for the affected citizenry and governments to plan and prepare and, thus, preclude the problems.

The emphasis of this report is on the problems in water resources peculiar to the Kankakee Basin which have been determined from study of past, present, and anticipated future developments in the region. The major areas of water resources development have been studied topically with a full discussion of background information, alternatives, and recommended solutions wherever applicable. In addition, the demands on water resources have been quantified for both the present and anticipated future conditions wherever this data is necessary in the formulation of recommended programs. The overriding consideration in report preparation has been to organize the data, alternatives, and recommendations in an orderly and understandable manner so that the conclusions can be readily evaluated by interested parties. It is hoped that the treatment of water resources development in this report will provide an improved basis for decision making.

In preparation of this report, the basic data was largely collected and compiled from available sources. These data were reviewed, evaluated, and modified as necessary for consistency and reliability. Several field investigations were made throughout the basin in order to obtain needed information and verify suspected conditions. Many agencies generously assisted the study by making data and unpublished reports in their files available for use.

In particular, the cooperation of the Illinois State Water Survey, the Illinois Division of Sanitary Engineering, the Illinois Division of Agricultural Statistics, the Illinois State Geological Survey, the U. S. Geological Survey, and the U. S. Soil Conservation Service is gratefully acknowledged.



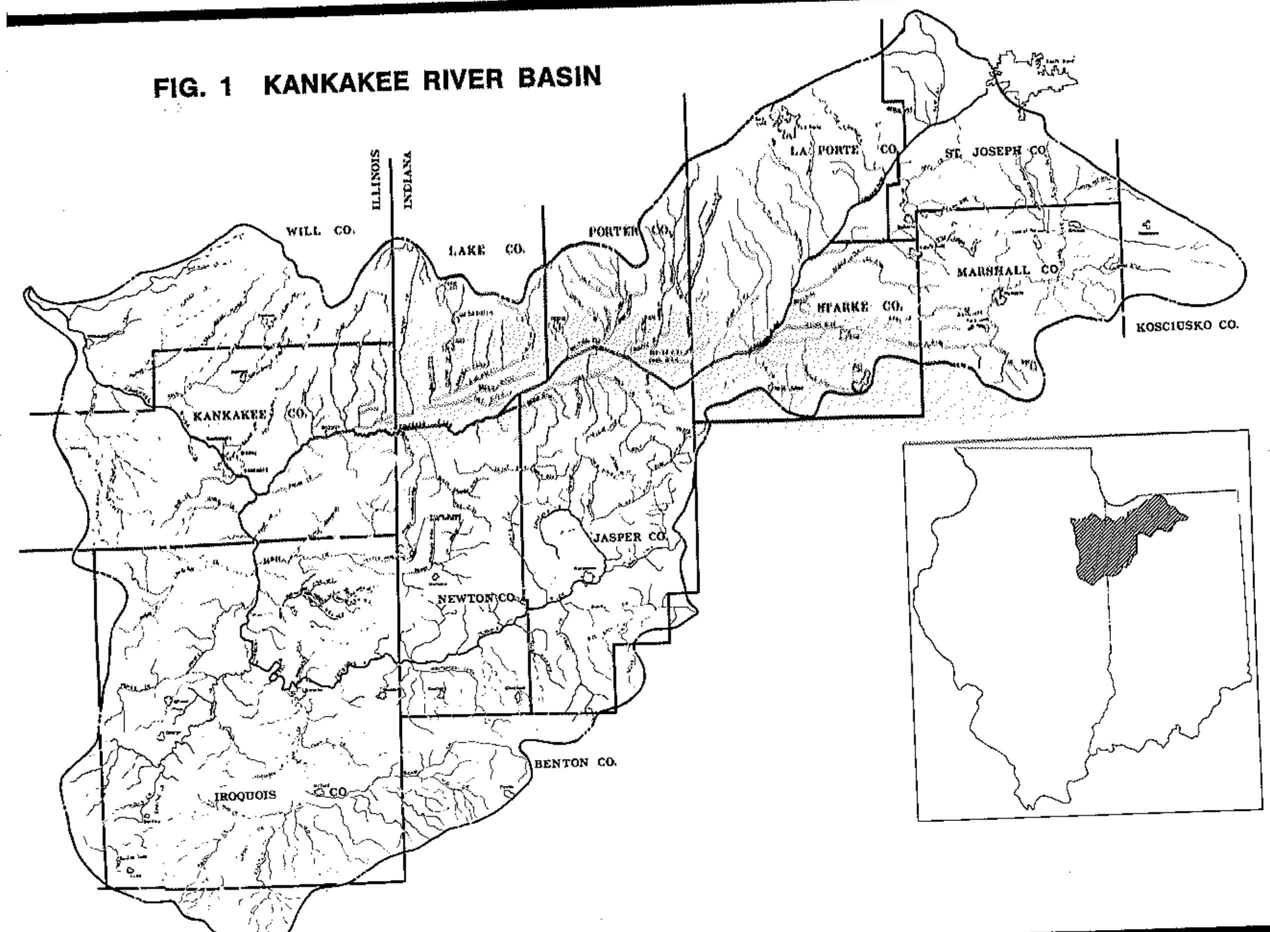
physical geography

Basin Description

The region under study in this report is primarily the Kankakee River Basin in Illinois. (Figure 1) The Kankakee River rises near South Bend, Indiana and flows southwesterly 111 miles to Aroma Park, Illinois, where it is joined by its largest tributary, the Iroquois River. The Kankakee then flows northwesterly for 38 miles to its junction with the Des Plaines River where the two rivers join to form the Illinois River. The Kankakee Basin is 130 miles long and 70 miles wide. The Kankakee River drains 5280 square miles of which 2155 are in Illinois and 3125 are in Indiana. The maximum relief in the basin between the mouth and the high point on the drainage divide near Valparaiso, Indiana, is 375 feet. The drainage divide is almost entirely defined by low ridges of glacial origin.

The Illinois portion of the basin comprises nearly all of Kankakee and Iroquois Counties, about half of Will County, and small parts of Grundy, Vermilion, and Ford Counties. Below the State Line, the Kankakee is 59 miles in length with widths varying from 200 to 800 feet and depths from 1 to 15 feet. The total fall from the State Line to the mouth is 127 feet. Channel slopes vary from less than one-half foot per mile to over 4 feet per mile. Table 1 gives channel slopes for various reaches of the river from the mouth to the State Line. Most of the river bed in Illinois is on or very near bedrock. Relatively thin sand and gravel overlie the bedrock with some small areas of silt. A prominent bedrock outcrop occurs in the channel near Momence and tends to maintain the water at a high level above Momence and into Indiana. There are two dams on the Kankakee River—one at

FIG. 1 KANKAKEE RIVER BASIN



Wilmington and the other at Kankakee. The Wilmington Dam is 11 feet high and forms a pool 2 miles long. The Kankakee Dam is 12 feet high and forms a pool 6 miles long. The reach of the river through Kankakee River State Park contains rock palisades and numerous riffles. The reach below Momence has a sandy and gravelly bed and provides some of the best sports fishing in the State.

The Iroquois River is the largest tributary to the Kankakee River and enters the main stream at Aroma Park 4.5 miles upstream from Kankakee. The Iroquois River is 94 miles long and drains 2175 square miles. Fifty-five miles of the stream and 1240 square miles of the drainage area are in Illinois. The river varies in width from 50 feet at the State Line to 400 feet near the mouth. Depths vary from less than 1 foot to more than 9 feet. The total fall from the State Line to the mouth is 31 feet. Nearly one-half of this fall occurs in the lower 6.5 miles below Sugar Island. A prominent rock outcrop at Sugar Island (near Chebanse) maintains a nearly level pool for over 27 miles upstream. Table 2 gives channel slopes for various reaches of the river from the mouth to the State Line. Table 3 gives the major tributaries and their drainage areas for the Kankakee and Iroquois Rivers.

TABLE 1

Kankakee River Channel Slopes

Reach	Fall (feet)	Slope (feet per mile)
Mile 0 (Mouth) to Mile 20	43	2.15
Mile 20 to Mile 30	41	4.10
Mile 30 to Mile 50 (Momence)	38	1.90
Mile 50 to Mile 59 (State Line)	5	0.55

TABLE 2

Iroquois River Channel Slopes

Reach	Fall (feet)	Slope (feet per mile)
Mile 0 (Mouth) to Mile 6.5 (Sugar Island)	14	2.15
Mile 6.5 to Mile 34	1	0.036
Mile 34 to Mile 55 (State Line)	16	0.76
Mile 55 to Mile 75.0	10	0.50

Physiographic History

Prior to the Pleistocene Epoch, about one million years ago, the area within the Kankakee Basin was drained by the Teays and Ticona Rivers. (Figure 2) The Teays was the predecessor of the present Ohio River. The Ticona was the predecessor of the Illinois River. The remnants of these ancient drainage systems are found in the bedrock underlying the glacial drift.

During the Pleistocene Epoch, four major continental glaciers covered portions of Illinois. The glacial periods are called the Nebraskan, Kansan, Illinoian, and Wisconsin. The Nebraskan occurred about one million years ago and the Wisconsin ended about ten thousand years ago. It is doubtful if the Nebraskan glacier, which entered Illinois from the west, ever reached the Kankakee Basin. Deposits from the Kansan and Illinoian glaciers have been identified in the Teays Valley in Southern Iroquois County. The surficial deposits in the Kankakee Basin are the result of the Wisconsin glaciation.

Glacial deposits are known collectively as drift. Drift deposits, which formed at the outer edge of the glacier when the rate of melting equaled the rate of advance, are known as terminal or end moraines. Heterogeneous deposits of clay, silt, sand, and gravel which were dropped by the receding glacier are known as till. Drift deposited by flowing melt water is called a glaciofluvial or outwash deposit, and drift deposited in slack water is called a glaciolacustrine or lake-bed deposit. Silt picked up from exposed drift by the wind and deposited over the land is known as loess. Sand dunes were also created by the wind and are common in southeastern Kankakee County. All of these deposits are found in the Kankakee Basin.

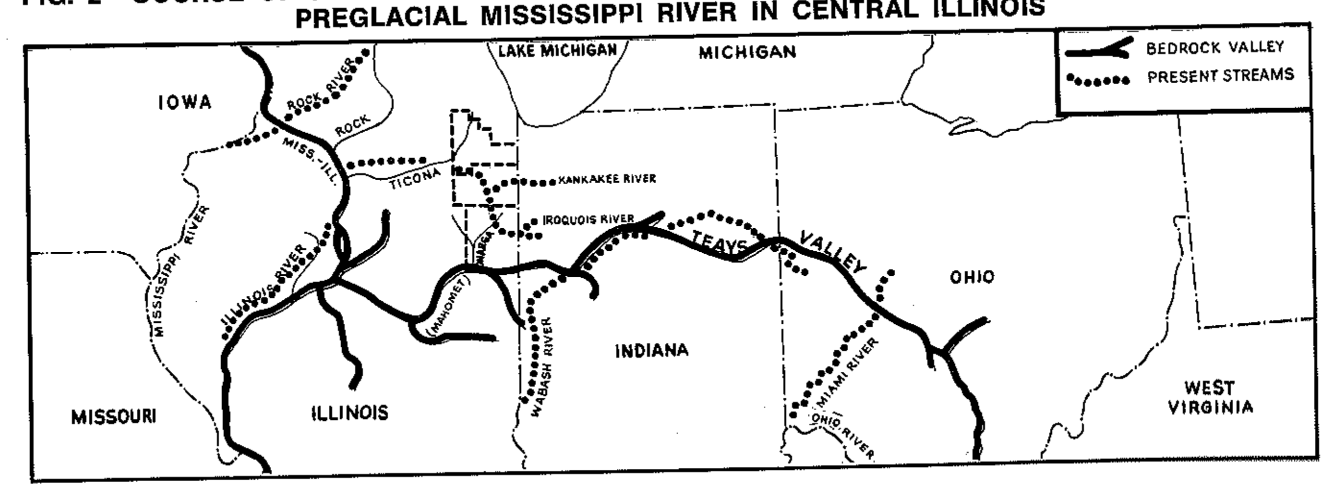
Most of the Kankakee Basin is included in a physiographic region delineated by Leighton, Ekblaw, and Horberg called the Kankakee Plain. The Kankakee Plain was inundated by widespread lakes of glacial melt water known as Lake Watseka and Lake Wauponsee. The former occupied most of Iroquois and the latter most of Kankakee County. (Figure 3) The ancient lake beds are enclosed by the various morainic ridges found in the basin. The lake bed or intermorainic areas are nearly flat and consist primarily of ground moraine overlain by sandy deposits, the latter existing locally as dunes, bars, and ridges. Lake-bed clays and silts are found in the glacial lake areas of the basin, but they are conspicuously thin.

Various Kankakee Torrent erosional features are also present. The steep slopes along the south side of the Minooka-Rockdale moraine and the north side of the Marseilles moraine are attributed to torrential erosion. Numerous channels and driftless areas along the river are other erosive features. The former generally have trends roughly parallel to the Kankakee River, and are either abandoned or occupied by small streams. Terry and Rayns Creeks are examples. Large, relatively smooth areas of dolomitic limestone are exposed where the drift has been removed.

TABLE NO. 3 **Kankakee River and Tributaries Drainage Areas**

Stream	Drainage Area (sq. mi.)
Kankakee	5,180
Iroquois	2,175
Sugar Creek	533
Mud Creek	225
Spring Creek	245
Prairie Creek	100
Yellowhead-Singleton Ditch	270
Forked Creek	151
Horse Creek	148
Rock Creek	107
Trim Creek	65
Prairie Creek	64
Exline Slough	62

FIG. 2 COURSE OF TEAYS RIVER FROM WEST VIRGINIA TO PREGLACIAL MISSISSIPPI RIVER IN CENTRAL ILLINOIS



than 125 feet on the north side. Silurian dolomites, associated with the bedrock surface of the Kankakee Arch, occur immediately below the drift in the north part of the basin. In the south, these rocks have been covered or overlapped by the Pennsylvania rocks of the Illinois Basin. The eastward dip of the rocks in Kankakee County is associated with the La Salle Anticline, a large north-south trending belt west of the basin.

Much of the bedrock has been removed by preglacial erosion. A good portion of the erosion is associated with folding and uplift which took place before the Pennsylvanian rocks were laid down. The older rocks of the basin were tilted and later beveled by erosive action. Deep troughs or valleys in the Pennsylvanian rocks indicate that extensive erosion took place after these rocks were laid down. The Mahomet Bedrock Valley (Teays) trends east-west along the south Iroquois County line. The bottom of this valley is about 300 feet below the surrounding bedrock uplands. A tributary to the Mahomet, the Onarga Valley, runs northeasterly from Onarga in Iroquois County. Drift aquifers in the bedrock valleys are a good source of water.

Soils

The majority of the soils in the Kankakee Basin have developed from parent materials of glacial origin. The Wisconsin Glacier removed the previously formed soils and left till, outwash, lake-bed sediments, and loess. The deposition of these materials has been previously described. The till has generally been covered by outwash, lake sediments, loess, and sands, or alluvial deposits of recent origin. The properties of the existing soils depend, among other things, upon the type and thickness of the upper deposits as well as the composition of the underlying materials. Various combinations of surface and sub-strata materials are found in the Kankakee Basin: loess on outwash, outwash on till, lake bed on till, loess on till, loess on lake bed, alluvium on outwash, and alluvium on bedrock.

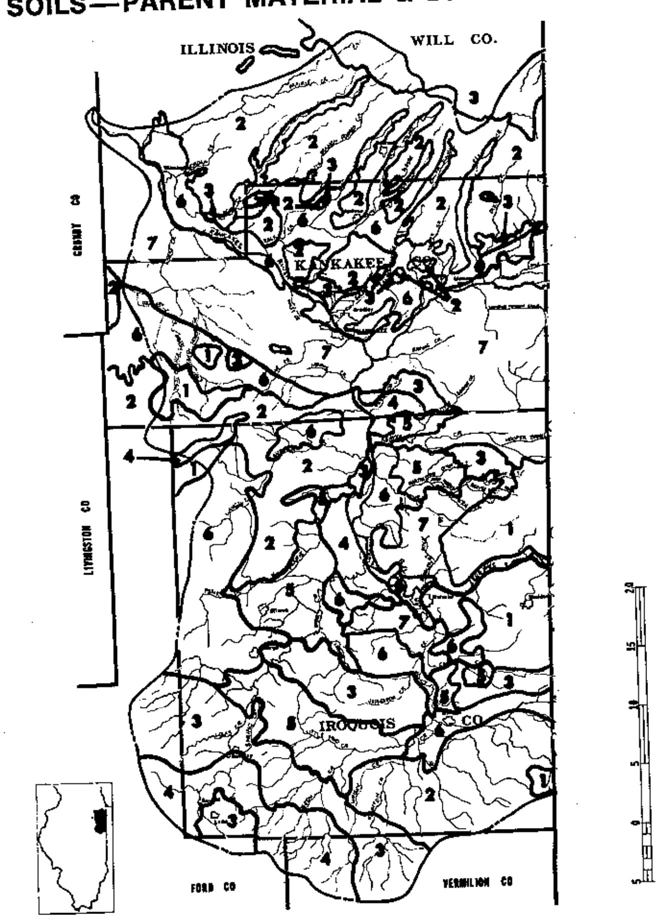
The underlying till is heterogeneous mixture of clay, silt, sand, and gravel. The physical and mineral composition of the till, as well as the degree of compaction it received during the Pleistocene, affect the permeability or underdrainage of the soils developed over till. The tills vary from slowly permeable to moderately permeable. The till in southwestern Iroquois County is composed primarily of compact material derived from shale and limestone rocks and is slowly permeable. The till in eastern Iroquois County associated with the Iroquois Moraine is less compact and moderately permeable. Figure 5 shows the general drainability of the soils of the basin.

Soils developed over lake sediments tend to have poor underdrainage due to the lower permeability of the fine-grained sediments. Lake Watseka sediments are fairly fine-grained, but Lake Wauponsee sediments tend to be sandy, gravelly, and better drained since the lake waters were flowing during the period of deposition.

Soils developed on outwash tend to have good underdrainage. These deposits have permeabilities ranging from moderate to rapid. These soils can be overdrained and the sandy topsoils tend to be droughty. Nearly one-fourth of the basin is covered by sandy soils.

Many of the soils of the basin are well suited to agriculture while others have serious limitations. Sandy soils on outwash are droughty and may be overdrained. Intensive management is required to maintain soil moisture, increase fertility, and minimize wind erosion. Thin loessal soils on impermeable till have poor underdrainage and are subject to water erosion. Thin, stony soils on bedrock are difficult to work and often suffer poor internal drainage.

FIG. 5
SOILS—PARENT MATERIAL & DRAINABILITY

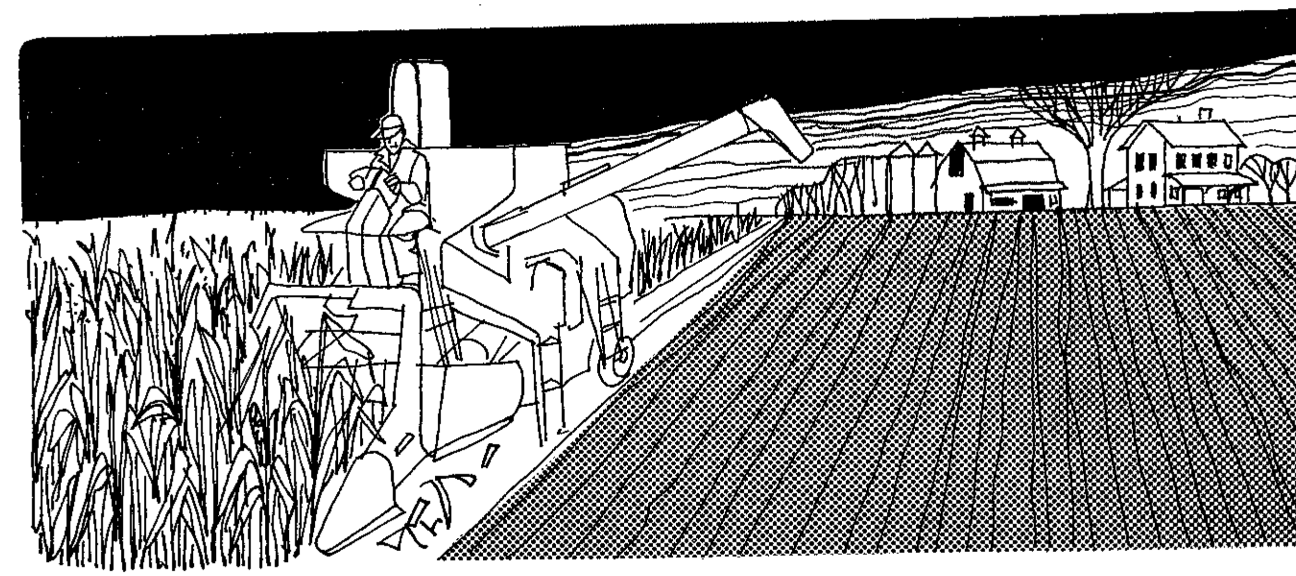


1. Moderately Permeable
2. Moderately Slowly Permeable
3. Slowly Permeable
4. Very Slowly Permeable

SOILS DEVELOPED ON TILL

5. Moderately Slowly Permeable
6. Moderately Permeable
7. Moderately Rapidly to Rapidly Permeable

SOILS DEVELOPED ON OUTWASH



Artificial drainage works have been required on many lands in the basin where the natural drainage system was poor. Ditches and field tiles have reclaimed large areas of wetlands and have converted these soils into excellent agricultural land.

Soil is an important consideration in the development of urban areas. Septic tanks are usually provided in subdivisions before sanitary sewers are built. It is essential that the soil be permeable enough to provide drainage from the septic tanks. Poor underdrainage may be a problem in some areas of eastern Will County where considerable urbanization is expected. It is also necessary for the soil to provide a stable and drainable foundation for buildings within the urban areas as well as provide a suitable topsoil for lawns.

Climate

The Kankakee Basin has the typical continental climate of the middle latitudes. Winters are cold with frequent snow, and summers are warm and humid with considerable thunderstorm activity. Temperature and precipitation vary greatly from season to season and year to year. The weather can change abruptly during a frontal passage which may occur 20 to 30 times a year.

Temperatures vary from an average high of 86°F in July to an average low of 18°F in February. The highest recorded temperature at Watseka was 106°F in July, 1901; the lowest was –23°F in February, 1905. The last killing frost in the spring usually occurs near the end of April or the beginning of May. The first killing frost in the fall generally occurs in the middle of October.

The average annual precipitation is about 36 inches. Approximately 22 inches occur during the growing season (middle of April to middle of October). The driest year recorded at Watseka was 1925, with a total precipitation of 23.24 inches; 43.87 inches of precipitation was measured in 1943, the wettest year recorded. A total of 50.68 inches was measured at Martinton in 1902 before measurements were made at Watseka. On the average, .1 inch precipitation, or more, is recorded 73 days per year at Watseka. The average annual snowfall is about 22 inches. Generally, 10 inches of snow will contain 1 inch of water.

The climate of the basin is fairly well suited to agriculture and any limitations on industry or commerce are minimal.

Summary

The physical geography imposes few serious limitations on the development of the Kankakee Basin. The immaturely developed stream system has caused drainage problems, but most of the basin has been artificially drained for agricultural enterprises. A large area of the basin soils tend to be droughty. The topography offers few suitable reservoir sites. Bedrock and drift aquifers as well as the sustained flow of the Kankakee River are generally sufficient for municipal, domestic, and agricultural water supplies. The Kankakee River offers an exceptionally fine opportunity for a recreation development. Most of the recoverable coal in the basin has been mined. There is an abundant supply of limestone, sand, and gravel available for construction purposes.

The geographical location of the basin makes it susceptible to considerable urbanization. The physical limitations which do exist in the basin must be given careful consideration when the Chicago Metropolitan Area population expands into the basin.

basin economy— past, present, and future

The planning of water resource development is the planning for future water use. To intelligently plan the orderly development of water resources, it is necessary to study past and present developments. The water resource is valuable only in so far as it satisfies wants and needs of the people. The basic element of water resource planning requires an estimate of the expected wants and needs that may be satisfied through the development of the water resource. Water uses are directly related to the social and economic development of an area. Consideration must not only be given to developments within the basin but also to developments outside the basin that will exert a demand upon the water resources of the basin.

Historical Development

The Kankakee Basin lies in northeastern Illinois and northwestern Indiana. Prior to development, the Kankakee Basin was a vast, wet prairie interspersed with numerous ponds and marshes all of which surrounded the Kankakee Marsh. Settlement and development of the region was retarded because of this. Since these marshy lands were not suitable for cultivation, the early settlers tended to specialize in livestock grazing. Some of these early cattle grazing enterprises encompassed several thousand acres. The Illinois Constitution of 1870 provided for the creation of drainage districts which were established under the Farm Drainage Act and the Levee Act. These legislative acts provided for the construction of outlet ditches and drain tiles by organized groups with powers of eminent domain and with special assessment taxing capability. The drainage districts which were created under the new legislation were far better able to undertake the necessary, large projects than were the individual land owners. New types of excavating machinery and the local production of drain tile greatly decreased the cost of drainage work and accelerated the development of agricultural drainage. Extensive land reclamation programs were undertaken which converted the marsh into arable land. The large cattle grazing enterprises were gradually broken up into smaller livestock and cash grain farms.

The Indiana portion of the Kankakee Basin was not developed as early as was the Illinois portion. The Kankakee Marsh in Indiana, encompassing about 400,000 acres, was virtually unoccupied until about 1880. Commercial hunting, trapping, and logging were the major industries for many years. Several owners of large tracts and several land reclamation companies began constructing drainage ditches and clearing the land at this time. One developer, Benjamin Gifford, profitably reclaimed over 40,000 acres of marshland between 1884 and 1896 in Jasper County, Indiana. By 1915 nearly one-third of the Kankakee Marsh had been reclaimed. Subsequent improvements have given fair drainage on most of the land while about 50,000 acres are still subject to frequent overflow from the Kankakee.

The earlier development of the Illinois portion of the basin was due to the earlier improvement of drainage and by the growth of manufacturing. The growth of manufacturing was enhanced by the development of water power, navigation, and coal mining.

Water power and water transportation were the key to industrial growth in the 19th Century. This combination was instrumental in the growth of Lockport, Joliet, Marseilles, Ottawa, Moline, Rock Island, Sterling, Rock Falls, and other Illinois cities. To a lesser extent, these factors influenced the Kankakee Basin. A mill dam was erected on the Kankakee at Momence in 1837 and was soon followed by similar projects at Aroma Park, Kankakee, Altorf, and Wilmington on the Kankakee River, and Sugar Island on the Iroquois. The crude brush dams at these sites were soon replaced by more substantial timber and masonry dams by manufacturing companies. The Kankakee Manufacturing Company was chartered by the legislature in 1840 for the construction of a dam on the river at Kankakee. In 1847, the legislature chartered the Kankakee and Iroquois Navigation and Manufacturing Company with powers to improve the navigation of both streams to the State Line, charge tolls, develop water power, and erect mills and machinery. This corporation, subsequently renamed the Kankakee Company, concentrated on the development of water power at Wilmington and finally established a navigable waterway from the Illinois and Michigan Canal to Warner's Landing.

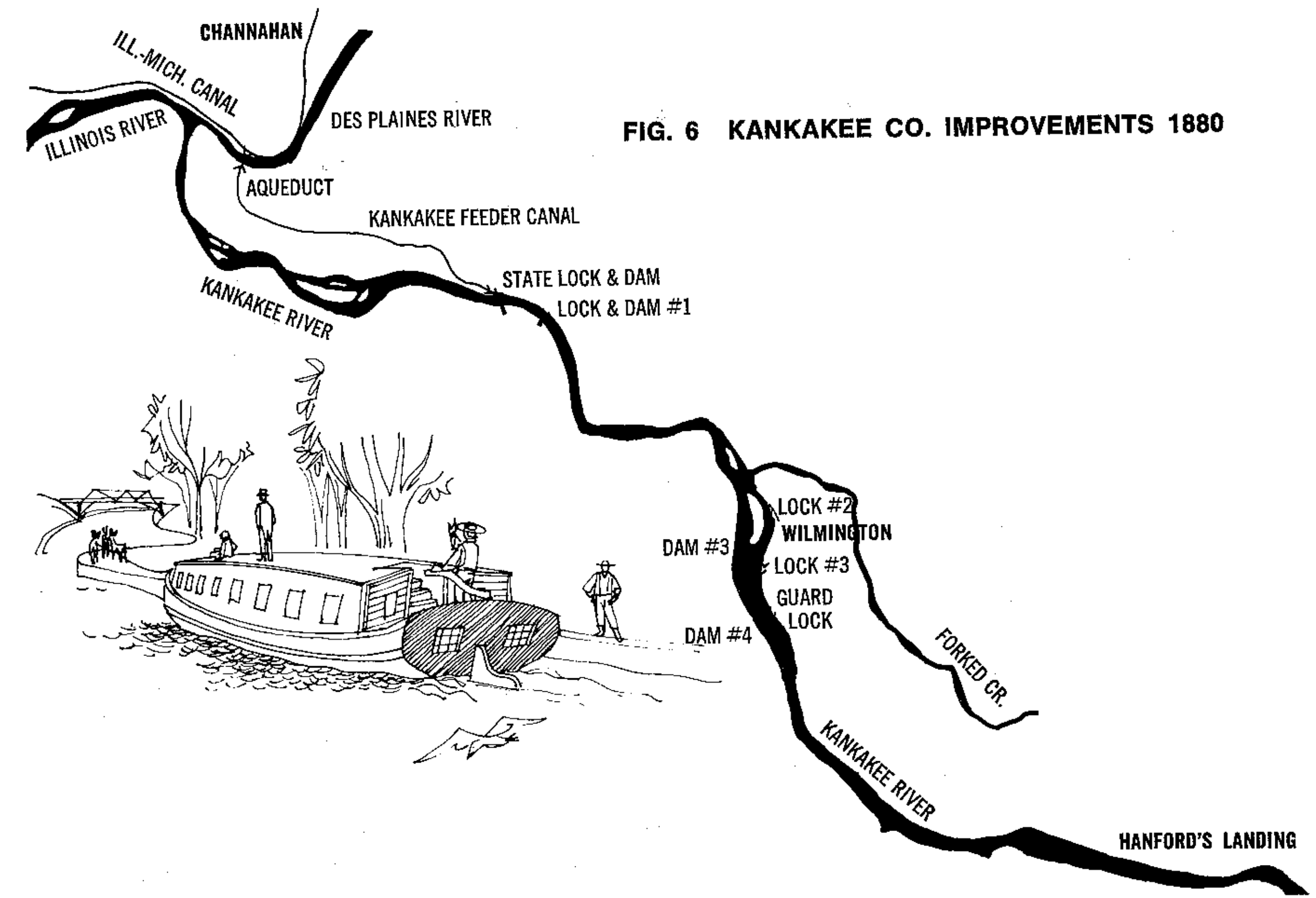


FIG. 6 KANKAKEE CO. IMPROVEMENTS 1880

The improvements of the Kankakee Company consisted of the construction of three dams and the raising of the State Dam at the head of the Kankakee Feeder Canal. (Figure 6) Dam No. 3 was about 1.3 miles upstream from Wilmington, and Dam No. 2 was at the head of Wilmington Island. The head race from Dam No. 3 was connected to the pool of Dam No. 2 by a lock near the head of the island. The easterly channel of the island served as a head race for the second level and was connected to the river below by another lock. About 3 miles downstream, Lock and Dam No. 1 connected the lower pool with the pool above the State Dam. Near the northerly abutment of the State Dam was the head of the Feeder Canal which was connected to the Illinois and Michigan Canal by an aqueduct over the Des Plaines River. The improvements had created a navigable channel 21 miles long with a minimum width of 100 feet and a minimum depth of 4.5 feet; the locks would admit the largest canal boats on the Illinois and Michigan Canal.

About 5000 horsepower was made available at the dams. The project had cost $3,500,000; but by 1880, the company offered its navigation improvements to the Federal Government for $350,000. The offer was rejected.

The Kankakee Company failed soon after 1880 due to financial and legal difficulties, the collapse of the Des Plaines aqueduct, and the destruction of several of their dams by floods.

About 1920, the Northern Illinois Public Service Company acquired mill dam properties and water power rights for the development of hydro-electric power on the Kankakee River. The utility acquired a 20% share in the reconstruction of the Wilmington Dam and installed a 200 kw hydro-electric plant. A power plant with 600 kw capacity was installed at the Kankakee Dam. The utility also acquired water power rights at Aroma Park and Altorf but never developed them. These hydro-plants have since become obsolete and the successor utility, Commonwealth Edison Company, has granted its properties at Altorf and Kankakee to the State. The properties at Aroma Park have been given to the Kankakee-Aroma Park District.

The water power and navigation developments were doomed to obsolescence by the advent of better railroad and highway transportation and by the development of a large and inexpensive energy source in the nearby Northern Illinois coal field. Hydro-electric power had a short lived career in Illinois and was rapidly replaced by steam-electric power plants. However, these early projects formed the nuclei for present day cities and villages along the Kankakee Valley.

Agriculture is still the largest land user and most important industry in the basin. The municipalities located away from the Kankakee River have been and are now primarily rural marketing and service centers. The better drained upland prairie soils are used for intensive cash grain farming. Livestock farming predominates on lands poorly suited for row crops. Even the shallow, sandy soils have been converted from a liability to an asset by irrigation of specialty crops such as flowers and vegetables.

Population

Census data are collected for political subdivisions, the boundaries of which do not generally coincide with drainage divides. The data which are presented in this report are for the Illinois portion of the Kankakee Basin and are estimates derived from the data available for Kankakee, Iroquois, and Will Counties.

The population of the basin was about 147,000 in 1960. About 54,700 people (37% of the total) lived in places with 2500 population or more (Census definition of urban places). If all incorporated municipalities are considered urban places, then 54% or 79,400 people live in urban places. Rural population density is less than 10 people per square mile in one township and averages 29 people per square mile throughout the basin. Urban population is increasing and rural farm population is decreasing. It is expected that the rural farm population will eventually decrease to less than 5 people per square mile (it is now less than 10). However, the urban fringe population will greatly increase. The eastern part of Will County may expect a large increase in population due to "spill" from the Chicago area. It is quite certain that by the year 2020 there will be relatively large suburban communities where only villages and agricultural land now exist.

Various population projections were studied in order to develop projections for the Kankakee Basin. The Chicago Area Transportation Study projected growth of the Chicago Metropolitan Area population into northern and eastern Will County. (References) This growth is expected to occur along the major transportation routes into Chicago: Interstate Highway 57, U. S. Highway 54, Illinois Highway 1, the Illinois Central Railroad, the Chicago and Eastern Illinois Railroad, and the Pennsylvania Railroad. It is expected that considerable growth will also occur in the Indiana portion of the basin.

An approach used by A. D. Little, Inc. in preparation of population projections for the Ohio Basin was simplified and modified for the Kankakee Basin. Projections developed by Candeub, Fleissig, Adley, and Associates for the Kankakee Development Corporation were expanded for the Kankakee Basin. Reference was also made to population projections made by the Wabash Valley Interstate Commission. The above studies and additional analysis were used to prepare the basin population projections.

The difficulty of making long-range projections for small areas is apparent. The low projection and the high projection given in Table 4 are intended to represent what is felt to be the lower and upper limits of growth which may be expected within the Kankakee Basin. The medium projection has the greater probability of occurring. It is also desirable to use different projections for different planning objectives. If a short length of time is required to plan and construct a project to meet future demands and if future, needed increments may be added relatively easily, then it is economically desirable to use the lower projections and risk underestimating. If a project requires a long period of time to plan and construct and if project increments are relatively difficult to add, it is generally best to use the higher projection and risk overestimating.

The chance of making erroneous projections increases directly with the length of time of the projection and inversely with the size of the population. Recognizing these limitations, the population projections for some municipalities are presented in Table 5. It is expected that the Kankakee urban area will provide the basis for most of the population growth with influx from the Chicago region providing a considerable amount in eastern Will County. The

TABLE NO. 4
Kankakee Basin Population Projections

Year	Low	Medium	High
1960	147,000	147,000	147,000
1980	170,000	227,000	240,000
2000	200,000	315,000	375,000
2020	230,000	435,000	620,000

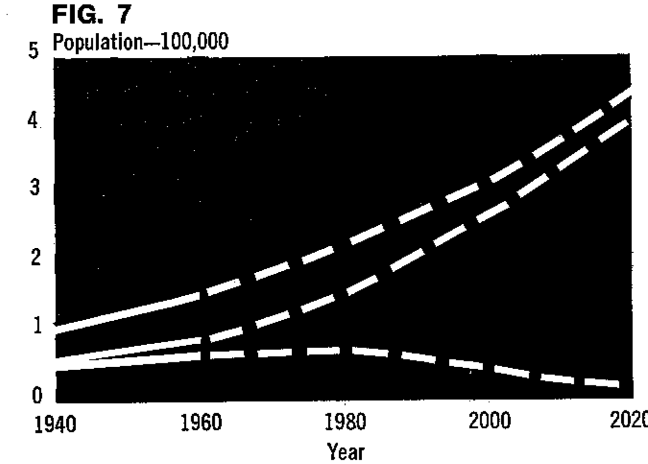
TABLE NO. 5
Population Projections for Municipal Areas

Municipality	1960	1980	2000	2020
Eastern Will County including Manhattan, Beecher, Monee, and Peotone	13,000	40,000	80,000	150,000
Watseka	5,219	6,500	8,000	10,000
Wilmington	4,210	5,100	6,200	7,500
Momence	2,949	3,600	4,300	5,200
Kankakee (Bradley, Bourbonnais, West Kankakee)	60,000	96,000	155,000	230,000

Kankakee area has a broad industrial base from which to grow. There is an ample source of water from the Kankakee River to meet nearly any industrial need. Costs of treated water are expected to remain moderately high and will tend not to favor the growth of heavy, water using industries.

As farm production becomes more mechanized, fewer people are needed to work the land. Some rural townships in the basin now have fewer than 10 persons per square mile. (Figure 7) The rural farm population is expected to continue to decline and may eventually have a density as low as five people per square mile. It is anticipated that the average rural population will decrease to a density of about ten persons per square mile by the year 2020.

FIG. 7



Industry and Trade

The largest industrial and trade center in the Kankakee Basin is the City of Kankakee and its suburbs. There is a broad industrial base with metal fabrication, chemicals, machinery, electrical machinery, and food processing being the largest employers. Value added due to manufacturing was over $200,000,000 in 1963. Manufacturing employees totaled over 12,000 and the value added per employee was nearly $17,000. With its present broad industrial base, proximity (60 miles) to the Chicago region, and aggressive action by local groups, the industrial output of the basin should continue at a vigorous pace.

Retail and wholesale trade and service businesses provide for about 50% of the employment within the basin. Retail and service businesses will expand concurrently with the population and will be largely located in the new suburban areas. Wholesale trade and finance will expand in the urban core communities. Although the rural farm population is projected to decline, the needs of the rural population will continue to increase. It is expected that the rural trade centers will continue to grow and possibly attract some light industry.

Agriculture

Agriculture is a major employer of people, services, and products in the basin. Iroquois County produces nearly two-thirds of the agricultural output of the basin. Agricultural production consists primarily of cash grain crops. The value of grain produced in 1965 was over $72 million. The livestock inventory was over $16 million. There are nearly 5000 farms in the basin with a total area of nearly 1.2 million acres. The average farm is 240 acres, and the average farm family is 3.7 people. The farm population has an areal density of about 10 people per square mile. Nearly 75% of the land is in grain farms and 1% is in vegetable farms, nurseries, and flower farms. Many of these specialty crops are irrigated. Most of the other land is used for hay and pasture.

Cash grain farming will remain the dominant type in the basin. Although, as the population of the basin grows and the Chicago Metropolitan Area expands into the basin, it is expected that dairy, vegetable, and specialty crop farming will become more important. Irrigation is being used on vegetable and speciality crops, and this practice is expected to increase.

Mining

There are clay pits, stone quarries, and coal mines in the Kankakee Basin. An extensive amount of strip mining has been done near the west edge of the basin in the Northern Illinois coal field, but most of the recoverable coal has been mined. Limestone is quarried in Will and Kankakee Counties. Clay is produced in Kankakee and Will Counties. Sand and gravel are produced in Iroquois, Kankakee, and Will Counties. The value of mineral production was about $6,000,000 in 1964.

Coal was the dominant mining product in the past. However, stone, sand, and gravel are now the most important minerals. As the area grows, more of these minerals will be required by the construction industry.

Transportation

Eight railroads and six main highways cross the basin. The basin is served by an airport at Kankakee. Interstate Highway I-57 will parallel U. S. 54. This will provide ready access to the Chicago Metropolitan area and place Kankakee on a major north-south route. I-55 crosses the basin near the mouth. I-80 crosses east-west just north of the basin.

Power

There are no major electric generating stations within the basin. The Commonwealth Edison Company has a nuclear-powered station at the mouth of the Kankakee (Dresden Plant) and a large steam-electric station near Joliet. The Dresden Plant obtains cooling water from the Kankakee River. Planned expansion of the plant includes 1600 megawatts additional capacity by 1970.

While the sustained flow of the Kankakee is quite high, there are no suitable sites for an economical hydro-electric plant. There is some potential for cooling water for a steam-electric or nuclear plant.

Summary

Historically, agriculture was the dominant force in the settlement of the Kankakee Basin. The availability of navigation and water power on the Kankakee River led to the development of manufacturing and provided the base for future industrialization. Iroquois County has remained predominantly agricultural. While agriculture is still important in Kankakee County, manufacturing is providing the basis for growth. The economy of the basin is oriented principally to the Chicago area. Considerable influx of population from growth of the Chicago area is expected in the future.

Consideration must be given to the needs of the new communities which will develop along the major transportation arteries from Chicago. The counties must plan for and be prepared to accept the influx of people. Adequate zoning ordinances will be required in order to achieve orderly growth and not chaos and urban sprawl.

hydrologic data

Application

Hydrology is the art and science pertaining to water. Study of hydrology involves the study of water in all occurrences—whether it is in the atmosphere, on the surface of the earth, or below the surface. Hydrology involves not only the occurrence of water but also the movement, distribution, and interrelation with the physical environment. Hydrology is a science insofar as water may be categorized according to the various physical laws. It is an art insofar as the measured data must be extrapolated, interpolated, and generalized in order to arrive at solutions applicable to the problem at hand. Mathematical statistics is an invaluable tool in interpreting and analyzing hydrologic measurements. Measurements of quantities and rates of movement of water at various locations constitute the body of hydrologic data.

When adequate hydrologic data are available, meaningful estimates can be made of: the quantities of water available in surface streams or ground-water aquifers, the frequency of droughts or floods, the frequency of intense rainstorms, and many other quantities. These estimates are not only valuable in preparing an inventory of the water resources of a region but are necessary in planning and design of water management projects.

Precipitation and streamflow data are systematically collected by government agencies at special measuring stations within the Kankakee Basin. Most of the precipitation data is collected by the U. S. Weather Bureau (Environmental Science Services Administration) through a nationwide network of rainfall gages.

Recording type rainfall gages provide a continuous record of precipitation at the station and are necessary in studying the variation of rainfall intensity during a storm period. Other gages, called non-recording, provide only the total precipitation occurring in a 24-hour period. The Illinois State Water Survey collects additional precipitation data for unusually severe storms from special gage networks and from field surveys. The published records of the Weather Bureau and reports of the State Water Survey are the basic sources of precipitation data. (See References)

Streamflow data are obtained at special measuring stations at several points within the Kankakee Basin. The most elaborate of these stations provide a continuous record of water stage which is converted to a continuous record of discharge through a stage-discharge table. The least elaborate stations measure only the highest water stage occurring within a year. Streamflow data are collected and published by the U. S. Geological Survey in a cooperative program with the State Water Survey, the Division of Waterways, the Corps of Engineers, and other government agencies. The published records and reports of these agencies are the basic sources of streamflow data.

Hydrologic phenomena, such as precipitation, are the result of the vagaries of nature and are, thus, highly variable. It is impossible to predict their occurrence at some remote date. By use of statistical analysis, it is possible to estimate the chances (probability) of occurrence of a phenomenon during some period of

time. For example, statistical analysis of basin rainfall data shows that a rainfall of 3.0 inches in a 24-hour period has a probability of occurrence of 50% in any year. This 3.0 inch rainfall is usually referred to as the 2-year, 24-hour rainfall. That is, the rainfall has an *average* recurrence interval of 2 years. The statistical approach is also used with floods. For example, the 50-year flood at the Wilmington gaging station has a discharge of 62,700 cfs. This flood has a 2% probability of occurring in any year.

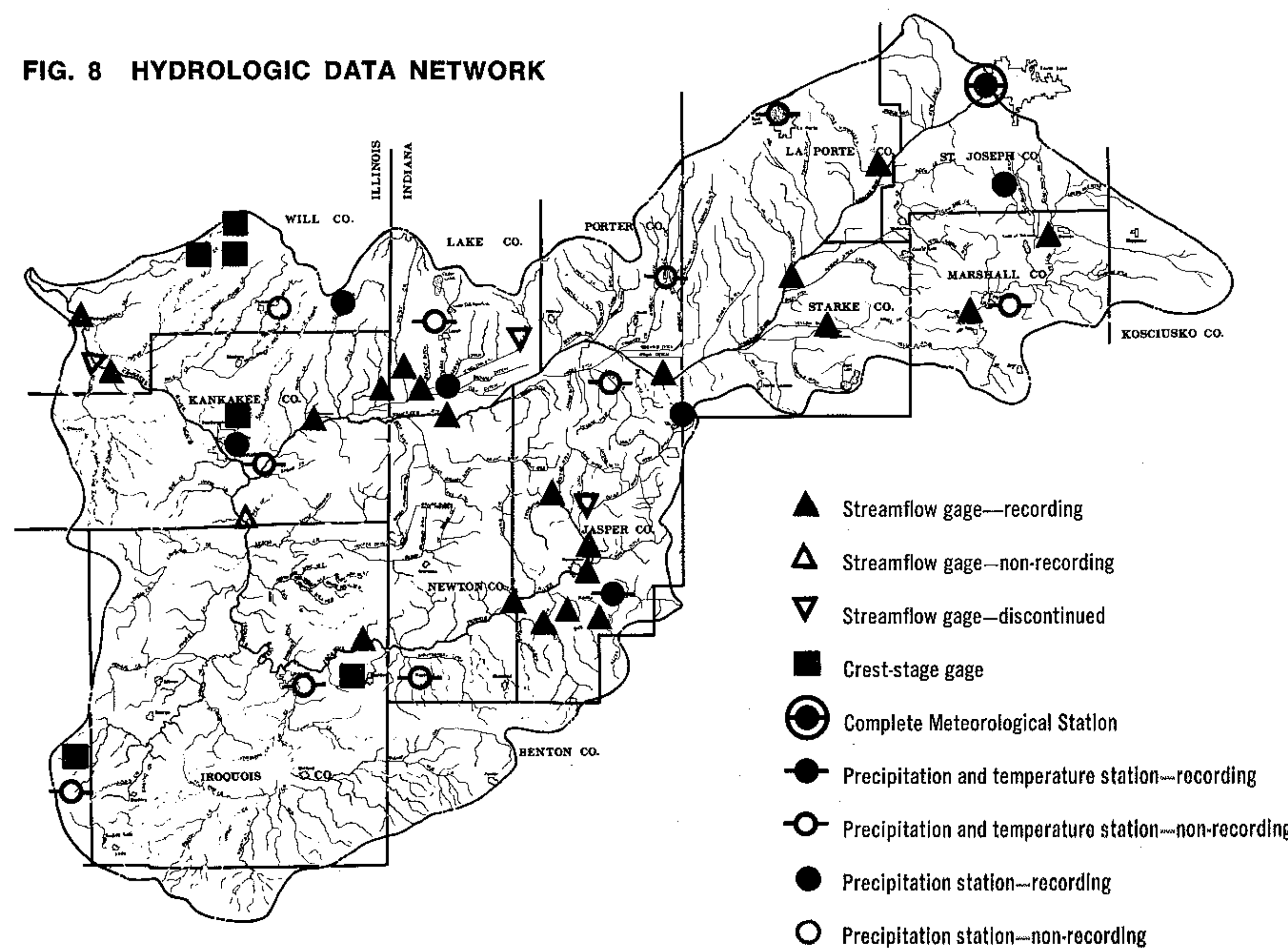
The statistical analysis of hydrologic data is a very strong tool in the planning and design of water resource projects because it gives an excellent estimate of the risks involved. Suppose a contractor built a cofferdam in a stream with its top elevation such that only the 20-year or a greater flood would overtop the structure. He is then taking a 5% risk that the cofferdam will be flooded in any year. However, if the project takes more than one year to complete, he will be taking a greater and greater risk, because the chances of a greater flood occurring are much higher. If the project took 2.1 years, the risk would be 10%, 4.4 years, the risk would be 20%, etc. Suppose a building was constructed near a stream at an elevation such that it could only be damaged by a flood equal or greater than the 50-year flood, and the building was expected to last for 25 years. Statistical analysis shows that there is a 40% chance that the building would be damaged by floods during its useful life of 25 years.

This example has been used to point out the inherent difference between structural damage and agricultural damage from flooding. Agricultural land at the same place as the building also has a 2% chance of being flooded in any one year, and a 40% chance of being flooded in 25 years. The farmer has a 40% chance of losing *one* crop in 25 years; whereas the owner of the building has a 40% chance of losing *one* building in 25 years.

Precipitation Data

Precipitation data are collected at 17 stations in the basin; over fifty years of record are available at six stations; and three of these stations have more than sixty years of record. (Figure 8) Five of the 17 stations are located in Illinois and 2 of these stations have recording gages. Of the 11 stations in Indiana, 5 have recording gages. The average annual precipitation in the basin is about 36 inches. About 60% of this rainfall

FIG. 8 HYDROLOGIC DATA NETWORK



(nearly 22 inches) occurs during the growing season from mid-April to mid-October. May is the wettest month; February the driest. The average monthly precipitation is shown in Figure 9.

The growing season rainfall is particularly important to agriculturalists. The average annual growing season rainfall is generally adequate for crop production. There is, however, no assurance that this rainfall will be ideally distributed nor that all of it will be available for plant growth. Figure 10 shows the probability that the growing season rainfall will be equal to or less than a given amount. For example, there is a 5% chance that the growing season rainfall will be 14 inches or less.

Figure 11 shows the relation between rainfall depth, duration, and frequency (probability) in the Kankakee Basin. These data were obtained from a statistical study by the U. S. Weather Bureau. (See References) This information is used in the design of numerous types of water control and water management works–storm sewers, drainage ditches, field terraces, retarding basins, etc.

15

FIG. 9 AVERAGE MONTHLY PRECIPITATION KANKAKEE BASIN

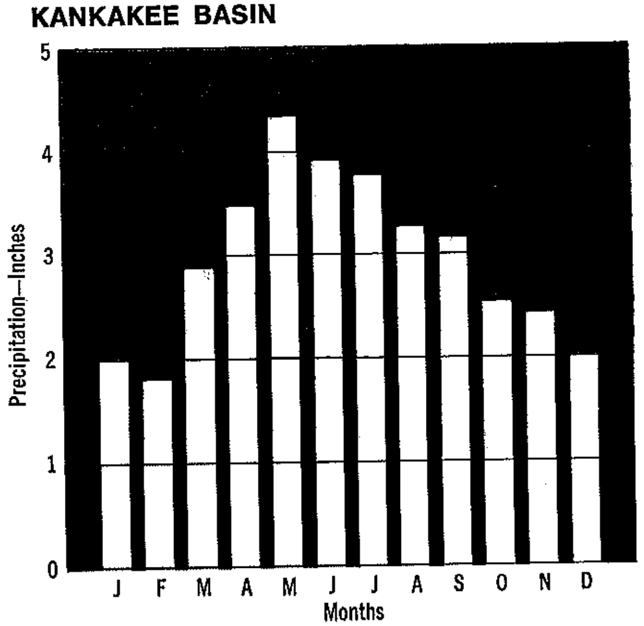


FIG. 10 PROBABILITY OF OCCURRENCE OF AT LEAST A GIVEN GROWING SEASON PRECIPITATION

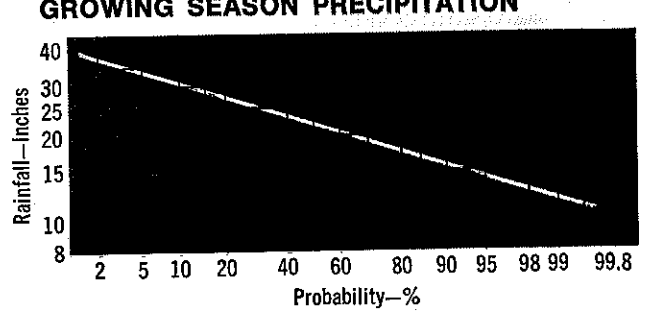
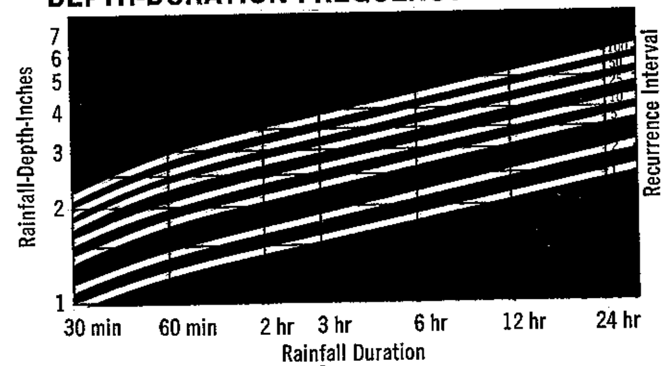


FIG. 11 KANKAKEE BASIN RAINFALL DEPTH-DURATION-FREQUENCY



Source U.S. Weather Bureau Technical Paper No. 40

Streamflow Data

Streamflow data are available from 32 gaging stations within the basin. (Figure 8) Six of these stations record only the annual maximum stage. These stations are all located in Illinois and three of these have been installed since 1961 and have insufficient record for analysis. Eighteen of the stations are located in Indiana. One Illinois station, Kankakee River at Custer Park, was operated from 1914 to 1933 at which time it was discontinued; and two Indiana stations, Oliver Ditch near Aix and Singleton Ditch near Hebron, were operated from 1948 to 1951 and then discontinued.

Table 6 gives the mean discharge for the period of record at each of the 26 existing stations for which data are available as well as the record maximum and minimum flows. There is an apparent linear relationship between the drainage area and mean discharge. The relation $Q_{mean} = 0.9A$ is applicable to the Kankakee River and tributaries above the State Line in the Kankakee Marsh area. The relation $Q_{mean} = 0.75A$ is applicable to the rest of the basin. Using the latter relation, it is determined that 10¼ inches is the annual runoff from the 36 inches average annual precipitation. The runoff constitutes 31.3% of the rainfall; the remainder is lost mainly through evaporation and plant transpiration.

The maximum and minimum discharges are useful insofar as they represent known extremes. These recorded extremes have likely been exceeded in the past and the probability exists that they will be exceeded in the future. Statistical analysis of recorded maxima and minima assigns a probability of occurrence to various streamflow data.

Analysis of the annual peak flows by the extreme-value theory yields the probability of occurrence for a given flow in any year. Flood frequency data are tabulated for 29 stations in Table 7. The table is set up to give average recurrence intervals. The probability of occurrence in any one year is the reciprocal of the recurrence interval. Also, the mean of the annual

TABLE NO. 6

Kankakee Basin Gaging Stations

Mean, Maximum, and Minimum Flows

Station	Drainage Area (sq. mi.)	Mean	Maximum (Flow in cfs)	Minimum
Terry Creek @ Custer Park, Illinois	12.0	7.71	545	0
Bice Ditch near South Marion, Indiana	22.6	16	780	0
Iroquois River @ Rosebud, Indiana	30.3	22.9	422	0.2
Carpenter Creek @ Egypt, Indiana	48.1	34.3	3,720	0
West Creek @ Schneider	54.5	37.1	1,840	1.3
Big Slough Creek near Collegeville, Ind.	84.1	60.9	2,030	0.7
Singleton Ditch @ Schneider, Indiana	122	89.3	1,120	3
Yellow River near Bremen, Indiana	132	89.6	1,380	6.2
Iroquois River near North Marion, Indiana	134	109	2,040	1.5
Kankakee River near North Liberty, Indiana	152	136	686	44
Iroquois River @ Rensselaer, Indiana	194	145	2,550	1.7
Singleton Ditch @ Illinoi, Illinois	219	159	2,040	4.5
Yellow River @ Plymouth, Indiana	284	234	5,390	12
Yellow River @ Knox, Indiana	425	369	5,660	39
Sugar Creek @ Milford, Illinois	430	322	22,900	2.8
Iroquois River near Foresman, Indiana	452	325	5,930	6.1
Kankakee River @ Davis, Indiana	508	473	1,700	154
Iroquois River @ Iroquois, Illinois	682	490	10,400	5.2
Kankakee River @ Dunns Bridge, Indiana	1,308	1,202	5,300	280
Kankakee River @ Shelby, Indiana	1,753	1,497	7,200	260
Iroquois River @ Chebanse, Illinois	2,120	1,507	27,000	9
Kankakee River @ Momence, Illinois	2,340	1,808	10,100	306
Kankakee River @ Wilmington, Illinois	5,250	3,719	75,900	204

maximum discharges has a recurrence interval of 2.33 years.

In order to better estimate the probability of occurrence of various discharges at ungaged points in the streams, a relationship has been developed between the drainage area and the mean annual flood ($Q_{2.33}$) and also between the drainage area and the 200-year flood (Q_{200}). For those points on the main stem of the Kankakee River above Momence, the following relations are applicable:

$$Q_{2.33} = 2.5A;\ Q_{200} = 5A$$

where Q = discharge in cubic feet per second

A = drainage area in square miles

If these two points are plotted on extreme-value (Gumbel) paper, the straight line connecting them will give the flood frequency relation. Table 8 gives the relations for the gaging stations within the basin. In order to extrapolate the data to ungaged areas, it is necessary to know which relations to use. In general, basins with similar storage capabilities and channel capacities will experience similar flood flows. The problem is in determining which basins are similar. Until better data become available, these relations and a study of an ungaged area may lead to a fair flood frequency relation. It should be noted that all the equations are linear except those for Group 4, which are a simple power function. It may be assumed that very small drainage areas respond to rainfall differently than do large areas.

From study of another basin, it has been found that the degree of urbanization of a watershed will influence the flood frequency relation. It has been found that moderate urbanization will double the mean annual flood over that for light urbanization and that heavy urbanization will double it again. It has also been found that the slope of the flood frequency line on Gumbel paper will

16

TABLE NO. 7

Flood Frequency Table (Peak Discharge in cfs)

Station	Drainage Area (sq. mi.)	Years Record in Analysis	Recurrence Interval (years) 2.33	5	10	20	50	100	200
Kankakee Tributary near Bourbonnais	.192	9	72	148	204	258	328	380	432
Prairie Creek near Frankfort	.830	8	181	406	571	730	936	1,090	1,244
Iroquois Tributary near Sheldon	9.34	6	592	1,264	1,754	2,220	2,830	3,290	3,740
Terry Creek near Custer Park	12.0	15	158	257	332	404	497	567	637
Bice Ditch near South Marion	22.6	16	434	568	670	768	895	990	1,084
Iroquois River at Rosebud	30.3	16	232	311	371	429	503	559	615
Carpenter Creek at Egypt	48.1	15	1,237	2,000	2,580	3,140	3,860	4,400	4,940
West Creek at Schneider	54.5	14	884	1,260	1,550	1,820	2,180	2,440	2,710
Big Slough Creek near Collegeville	84.1	15	1,160	1,600	1,940	2,260	2,680	2.990	3,300
Singleton Ditch at Schneider	122	16	876	1,050	1,190	1,320	1,480	1,610	1,730
Yellow River at Bremen	132	9	1,106	1,260	1,380	1,500	1,640	1,750	1,860
Iroquois River at North Marion	134	16	861	1,220	1,490	1,750	2,090	2,350	2,600
Kankakee River at North Liberty	152	14	526	644	733	818	929	1,010	1,100
Iroquois River at Rensselaer	194	16	1,234	1,670	2,010	2,330	2,740	3,050	3,360
Singleton Ditch at Illinoi	219	20	1,604	1,910	2,150	2,380	2,670	2,890	3,110
Yellow River at Plymouth	284	16	2,230	2,400	3,030	3,630	4,400	4,990	5,570
Yellow River at Knox	425	21	2,276	3,090	3,710	4,310	5,080	5,660	6,240
Sugar Creek at Milford	430	16	8,750	14,060	18,100	22,000	27,000	30,800	34,500
Iroquois River near Foresman	452	16	2,645	3,640	4,400	5,120	6,070	6,770	7,470
Kankakee River at Davis	508	38	1,155	1,340	1,490	1,630	1,810	1,950	2,080
Iroquois River at Iroquois	682	20	3,813	5,610	6,990	8,310	10,020	11,300	12,600
Kankakee River at Dunns Bridge	1,308	16	3,436	4,280	4,920	5,540	6,340	6,930	7,530
Kankakee River at Shelby	1,753	42	4,085	5,020	5,760	6,460	7,370	8,060	8,740
Iroquois at Chebanse	2,120	41	12,482	17,300	21,100	24,700	29,400	32,900	36,500
Kankakee at Momence	2,340	50	6,020	7,480	8,640	9,740	11,200	12,200	13,300
Kankakee at Wilmington	5,250	31	23,967	35,100	43,700	52,000	62,700	70,700	78,700

TABLE NO. 8

Generalized Flood Frequency

Group #	Stations	Q2.33	Q200
1	Kankakee River @ North Liberty Kankakee River @ Davis Kankakee River @ Dunns Bridge Kankakee River @ Shelby Kankakee @ Momence	2.5A	5A
2	Iroquois River @ Rosebud Singleton Ditch @ Schneider Yellow River @ Bremen Iroquois River @ North Marion Iroquois River @ Rensselaer Singleton Ditch @ Illinoi Yellow River @ Plymouth Yellow River @ Knox Iroquois River @ Foresman Iroquois River @ Iroquois Iroquois River @ Chebanse Kankakee River @ Wilmington	6.5A	18A
3	Terry Creek near Custer Park Bice Ditch near South Marion West Creek @ Schneider Big Slough Creek near Collegeville Sugar Creek @ Milford Carpenter Creek @ Egypt	19A	70A
4	Kankakee Tributary near Bourbonnais Prairie Creek near Frankfort Iroquois Tributary near Sheldon	$180A^{0.5}$	$1200A^{0.5}$

TABLE NO. 9

High Flow—Duration—Frequency

(Mean Discharge for Duration of High-Flow in cfs)

Recurrence Interval Years	Duration 3-day	7-day	30-day
Sugar Creek @ Milford. . . . D.A. = 430 sq. mi.			
5	6,350	3,900	1,850
10	7,800	4,750	2,250
20	9,100	5,600	2,650
50	10,900	6,650	3,150
Iroquois River @ Iroquois. . . . D.A. = 682 sq. mi.			
5	4,920	4,330	2,450
10	5,960	5,210	2,910
20	6,930	6,080	3,370
50	8,210	7,180	3,940
Iroquois River @ Chebanse. . . . D.A. = 2,120 sq. mi.			
5	15,600	13,600	7,120
10	18,700	16,600	8,480
20	21,600	19,500	9,920
50	25,600	23,000	11,700
Kankakee River @ Momence. . . . D.A. = 2,340 sq. mi.			
5	6,920	6,430	5,210
10	7,880	7,270	6,000
20	8,790	8,050	6,720
50	9,920	9,090	7,690
Kankakee River @ Wilmington. . . . D.A. = 5,250 sq. mi.			
5	27,400	23,100	14,000
10	33,200	27,900	16,600
20	38,600	32,500	19,400
50	45,800	38,500	22,600

TABLE NO. 10

Low Flow—Duration—Frequency Table

(Mean Discharge for Duration of Low-Flow in cfs)

Recurrence Interval Years	Duration 3-day	7-day	30-day
Terry Creek @ Custer Park. . . . D.A. = 12.0 sq. mi.			
5	0.2	0.4	0.6
10	0.1	0.2	0.3
20	0	0.1	0.2
Singleton Ditch @ Illinoi. . . . D.A. = 219 sq. mi.			
5	17.0	18.5	21.0
10	14.7	16.0	18.0
20	13.0	14.2	16.2
Sugar Creek @ Milford. . . . D.A. = 430 sq. mi.			
5	3.6	3.8	5.5
10	2.6	2.7	3.8
20	1.9	2.0	2.8
Iroquois River @ Iroquois. . . . D.A. = 682 sq. mi.			
5	11.8	12.6	17.8
10	9.2	9.8	13.7
20	7.5	8.0	11.0

Recurrence Interval Years	Duration 3-day	7-day	30-day
Iroquois River near Chebanse. . . . D.A. = 2,120 sq. mi.			
5	23.4	25.6	35.5
10	17.0	18.6	26.0
20	13.3	14.5	20.0
Kankakee River @ Momence. . . . D.A. = 2,340 sq. mi.			
5	404	415	470
10	342	352	400
20	302	310	351
Kankakee River @ Wilmington. . . . D.A. = 5,250 sq. mi.			
5	503	520	600
10	430	445	515
20	378	390	452

remain a constant for various degrees of urbanization.

The annual maximum flood series gives the momentary peak discharge. Other frequency studies may be made for flood volumes, flood stages, and flood duration. Flood duration-frequency studies may be more valuable in estimating agricultural flood damages since duration of flooding is as important as the stage. Table 9 shows the highest mean 3, 7, and 30-day discharges for 5, 10, 20, and 50-year recurrence intervals for the larger drainage areas.

Analysis of the minimum flows can be made which will determine the probability of various low flows in streams. Table 10 shows the estimated low flow discharges for durations of 3, 7, and 30-days for average recurrence intervals of 5, 10, and 20-years for the Illinois stations.

Topography and surficial geology determine the availability of low flows. The great variability of topography and surficial geology make the prediction of low flow for an ungaged area very uncertain.

Summary

Hydrologic data are the basic information used in the planning and design of water management projects. Because of the great variability of hydrologic phenomena, statistical analysis of the hydrologic data is required in order to evaluate the probability of occurrence of the various phenomena. Statistical analysis permits the determination of risk involved in the construction of water resources projects, and knowledge of risk is necessary in evaluating the adequacy of design.

water supply

Ground-Water Resources

In the Kankakee Basin ground water is obtained from either drift or bedrock. The availability of water from each source varies considerably in different parts of the basin and is closely related to geologic conditions. Over much of the north half of the basin, drift deposits are thin and contain only scattered sand and gravel aquifers. These aquifers usually yield enough water for farm and domestic needs when penetrated by a small diameter well. They are rarely large enough for municipal and industrial supplies; and in the north half of the basin, such supplies are obtained from bedrock sources. The most prolific of these are shallow dolomite rocks lying immediately below the drift. The dolomite aquifer extends into northern Iroquois County where it deepens and also is overlapped by younger rocks. As a result of these changes, the dolomites and other bedrock aquifers are not important ground-water sources in the south half of the basin. Here, drift deposits are important sources. Southward across Iroquois County, the drift deposits thicken considerably and contain excellent sand and gravel aquifers; many are adequate for municipal and industrial supplies.

Sand and Gravel Aquifers As indicated above, drift sources occur over much of the basin and are best in the south half where drift deposits are thickest. (Figure 12) Sand and gravel aquifers within the drift are generally distributed at random and, therefore, are more likely found in thick deposits. Also, the largest and most prolific drift aquifers are often encountered in thick deposits which overlie buried bedrock valleys.

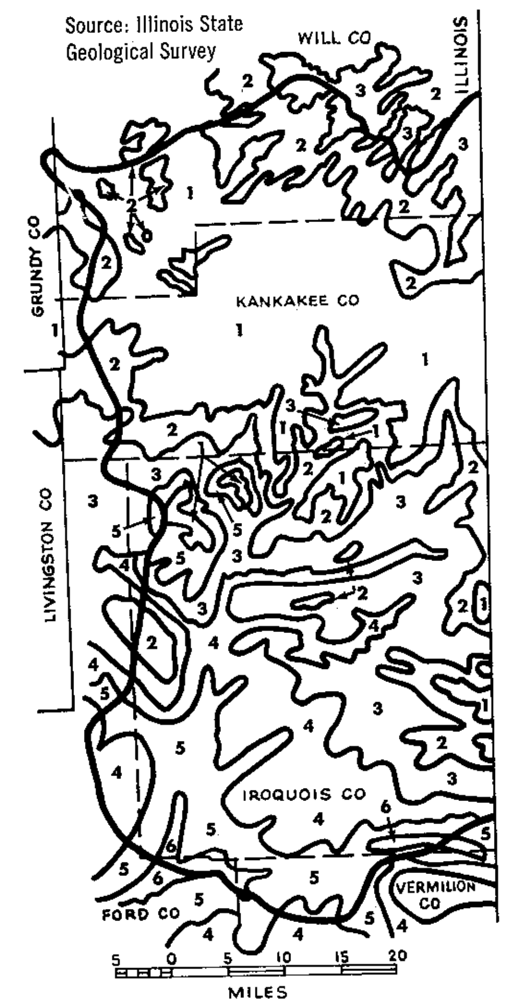
The various kinds of material comprising the drift differ in permeability or their ability to transmit water. The coarse sand and gravel aquifers readily transmit water to small diameter wells, while fine-grained silts and clays greatly impede the movement of water. Fine-grained material predominates in the drift of the basin and envelops the numerous aquifers. Therefore, water within the aquifers is contained by relatively impervious boundaries and quite often is found to be under artesian pressure when tapped by wells. Pressures may be great enough to bring water to the surface. Such conditions exist in parts of Iroquois County. Flowing wells occur at Cissna Park and Gilman and have been reported in the vicinity of Crescent City and Goodwine.

Sand and gravel aquifers are replenished or recharged by downward percolation of water from overlying drift. This water originates as precipitation so that recharge to the aquifers is greatest during seasonal periods of heavy rainfall.

The recharge, size, and continuity of an aquifer are important determinants of its potential yield. Potential yield is the maximum rate of water withdrawal which an aquifer can sustain indefinitely without undergoing a continuous decline in water level. High potential yields are associated with large sand and gravel deposits having good continuity. Such aquifers contain large volumes of water and have adequate recharge.

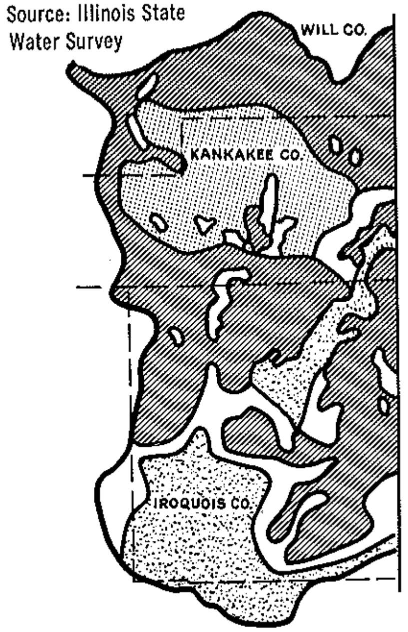
Figure 13 shows that potential yields of sand and gravel deposits are highest in the south end of the basin. Several buried bedrock valleys are located here; the principal ones are the Mahomet Valley in the extreme south end of Iroquois County and the Onarga in the southwest corner of the same county. Sand and gravel deposits are exceptionally thick in these valleys and some may be continuous for several miles. Thus small domestic and farm supplies are easily obtained over the bedrock valleys. Municipal and industrial supplies are also available, but more effort may be required to

FIG. 12 DRIFT THICKNESS



1. 50' or less
2. 50' to 100'
3. 100' to 200'
4. 200' to 300'
5. 300' to 400'
6. 400' or Greater

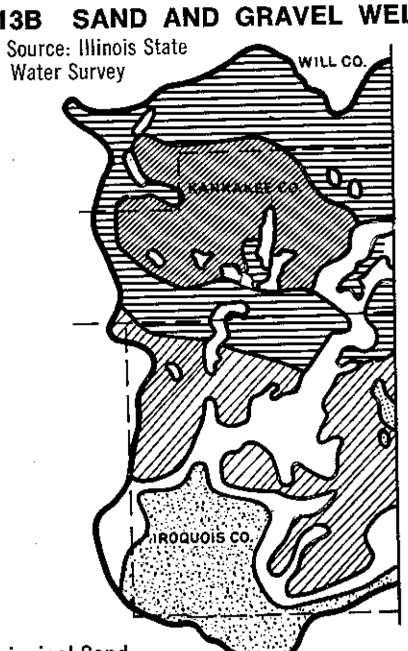
FIG. 13A ESTIMATED POTENTIAL YIELD OF PRINCIPAL SAND & GRAVEL AQUIFERS



Expressed in Gallons Per Day Per Square Mile

- 150,000 to 200,000 G.P.D. per square mile.
- 100,000 to 150,000 G.P.D. per square mile.
- Area where Municipal & Industrial Supplies are usually from other sources.
- Area where small Municipal & Industrial waterwell development in thin Sand & Gravel Aquifers may be possible.

FIG. 13B SAND AND GRAVEL WELL YIELD



Principal Sand and Gravel Aquifers 15 Ft. Thick or Greater

- Chances of Obtaining a Well Yielding 500 G.P.M. or more are good.
- Chances of Obtaining a Well Yielding 100 G.P.M. or more are good.
- Chances of Obtaining a Well Yielding 20 G.P.M. or more are good.

Possible Sand and Gravel Aquifers

- Chances of Obtaining a Well Yielding 100 G.P.M. or more are possible.
- Chances of Obtaining a Well Yielding 20 G.P.M. or more are possible.
- Area where Municipal and Industrial Supplies are usually from other sources.

locate them. Properly constructed and developed wells in these aquifers commonly yield as much as 500 gpm (gallons per minute). Watseka, Onarga, Buckley, Loda, and Cissna Park in Iroquois County have municipal wells in drift which fills the Onarga and Mahomet Bedrock Valleys. Also, Roberts and Rankin in Ford and Vermilion Counties, respectively, have municipal wells in these deposits.

In contrast to the bedrock valley areas mentioned above, the poorest drift resources in the basin are found in central Kankakee County. This limited source area extends into southwest Will County; and in Kankakee County it is bounded approximately by Momence, Aroma Park, Union Hill, and in the north by the Will County Line. Here, drift deposits are thin, often less than 50 feet thick, and water-bearing deposits are scarce. As indicated by Figure 13 and Figure 14, municipal and industrial supplies in central Kankakee County and the surrounding area are best obtained from bedrock sources. Supplies adequate for domestic and farm uses may be found at scattered locations in the drift and in sand and rubble deposits along the Kankakee River.

Over the rest of the basin, ground-water conditions in the drift can be considered as intermediate between the two areas mentioned above. Surficial deposits range in thickness from 50 to 200 feet and contain scattered sand and gravel deposits. Compared to the bedrock valley aquifers, these are quite small and discontinuous, often in the form of pockets, lenses, and thin stringers. As a result, potential yields are not large, and high-yield wells are difficult to obtain. (Figure 13) Isolated from each other by fine-grained impermeable drift, such as clay and silt, these water-bearing deposits sometimes may be difficult to find. Many of them are even too small for domestic and farm supplies, but generally wells of this type can be drilled locally. Extensive test drilling may be required to locate aquifers large enough for municipal and industrial wells. In parts of northeast and east central Iroquois County, drift deposits thicken to around 200 feet and wells may be found more easily. Sheldon and Donovan are located in east Iroquois County and both have wells in sand and gravel aquifers.

Water-bearing deposits may be encountered along certain stream courses in the basin. Such aquifers usually consist of sand and gravel and receive considerable recharge from stream water infiltration. The municipal supply at Milford is obtained from sand and gravel deposits in Sugar Creek.

Bedrock Aquifers Silurian dolomites are the most productive bedrock in the Kankakee Basin. They are essentially limestones with high magnesium contents and occur throughout the north half of the basin immediately below the drift mantle. Two rock series comprise the dolomites, the Niagaran above and the Alexandrian below. Typically, both series are massive, finely crystalline, and resistant to erosion. The rocks dip slightly eastward and thicken in the same direction. They thin toward the west and eventually disappear, the Niagaran first and then the Alexandrian a few miles farther west. Therefore, in the north half of the basin, the thickness of the dolomites ranges from zero in the extreme west to over 400 feet in the eastern part.

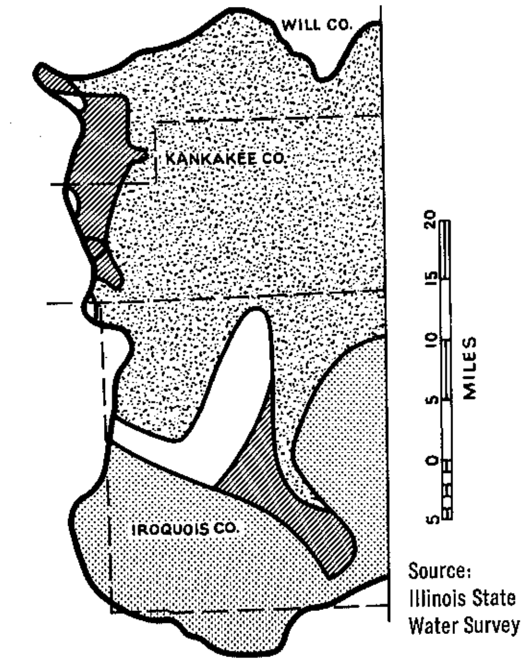
The dolomite aquifer stores and transmits ground water to wells by means of various interconnected openings such as joints, fissures, cavities, and solution channels. Such openings have been formed primarily by the dissolving action of water, and their size and/or number determine how much water the rock will yield at a given location. The openings often are continuous over considerable areas and distances. However, the occurrence of the openings is highly erratic so that accurate predictions with respect to prospective well sites and yields are difficult to make, especially in undeveloped areas.

Studies of existing wells in the Silurian dolomites have contributed much information about these aquifers. Analyses of well data reveal that the upper portions of the rock are much more permeable and productive than the lower parts. Therefore, the Niagaran series probably yields the largest quantity of water in the north half of the basin. Evidence also indicates that yields are influenced by the permeability of the drift which lies immediately on top of the dolomite aquifer. It is believed that ground water circulates between the drift and dolomite rocks where the two are in contact. The extent of this hydraulic connection varies and is best developed where rock openings are overlain by permeable sand and gravel deposits. Yields of the dolomites are generally good where these conditions exist. Also, it has been found that yields increase as the thickness of the sand and gravel above the aquifers increases. In comparison, lower yields are associated with those areas where silts, clays, and other impermeable drift material lie directly above the rock. Also, well data reveal that yields are quite low where the Silurian dolomites are overlain by younger rocks. This situation exists only in relatively small areas in the north half of the basin where the Silurian rocks are an important source. The most notable area is in north central and northeast Iroquois County where Pennsylvanian, Mississippian, and Devonian rocks overlie the Silurian. (Figure 15)

Water in the Silurian dolomites originates mainly from precipitation which percolates into the rock from overlying drift deposits. Replenishment or recharge is quite limited where thick and impermeable drift composed of clay and silts overlie the dolomites. Recharge is best where only thin sand and gravel deposits overlie the dolomites. However, the dolomites may be easily polluted by surface water where surficial deposits are thin.

As shown by Figures 14 and 16, good supplies of water are available in the shallow dolomites. Well yields of several hundred gallons per minute are not unusual for this aquifer, and its potential yield is large enough for municipal and industrial supplies. In south Will County, Elwood, Monee, Beecher, and Peotone have municipal wells in dolomite rocks. Also, numerous farm and domestic wells in south Will County are drilled in dolomites since drift deposits are quite thin. Southward, into Kankakee County, the dolomite aquifer supplies water to Manteno, Grant Park, Momence, Aroma Park, and St. Anne. In the latter community dolomite wells are used for irrigation. In the central and north central parts of Kankakee County sand and gravel aquifers are scarce, and numerous farm and domestic wells have been drilled in dolomite rocks. Bradley, Bourbannais, and the State Hospital at Manteno were formerly served by dolomite wells but now obtain water from the Kankakee municipal supply. The Kankakee River supplies the latter community, but numerous domestic and industrial wells in the area are drilled in shallow dolomites. Several municipal supplies in north Iroquois County also come from the

FIG. 14 ESTIMATED POTENTIAL YIELD OF SHALLOW DOLOMITE AQUIFER

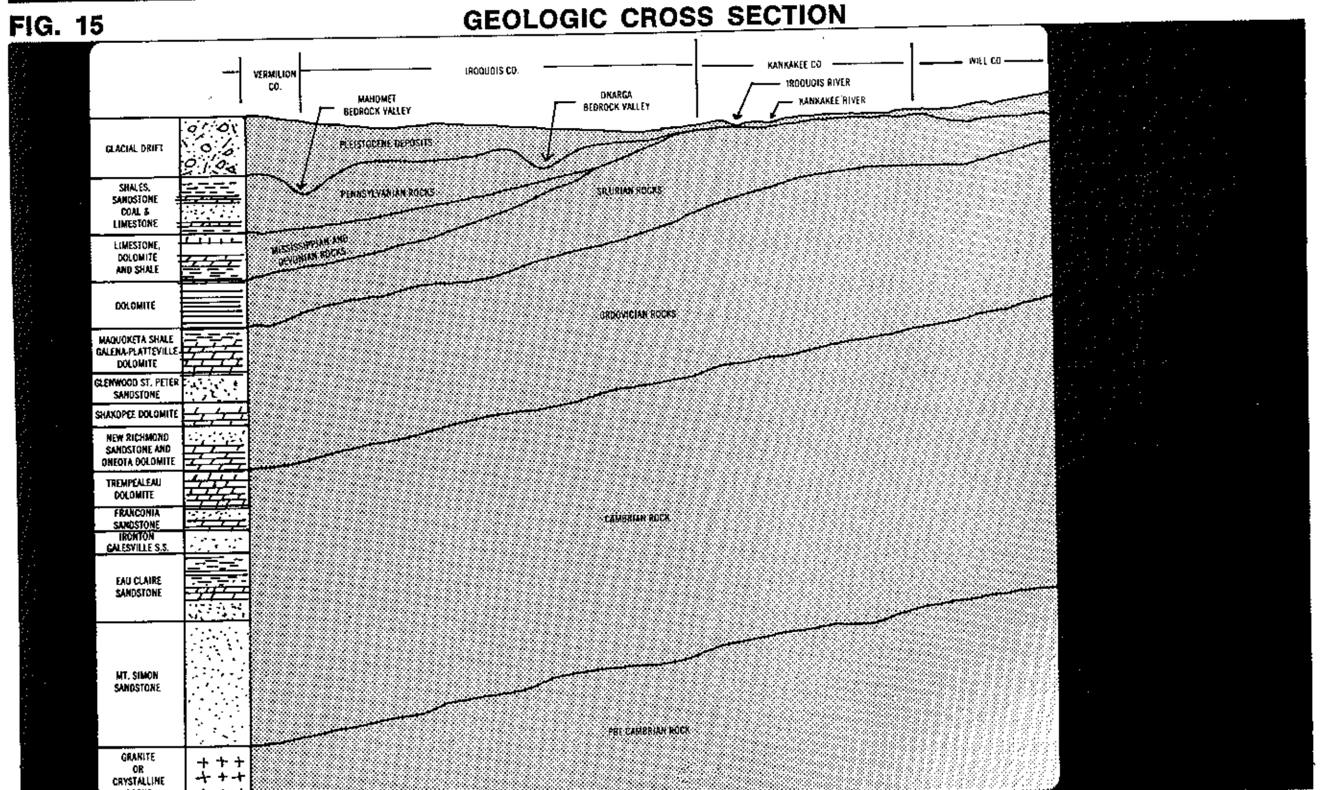


Source: Illinois State Water Survey

EXPRESSED IN GALLONS PER DAY PER SQUARE MILE

- 100,000 to 200,000 G.P.D. PER SQUARE MILE.
- 50,000 to 100,000 G.P.D. PER SQUARE MILE.
- LESS THAN 50,000 G.P.D. PER SQUARE MILE.
- GEOLOGIC CONDITIONS GENERALLY FAVOR DEVELOPMENT FROM DRIFT.

FIG. 15 GEOLOGIC CROSS SECTION



Silurian rocks. Beaverville, Chebanse, Clifton, Martinon, Ashkum, and Danforth have wells in the shallow dolomites.

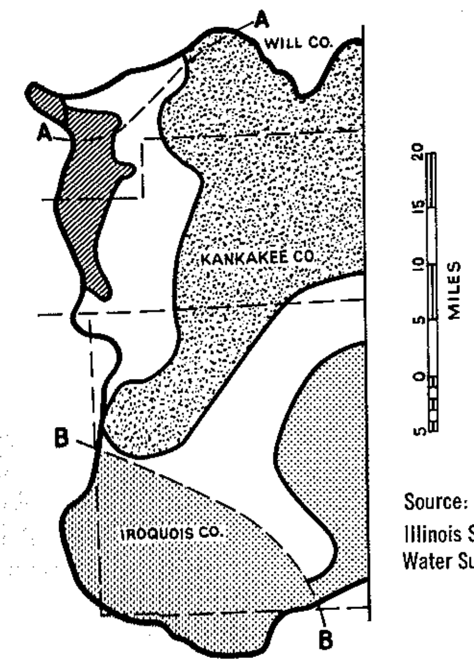
South and west of Kankakee County dolomite yields decrease. Toward the west, the dolomites thin while south of Kankakee County they deepen and eventually are overlain by younger rocks.

Deep sandstones may yield small to large supplies throughout Kankakee and south Will Counties. Notable are the Ironton-Galesville and St. Peter sandstones. The top of the Ironton-Galesville is about 1500 feet deep in southwest Will County and over 2200 feet below the surface in southeast Kankakee County. Municipal Well No. 3 at Wilmington (southwest Will County) is 1578 feet deep and ends in the Ironton-Galesville aquifer. Because this aquifer is quite deep, it may yield water which is highly mineralized. The St. Peter sandstone is less prolific but shallower than the Ironton-Galesville aquifer. It is approximately 500 feet deep in west Kankakee County and more than 1000 feet below the surface in the east part of the county. Herscher, located in southwest Kankakee County, has a well 789 feet deep in the St. Peter sandstone. Also, several wells in the City of Kankakee obtain water from this aquifer. Again, water from the St. Peter formation may be poor in quality. It is interesting to note that much larger quantities of water are taken from the Ironton-Galesville and St. Peter sandstones north of the basin. In the Chicago area, the rocks are especially prolific since they are shallower and more permeable in this area than they are farther south.

Smaller quantities of water may be obtained from rocks which lie between the deep sandstones and Silurian dolomites. Worth mentioning are the Galena-Platteville dolomite and the Maquoketa formation, a dolomitic shale. Such rocks often contribute to yields of deep sandstone wells since bedrock wells are usually constructed without casing. Similar to the St. Peter and Galesville formations, these rocks dip eastward so that they deepen considerably from west to east. In parts of southwest Will and west Kankakee Counties, the Maquoketa shale lies immediately below the drift mantle. At scattered locations in this part of the basin, the rock yields small supplies for domestic and farm uses.

At some locations in the north half of the basin, younger water-bearing rocks overlie the Silurian dolomites. Pennsylvanian rocks are encountered immediately below the drift in the extreme southwest corner of Will County and along the western edge of Kankakee County. Small quantities of water might be obtained from these rocks at scattered locations. Similar possibilities exist in northeast Iroquois County where Mississippian and Devonian rocks lie directly below the drift.

FIG. 16 SHALLOW DOLOMITE WELL YIELD



Source:
Illinois State
Water Survey

- Chances of Obtaining a Well Yielding 500 G.P.M. are good.
- Chances of Obtaining a Well Yielding 100 G.P.M. are good.
- Chances of Obtaining a Well Yielding 10 G.P.M. are poor.
- Geologic Conditions Favor Development in Drift.
- A-A South Limit of Potable Water (1500 PPM) From Deep Sandstone.
- B-B South Limit of Potable Water (1500 PPM) From Shallow Dolomite.

Well Characteristics Existing wells in the basin may be summarized with respect to types, depths, yields, and other pertinent characteristics. (Tables 11 and 12) Drilled type wells predominate in both drift and bedrock. Driven and dug-type wells in unconsolidated deposits are relatively uncommon. Municipal and industrial wells drilled in the shallow Silurian dolomites usually are 100 feet to 400 feet deep with an average depth around 200 feet. High capacity wells of the same kind in drift often have depths between 100 feet and 200 feet. Smaller capacity wells for domestic and farm use are generally less than 150 deep when finished in shallow dolomites or drift.

Yields, like depths, show much variation throughout the basin. High-capacity municipal and industrial wells in shallow dolomites quite often produce 200 to 600 gpm. Similar wells in drift generally produce 100 to 300 gpm. Farm and domestic wells completed in drift commonly pump around 5 gpm. Wells of this kind produce considerably more when drilled in Silurian dolomite rocks, and capacities of 20 gpm or more are not uncommon.

Yields of shallow dolomite wells may be increased considerably by treating them with solutions of hydrochloric acid. Production increases have been observed in both old and newly drilled wells—the old showing the largest increases.

Figures 13 and 14 are based on data from existing wells and show probable yields from drift and shallow dolomite sources. Both figures assume that wells are properly constructed, developed, and reasonably spaced.

Drift wells are generally constructed with a single string of casing and finished with commercial screens. (Figure 17) Dolomite wells are cased only down to the top of the rock. The part of the aquifer penetrated by the well is usually left as an open hole since the rock does not cave or swell easily. Casing diameters for domestic and farm wells generally range from 2 inches to 4 inches in drift wells and 4 inches to 6 inches in dolomite wells. Municipal and industrial wells usually have diameters from 6 inches to 20 inches.

Ground-Water Quality Chemical analyses of municipal supplies indicate that the quality of water from drift and shallow dolomite aquifers is quite similar. This is especially true in the north half of the basin where the two aquifers are closely associated. Mineral contents of waters from other bedrock sources are generally much higher.

In general, ground water from the dolomites and drift is moderately mineralized, excessively hard, and contains appreciable iron. (Table 13) Total minerals of 300 to 700 ppm (parts per million) and hardness concentrations of 300 ppm are common. Both carbonate and noncarbonate hardness are present. Frequently, iron concentrations are around 1.0 ppm, and concentrations over 2.0 ppm are not unusual. Temperatures of water from the drift and shallow dolomites generally are between 52°F and 55°F. Water from the deeper rocks underlying the basin may be too highly mineralized for most uses. This is especially true with respect to the deep sandstones. At certain localities in the basin, methane gas may be present in the ground water. The occurrence of methane gas in ground water has been reported in the vicinity of Watseka.

Adequacy of Ground-Water Sources It is concluded from this brief survey that good ground-water resources exist in the Kankakee Basin. Water is derived primarily from two sources: shallow dolomite rocks lying immediately below the drift in the north half of the basin and sand and gravel deposits in the south half. Drift deposits are thin throughout Kankakee County and the south part of Will County. In this area, municipal and industrial supplies are obtained from shallow dolomite rocks since few large sand and gravel aquifers are present in the thin covering of drift. The shallow dolomites store and transmit water by means of joints, fissures, cavities, and solution channels; and high-yield wells are common. Southward into Iroquois County, the dolomite rocks deepen and over most of the county are overlain by younger rocks. Hence, they are not an important source in the south half of the basin. Here most supplies are obtained from thick drift deposits which contain good sand and gravel aquifers, many adequate for municipal and industrial supplies. Exceptionally thick drift deposits containing excellent water-bearing sand and gravel aquifers occur along buried bedrock valleys in the southwest corner and extreme south end of the basin.

Surface-Water Resources

Surface-water supplies may be obtained from natural lakes, man-made reservoirs, or from flowing streams. There are no natural lakes in the Kankakee Basin (Illinois). In order to develop a satisfactory water supply from a flowing stream, the low flow occurring in the stream must be adequate to supply the demand or draft rate. If the low flow is inadequate, an impoundment or man-made reservoir is necessary to capture and retain high flows for use during times of low flow.

Low flows occur in streams during extended periods of no rainfall. Low flow consists almost entirely of ground-water seepage into the stream through its bed and banks. In some instances, the low flow may consist entirely of wastewater treatment plant effluent. The quantity of natural low flow is directly related to the amount of ground water available for percolation into the stream. Streams which intersect large ground-water sources will have larger low flows than streams which intersect small ground-water sources. Streams with large drainage areas have a greater probability of intersecting a ground-water source than does a stream with a small drainage area. Shallow headwater streams seldom intersect dependable ground-water sources, while deeply incised rivers have greater probabilities of intersecting dependable sources. Topography and surficial geology determine the availability of ground-water sources from which low flows may originate. A statistical analysis of low flows is explained in *STREAMFLOW DATA* and the results of the analysis are presented in Table 10.

The portion of the Kankakee Basin in Indiana above Momence, known as the Kankakee Marsh, is underlain by relatively permeable sands. These permeable sands act as a large, natural, underground reservoir. Water accumulates in this reservoir from downward percolation during rainfall. The sands, slowly but consistently, release the stored water to the drainage and stream systems. The marsh area tends to reduce peak flows on the main stem Kankakee by storing excess rainfall and tends to maintain a relatively high low flow, throughout sustained periods of no rainfall, by releasing the stored water.

Due to the topography, there are limited opportunities for the development of surface water impoundments. A private lake and home-site development has been constructed in southwestern Iroquois near Loda. There

TABLE NO. 11

Well Construction Data

COMMUNITY and WELL NUMBER	Casing Diameter and Length	Screen: Length (feet)	Screen: Type	Screen: Slot Size	Pump Assembly: Pump Type	Rating: Capacity (gpm)	Rating: Head (feet)	Motor Type and Size (hp)	Column: Length (feet)	Column: Diameter (inches)	Remarks
Iroquois County					6 Stg. Turbine	50	70	Elect 2	60	3	
Ashkum #1	8″ x 153′4″	—	None		Submersible	60	140	Elect 5	—	—	
Ashkum #2	6″ x 140′	4′	Johnson	0.020	16 Stg. Turbine	130	140	Elect 7½	146	—	
Beaverville #1	8″ x 112.5′	6″ Liner	110.5′ to 153.5′		—	—	—	—	—	—	
Beaverville #2	8″ x 151′		None		8 Stg. Turbine	55	60	Elect 1½	80	3	
Buckley #3	8″ x 142′	12′	Johnson Everdur	#20 & #40	Turbine	200	Unknown	Elect 15	Unknown	Unknown	
Chebanse #2	10″ x 85′		None		11 Stg. Turbine	150	Unknown	Elect 5	30	4	Old Well
Cissna Park #3	6″ x 150′	13′	Copper Screen		3 Stg. Turbine	200	Unknown	Elect 5	60	Unknown	Redrilled
Cissna Park #3	6″ x 184′	16′	Screen		9 Stg. Turbine	150	Unknown	Elect 7½	40	4	
Crescent City #2	6″ x 125′	7′			—	—	—	— —	—	—	
Danforth #7	8″ x 142′7″	—	—		Turbine	50	203	Elect 5	Unknown	Unknown	
Donovan	6″ x 155′	15′	Screen—5″		—	—	—	— —	—	—	
Gilman (5″ Well)	5″ x 124′	5′	Johnson Everdur	#40	—	—	—	— —	—	—	
Gilman #8	12″ x 185′	12′	Johnson S.S.	#15, #18, #20	Turbine	150	—	Elect 15	—	—	
Loda #2	8″ x 149′	12′2″	Houston S.S.	#30, #20	Turbine	280	Unknown	Elect 15	Unknown	Unknown	
Martinton #1	10″ x 148′		None		Turbine	—	—	Elect 20	—	—	Gravel Packed
Milford #7	48″ x 58′—26″ x 58′	20′	Layne Shutter		—	—	—	— —	340	8	Gravel Packed
Milford #8	16″ x 55′	25′	Layne Shutter #5		Airlift	—	—	—	—	—	
Onarga	6″ x 146′	Bottom 10′ of Casing Slotted			Turbine	360	100	Elect 15	—	—	
Sheldon #4	10″	16′	Johnson		16 Stg. Turbine	100	170	Elect 7½	70	4	
Thawville #1	8″ x 110′1″	10′11″	Johnson Everdur	#4 & #20	11 Stg. Pomona	400	220	Elect 30	120	6	
Watseka #4	8″ x 130′	30′	Johnson	#40	—	500	170	Elect 30	—	—	
Watseka #6	12″ x 145′	15′	Johnson	#125							
Kankakee County					11 Stg. Turbine	100	—	Elect 7½	50	4	
Aroma Park #1	8″ x 54′		None		—	—	—	—	—	—	
Aroma Park #3	10″ x 51′		None		9 Stg. Turbine	—	—	Elect 25	200	6	
Bradley #3	—		—		11 Stg. Turbine	100	—	Elect 25	300	4	
Hercher #5	8″ x 654′		—		9 Stg. Turbine	250	170	Elect 15	60	6	
Manteno #1 South	12″ x 20′		—		Submersible	310	270	Elect 30	—	—	
Manteno #3	18″ x 20½′—12″ x 9.5′		—		5 Stg. Turbine	500	160	Elect 30	60	8	
Momence #2	12″ x 20′		None		9 Stg. Turbine	300	—	Elect 40	100	6	#2 used for emergencies
St. Anne #2	10″ x 94′		—								
Will County					12 Stg. Turbine	300	220	Elect 30	50	6	
Beecher	— 91′10″		—		16 Stg. Turbine	80	210	Elect 7½	80	3½	
Manhattan	8″ x 35′		—		13 Stg. Turbine	500	500	Elect 75	340	8	
Monee	20″o.d.x78′—18″o.d.x131′		None		10 Stg. Turbine	300	170	Elect 25	80	6	#2 used for emergencies
Peotone	10″ x 60′		None		15 Stg. Turbine	—	—	Elect	—	—	
Wilmington #3	20″ x 14′—16″ x 174′		—		—	—	—	—	—	—	
Wilmington #2	12½″ x 23′—10″ x 218′		None								
Ford County								Elect 15	—	—	
Roberts #5	8″ x 214.5′	12.3′	Johnson Everdur	#10 & #20	Turbine	105	—				

—Information not available.

TABLE No. 12

Well Production Data

COMMUNITY and WELL NUMBER	Source	Date Drilled	Elevation (feet)	Depth and Hole Size	Date of Test	Length of Test (hours)	Pumping Rate (gpm)	Pumping Water Level (feet)	Static Water Level (feet)	Draw-down (feet)	Remarks
Iroquois County											
± Ashkum #1	B.R. Dolo	5/47	662	196′	—	5/47	23½	75	−61	−27	34	
Ashkum #2	S&G	1964	—	147′	—	—	—	—	—	−48	—	
Beaverville #1	B.R. Dolo	8/49	660±	200′	—	—	—	—	—	—	—	
Beaverville #2	B.R. Dolo	9/65	660±	203′	10″x151′ & 8″x52′	9/65	2	90	—	—	22.10	
Buckley #3	S&G	4/48	—	152′	—	4/48	4	192	−26.7	−16.8	9.9	
Chebanse #2	B.R. Dolo	4/57	660±	150′	10″x150′	4/57	2½	323	−65	−45	20	
Cissna Park #3	B.R. Dolo	9/44	674±	163′	—	9/44	—	200	−22′11″	+3′1″	26	Flowing—Deepened to 200′ in 1954
Cissna Park #3	B.R. Dolo	1954	674±	200′	—	—	—	—	—	0′	—	Static water level = Ground level 12/59
Crescent City #2	S&G	6/54	645	132′	—	—	—	—	—	—	—	
Danforth #7	B.R. Dolo	7/60	—	250′	8″x250′	8/60	7	40	−158	−37	121	
Donovan	S&G	4/45	—	170′	—	4/45	—	65	−62	−53	9	
Donovan	S&G	4/45	—	170′	—	11/48	—	—	−64	−47	17	After intermittent pumping
Gilman (5″ Well)	S&G	10/48	—	129′	—	10/48	3	112½	−27	−2	25	
Gilman (Test 2—5″W)	S&G	10/48	—	129′	—	6/50	¾	63	−25.25	−0.95	24.3	Flowed at 12 gpm
Gilman #8	S&G	9/60	654	197′	—	9/60	5½	280	−37.4	0′	37.4	Static level = Ground level
Loda #2	S&G	6/51	780	158′	—	6/51	2½	157	−112.8	−88	24.8	
Martinon #1	B.R. Dolo	5/59	630	265′	10″x265′	5/59	8	530	−21	−9	13	
Milford #7	S&G	1940	655.5	78′	—	7/40 11/48	8 —	600 —	−32.4 —	−22.4 −32.3	10 —	
Milford #8	S&G	11/63	—	80′	38″x80′	11/63	8	805	−43	−30	13	
Onarga (2 Wells)	S&G	1930	—	156′	—	—	—	—	—	−12	—	Wells are 25′ apart and are identical
Sheldon #4	S&G	1945	683±	116′	—	1945	several hours	450	—	−47	—	
Thawville #1	S&G	8/50	690±	120′	8″x120′	8/50	4½	68→197	−33.9	−9.3	24.6	
Watseka #4	S&G	1944	632±	160′	—	1944	5	520	—	−14	—	
Watseka #6	S&G	1961	—	160′	12″x160′	1961	1	580	−15.3	−10.2	5.1	
Kankakee County											
Aroma Park #3	—	12/62	621	432′	15½″x50′ & 10″x382′	—	—	—	—	−15	—	
Aroma Park #1	B.R. Dolo	6/50	621±	182′	10″x50′ & 7⅞″x132′	7/50	6½	187	−52	−16	36	
Aroma Park #1	B.R. Dolo	6/50	621±	182′	10″x50′ & 7⅞″x132′	5/57	3	100±	−44	−15	29	
Bradley #3	B.R. Dolo and S.S.	1927	657±	1043′	16″x391′ & 12″x156′ & 10″x495′	5/28	2	175	−350	—	—	
Bradley #3	B.R. Dolo and S.S.	1927	657±	1043′	16″x391′ & 12″x156′ & 10″x495′	1942	—	90	−250	—	—	
Hercher #5	B.R. & S.S.	1953	—	789′	—	—	—	—	—	—	—	
Manteno #1 South	B.R. Dolo	1936	675±	100′	30″x20′ & 12″x80′	1936 1939	— —	450 210	−42 −49	−17 −24	25 25	
Manteno #3	B.R. Dolo	1964	—	279′	18″x30′ & 12″x249′	5/64	4	325	−94	−26	68	
Momence #1	—	1936	620±	125′	—	1936 6/47	— 5	— 450	— −48	−8 −2	— 46	
St. Anne #2	B.R. Dolo	1929	—	265′	—	1937	—	300	−73	−57	16	
Will County											
Beecher	B.R. Dolo	1930	—	230′	—	—	—	—	−28½	−26	2½	Levels recorded on 4/27/44
Manhattan #2	B.R. Dolo	1939	—	156′	—	1939	several hours	60	—	−28	negligible	
Monee	B.R. Dolo	4/45	—	408′	17½″ x Lower 199′	5/45 5/46	6 —	195 300	−102 −190	−59 −130	43 60	
Peotone	B.R. Dolo	1930	—	135′	—	—	—	—	—	—	—	
Wilmington #3	B.R. Dolo and S.S.	1964	—	1578′	20″x14′ & 19″x160′ & 16″x591′ & 12′x813′	12/64	24	1200	−467	−169	298	
Wilmington #2	B.R. Dolo and S.S.	1936	545±	1566′	10″ x Bottom 1348′	1936 11/42	— 24	485 800	−65.5 −140	−59 −124	6.5 16	
Ford County											
Roberts #5	S&G	9/50	775	226′	—	9/50	4	105	−114.2	−79.6	34.6	
Roberts #5	(Test No. 2)					9/51	—	105	−104	−83	21	

—Information not available / B.R.: Bedrock / Dolo: Dolomitic Limestone / S&G: Sand & Gravel / S.S.: Sandstone

TABLE 13

Ground-Water Quality

MINERAL CONTENTS of SELECTED MUNICIPAL WELLS

Locations	Source: Drift	Source: Bedrock	Date of Test	Fe—Iron	Mn—Manganese	Ca—Calcium	Mg—Magnesium	NH_4—Ammonium	Na—Sodium	S_iO_2—Silica	F—Fluoride	B—Boron	CL—Chloride	NO_3—Nitrate	SO_4—Sulfate	Alkalinity as $CaCO_3$	Hardness as $CaCO_3$	Total Dissolved Minerals	Turbidity	Color	Odor	Temperature	Remarks
Iroquois County																							
Ashkum #1	—	Dolo	5/47	1.2	0.1	55.0	37.2	2.2	50.6	12.4	0.4	—	50	1.1	76.1	256	291	444	20	0	0	53.5	
Ashkum #2	—	—	4/64	1.6	0.05	—	—	—	—	—	0.4	—	28	1.2	—	200	236	492	7	15	0	—	
Beaverville #1	—	Dolo	8/49	1.0	0.1	60.9	21.4	5.1	28.8	15.7	0.3	—	29.0	0.2	4.3	272	241	302	10	0	0	53.9	
Beaverville #2	—	Dolo	9/65	1.2	0.07	—	—	—	—	—	0.5	—	30	0.2	—	324	244	373	19	0	0	—	
Buckley #3	S&G	—	11/48	1.4	0.2	188.4	73.2	3.3	55.7	25.6	0.3	—	4.0	0.4	531.1	344	772	1149	12	0	0	54.3	pH=7.1
Chebanse #2	—	Dolo	6/60	0.1	0.0	68.2	31.5	1.0	60	8.7	0.6	0.8	6.0	1.0	168.3	248	300	501	0	0	0	54	
Cissna Park #4	S&G	—	6/60	0.9	0.1	82.8	37.2	2.1	23.0	15.3	0.2	0.2	3.0	0.8	25.3	384	360	424	2	0	0	54.5	pH=7.5
Cissna Park #3	S&G	—	11/48	0.7	Tr.	86.9	37.5	2.7	14.5	20.7	0.1	—	2.0	0.2	30.2	376	372	430	7	0	0	54	pH=7.5
Clifton #1	—	Dolo	11/48	0.8	Tr.	105.2	44.2	2.5	52.7	12.2	0.5	—	4.0	0.4	242.9	308	445	664	7	0	0	53	pH=7.05
Crescent City #2	S&G	—	6/60	0.9	0.1	85.8	35.6	Tr.	31	16.9	0.2	0.3	5.0	4.8	94.4	320	361	479	3	0	0	55	
Danforth #7	—	Dolo	8/60	0.5	0.0	—	—	—	—	—	1.8	—	290	0.8	—	420	48	969	2	0	0	55	
Donovan	S&G	—	11/48	2.3	0	40	9	0.7	64	17	0.7	—	30	0.2	1	236	137	315	11	0	Tr.	54	pH=7.7
Gilman #52	S&G	—	8/52	2.4	Tr.	143	59.2	2.1	79	19.0	0.4	—	24	0.2	411.4	316	601	954	9	0	0	54.2	pH=7.7
Loda #2	S&G	—	6/60	1.4	0.1	123.2	68.6	1.2	56	17.5	0.2	0.5	5	0.9	338	356	590	866	0	0	0	55	
Martinton	—	Dolo	5/59	1.4	Tr.	—	—	—	—	—	0.4	—	3.5	0.1	—	324	256	387	10	0	0	—	
Milford #7	S&G	—	11/48	2.5	Tr.	99.1	47.6	0.8	23.2	20.1	0.2	—	7	0.1	165.2	316	444	575	22	0	0	55	pH=7.15
Milford #8	S&G	—	—	0.4	0.03	—	—	—	—	—	0.3	—	3.0	0.4	—	276	320	366	2	0	0	—	
Onarga	S&G	—	11/48	2.0	0.1	151	55	1.6	55.9	20.4	0.3	—	8	0.5	397.8	304	604	891	17	0	0	—	pH=7.35
Sheldon #4	S&G	—	11/48	0.9	—	42.2	14.3	0.6	56.4	17.6	0.8	—	3	0.2	3.7	280	165	302	3	0	0	54	pH=7.6
Thawville #1	S&G	—	8/50	1.3	0.1	115.7	50.3	Tr.	61.2	26.9	0.5	—	1.0	7.2	294.2	316	497	748	7	0	0	54	
Watseka #3	S&G	—	11/48	0.8	Tr.	39.9	13.4	3.6	66.0	18.1	0.4	—	5	0.3	9.3	292	156	306	10	0	0	55	pH=7.5
Woodland #4	S&G	—	11/48	0.5	Tr.	96.8	38.2	7.9	39.3	19.9	0.3	—	10.0	2.1	33.7	456	399	498	3	0	0	—	2 Wells 2 & 4 pH=7.5
Kankakee County																							
Aroma Park #1	—	Dolo	5/57	0.2	0.0	84.3	43.1	0.1	24	7.9	0.3	0.4	27	3.1	123.6	272	388	483	0	0	0	54.2	
Bourbonnais	—	Dolo	11/47	0.9	0.1	83.4	39.9	0.1	2.5	16.8	0.0	—	3.0	2.4	43.2	328	373	401	20	0	Tr.	52.7	
Bradley #3	—	Dolo-S.S.	11/47	0.2	0.0	116.3	59.3	0.7	256.7	11.0	1.4	—	270	13.3	445.8	240	535	1354	Tr.	0	0	58	pH=7.3
Grant Park #3	—	Dolo	1/49	3.2	Tr.	112.1	46.0	0.3	11.7	23.8	0.1	—	12.0	0.1	106.8	368	470	538	40	0	0	53.5	pH=7.1
Herscher #5	—	S.S.	6/60	0.2	0.0	87.7	44.0	1.0	358	8.1	1.6	0.4	365	0.9	399.1	252	400	1442	0	0	0	57	
Manteno #2 South	—	Dolo	12/47	0.22	0.2	106.6	50.8	Tr.	15.9	13.4	0.1	—	14.0	8.7	165.0	312	476	566	Tr.	0	0	52.5	pH=7.2
Momence #6	—	Dolo	11/47	Tr.	0.0	63.5	34.2	0.1	13.1	11.7	0.1	—	6.0	5.1	84.5	228	300	362	Tr.	0	E	54.2	pH=7.3
St. Anne #2	—	Dolo	11/37	1.8	0.0	100.6	41.8	Tr.	45.7	15.3	0.3	—	5.0	4.2	280.8	220	423	659	10	0	0	53.5	pH=7.3
Will County																							
Beecher	—	Dolo	10/46	0.4	0.0	162.1	49.0	0.8	50.4	12.6	0.7	—	3.0	0.0	456.2	240	607	870	10	0	Tr.	52.5	pH=7.2
Manhattan #2	—	Dolo	10/46	0.4	Tr.	93.0	45.4	0.0	12.0	21.4	0.3	—	4.0	0.1	57.6	380	420	469	Tr.	0	0	52	pH=7.05
Monee #2	—	Dolo	10/46	0.5	Tr.	167.3	47.4	0.8	23.7	18.6	0.3	—	2.0	1.5	310.6	340	614	776	Tr.	0	0	52	pH=7.05
Peotone	—	Dolo	10/46	0.8	0.0	117.5	37.6	0.6	23.2	15.7	0.4	—	2.0	0.0	194.4	296	449	605	Tr.	0	0	52.5	pH=7.25
Wilmington #2	—	Dolo	10/46	0.1	Tr.	110.2	39.7	1.0	251.4	11.9	1.2	—	295.0	0.7	322.9	236	439	1188	0	0	0	59.5	pH=7.35
Vermilion County																							
Rankin #2	S&G	—	11/48	1.8	Tr.	71.6	30.5	2.3	35.4	20.9	Tr.	—	10.0	0.4	1.2	372	305	395	6	0	0	55	pH=7.4
Ford County																							
Roberts #6	S&G	—	11/60	1.2	Tr.	—	—	—	—	—	0.5	—	1.0	0.7	—	288	426	681	3	0	0	56.5	
U.S. Public Health Service Drinking Water Standards	—	—	—	0.3	0.05	—	100	—	—	—	1.0	—	250	45	250	Non-Caustic	—	500	10	20	0	—	

— Information not available / S&G: Sand & Gravel / Dolo: Dolomite Limestone / S.S.: Sand stone

is a possibility of developing another reservoir in this area on Spring Creek. There are also several sites with limited possibilities in the upper reaches of tributaries to the Kankakee River in Will County. None of these sites will provide excellent water supplies. Ground-water sources are adequate in these areas and surface supplies generally require more treatment and are, therefore, more expensive.

The Kankakee River may be utilized for the Joliet area water supply. The 3-day, 20-year low-flow at Wilmington is 378 cfs. This is 244 mgd—sufficient for a population of 1,220,000 with a 200 gpcd requirement.

Municipal and Industrial Water Supply

Water supplies, obtained from either underground or surface sources, should be capable of providing both existing and future water demands. Water demands on municipal supplies vary with the size and affluency of the population served, the number and types of industry served, as well as the rate paid by the consumer and his willingness to buy water. When water is cheap or free, the per capita use will be large, usually resulting in much waste. Municipalities which do not have a metering system tend to have large per capita water uses. Per capita water use also increases with affluency of the population. The population projections shown in Table 14 assume that industrial output and per capita income will increase. Therefore, it also is assumed that per capita water use will increase. Further, it is expected that some of the smaller municipal water supplies with large per capita pumpages will increase rates and install meters to prevent waste.

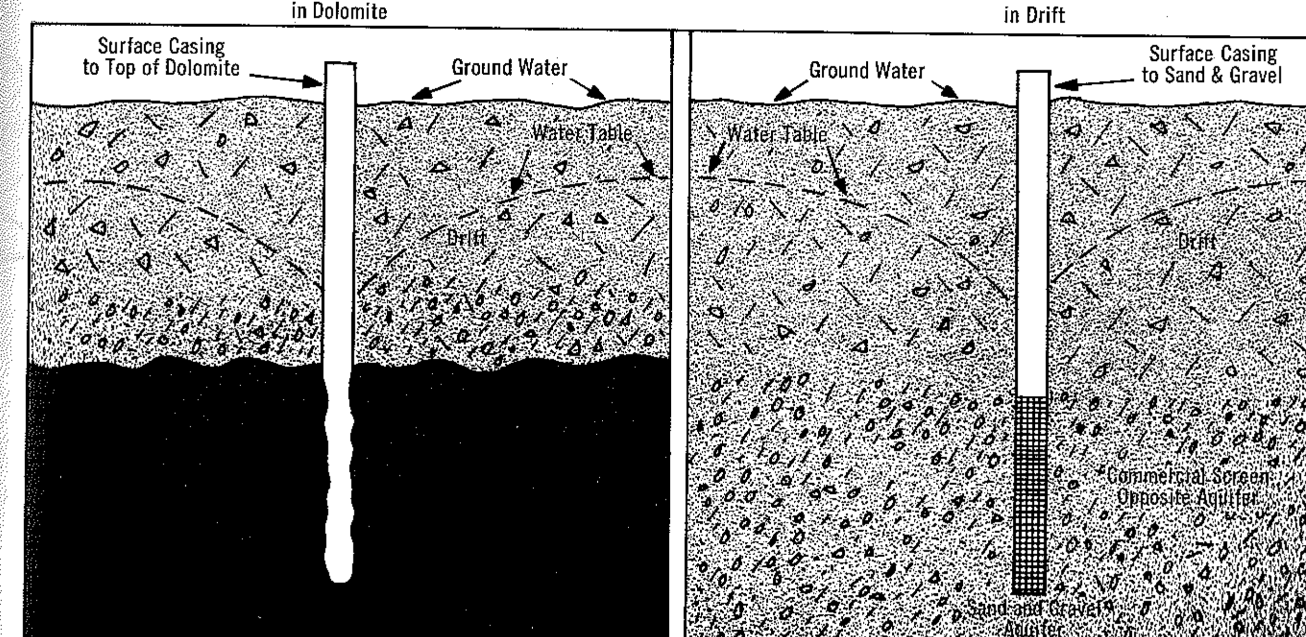
TABLE NO. 14

Municipality	1960 Population	1960 Per Capita Use (gpcd)	1960 Pumpage (mgd)	1980 Population	1980 Per Capita Use (gpcd)	1980 Pumpage (mgd)
Kankakee and Vicinity	52,000	161	8.37	96,000	170	16.3
Watseka	5,219	115	0.60	6,500	120	.78
Wilmington	4,210	190	.85	5,100	180	.92
Momence	2,949	132	0.40	3,600	125	.45
East Will County:	13,000	—	—	40,000	100	4.0
Manhattan Green Garden						
Monee Peotone						
Will Washington						

Municipality	2000 Population	2000 Per Capita Use (gpcd)	2000 Pumpage (mgd)	2020 Population	2020 Per Capita Use (gpcd)	2020 Pumpage (mgd)
Kankakee and Vicinity	155,000	175	27.2	230,000	180	41.4
Watseka	8,000	130	1.04	10,000	140	1.4
Wilmington	6,200	170	1.05	7,500	160	1.2
Momence	4,300	130	.56	5,200	140	.73
East Will County:	80,000	120	9.6	150,000	140	21.0
Manhattan Green Garden						
Monee Peotone						
Will Washington						

FIG. 17 TYPICAL WELL CONSTRUCTION

a in Dolomite — b in Drift



Thirty-six municipalities in the basin have water supplies. Of these, only one obtains water from a surface source. (Figure 18) Kankakee, through the Kankakee Water Company, obtains water from the Kankakee River. The Kankakee Water Company also serves Bourbonnais and Bradley, the supply to the latter supplementing a well. Reported daily average pumpages range from 10,000 gallons per day at Martinton to 8,370,000 gallons per day at Kankakee (Table 15).

Table 15 summarizes the available data on municipal water supplies in the basin. It shows that only Cissna Park and Wilmington are pumping near the capacity of their supplies. Also, it appears that Ashkum, Cissna Park, Clifton, Gilman, and Kankakee may need increased treatment facilities in the near future.

A comparison of Tables 14 and 15 shows that Kankakee has a sufficient supply up to 2020 but will need increased treatment facilities before 1970; Watseka has a sufficient supply to 2020 but probably should drill additional wells before then; Wilmington has an adequate supply and treatment plant to 2020.

As indicated above, only one municipal supply is obtained from the Kankakee River. No additional municipal supplies in the basin are expected to be obtained from this source at the present time. However, outside of the basin, it is highly probable that the City of Joliet will eventually utilize the Kankakee River for its water supply. Situated immediately north of the basin, Joliet now obtains water from deep sandstone and drift sources. Heavy pumping from the sandstones has resulted in severe declines in water levels and excessive pumping costs. Pumping and treatment costs will eventually become prohibitive, and the city will then have to find another source for its supply. A pipeline to the Kankakee River appears to be the most economical alternative and probably will have to be completed sometime between 1980 and 1990.

Table 14 shows that comparatively large population increases are projected for eastern Will County. Moderately dense suburban development is expected here; and future demands should be supplied by wells in shallow dolomite rocks.

It is believed that future municipal water needs in the basin will continue to be satisfied mainly by ground-water sources. The potential yields of both shallow dolomite and drift aquifers are large enough to support projected demands assuming that new wells will be properly located, constructed, and developed.

FIG. 18 MUNICIPAL WATER SUPPLIES

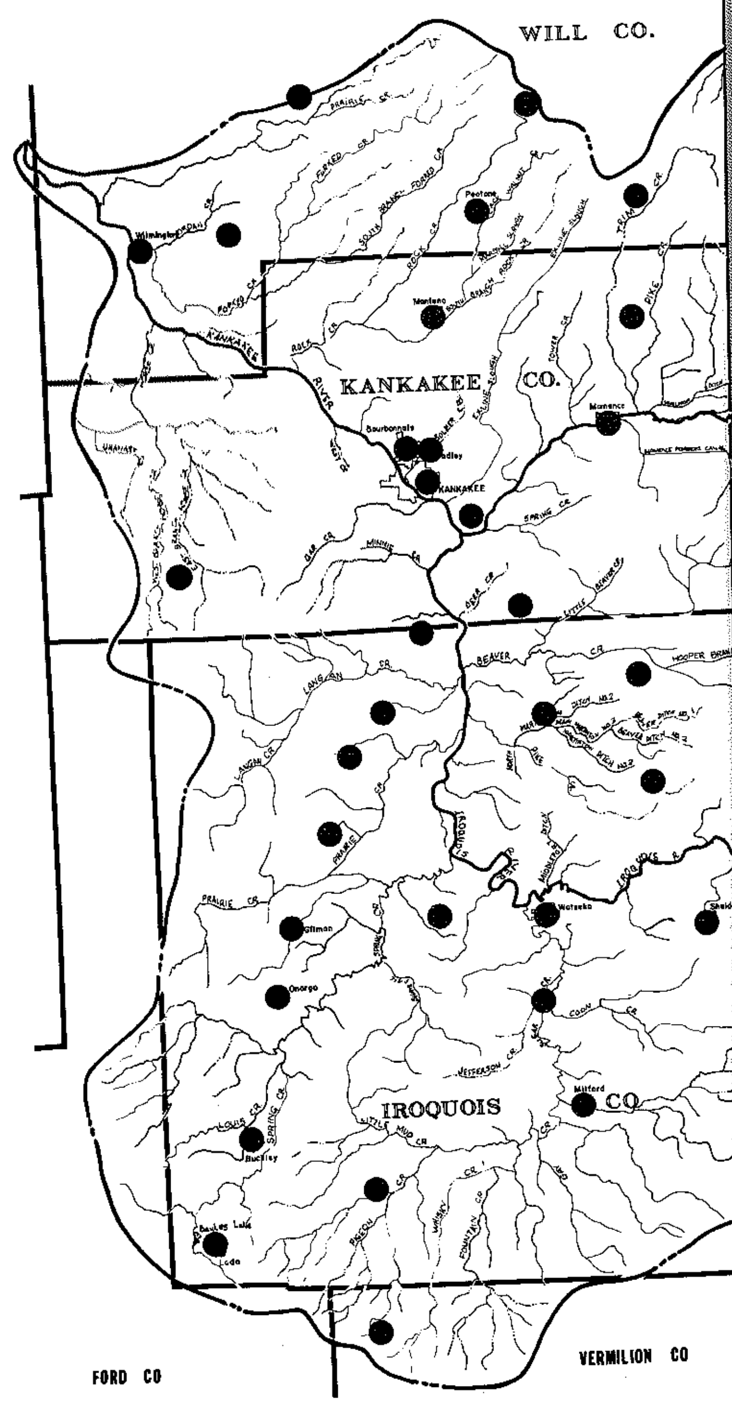


TABLE NO. 15

Municipal Water Supplies

Municipality (1)	Population Served (2)	Source (3)	Safe Yield for Wells or Draft Rate for Reservoirs (mgd) (4)	Treatment Plant Capacity (mgd) (5)	Average Output (mgd) (6)	Average Daily per Capita Use (gallons) (7)	Ratio of Yield Cap. To Use (4÷6) (8)	Ratio of Treat ment Capaciy to Use (5÷6) (9)
Aroma Park	1,755	Well	.144	.196	.072	41	2.0	2.72
Ashkum	625	Rock Well	.104	.072	.038	61	2.74	1.89
Beaverville	445	Well	.200	.187	.020	45	10.0	9.35
Beecher	1,485	2 Wells	*	.860	*	*	*	*
Bourbonnais	3,855	Rock Well	.238	.233	.100	Receive supplemental water from Kankakee		
Bradley	8,795	Kankakee	—	—	—	—	—	—
Buckley	725	2 Drift Wells	*	.080	.037	51	*	2.16
Chebanse	1,070	2 Rock Wells	.430	.430	.120	112	3.58	3.58
Cissna Park	800	Rock Well	.250	.250	.200	250	1.25	1.25
Clifton	1,020	Rock Well	*	.070	.047	46	*	1.49
Crescent City	495	2 Drift Wells	*	.215	.025	50	*	8.6
Danforth	395	2 Rock Wells	.130	.090	.020	51	6.5	4.5
Donovan	400	2 Wells	.108	**	*	*	*	*
Gilman	1,740	Wells	*	.330	.185	106	*	1.78
Grant Park	815	2 Wells	*	*	*	*	*	*
Herscher	735	2 Rock Wells	*	.200	.060	82	*	3.33
Kankakee	52,000	Kankakee River	131.8	10.50	8.37	161	15.7	1.25
Belle Aire Subdivision	545	2 Wells	.140	.140	*	*	*	*
Loda	590	2 Drift Wells	.390	.390	.040	68	9.75	9.75
Manhattan	1,240	2 Rock Wells	*	*	.060	48	*	*
Manteno	2,360	Wells	*	*	.150	64	*	*
Martinton	240	Well	2.10	.500	.010	42	210.	50.0
Milford	2,300	Drift Wells	.500	.800	*	*	*	*
Momence	3,040	4 Wells	3.160	3.160	.400	132	7.9	7.9
Monee	755	2 Rock Wells	.330	1.270	.070	93	4.72	18.1
Onarga	1,380	2 Drift Wells	.432	.216	*	*	*	*
Peotone	1,910	2 Rock Wells	*	.980	*	*	*	*
Rankin	770	2 Drift Wells	.260	*	*	*	*	*
Roberts	530	2 Drift Wells	.345	**	.040	76	8.63	*
Saint Anne	1,370	2 Rock Wells	.830	.830	.100	73	8.3	8.3
Sheldon	1,145	2 Drift Wells	.740	.740	.125	109	5.92	5.92
Symerton	Fire Protection	Well	—	—	—	—	—	—
Thawville	240	Drift Well	.110	.100	.020	83	5.5	5.0
Watseka	5,210	3 Rock Wells	1.440	*	.600	115	2.4	*
Wilmington	4,465	2 Rock Wells	1.400	1.370	.850	190	1.65	1.61
Woodland	330	Drift Wells	*	*	*	*	*	*

*Information not available. **No Treatment.

water-oriented recreation

Recreation Needs

This is a rapidly growing demand for a greater quantity of better quality public, outdoor, recreation lands which are readily accessible to the populace. This is true for the United States; it is true for the State of Illinois; it is true for the Kankakee Basin. The growth in the demand for outdoor recreation facilities is related to personal income, leisure time, and mobility of the population. The Outdoor Recreation Resources Review Commission (ORRRC) Studies forecast a doubling of the number of recreation outings per person from 1960 to 2000 in the United States. It appears reasonable to assume that the recreation demand in the Kankakee Basin would tend to follow the national trend.

The various outdoor activities require a wide range of facilities and types of lands. Present uses of outdoor recreation lands indicate that between one-half to three-fourths of the outdoor recreation lands should be water oriented. Water is essential for many outdoor activities such as fishing, swimming, boating, and scuba diving. It greatly enhances many other activities such as hunting, camping, hiking, driving, or picnicking.

Various guidelines for the determination of the quantity of needed outdoor recreation lands have been used throughout the United States. One which has been accepted and widely used recommends 10 acres of land per 1000 population for each of three categories: 1) local parks and playgrounds, 2) regional parks, and 3) extra-regional parks.

Local parks and playgrounds are commonly provided by municipalities, school districts, and park districts. The provision of this type of recreation land is a local responsibility for meeting local needs. Growing municipalities should insure that sufficient lands are included in new subdivisions to provide an adequate and desirable distribution of local parks and playgrounds.

Regional parks are commonly provided by forest preserve districts, conservation districts, and the Department of Conservation. The primary function of the regional park is to provide recreation facilities for the day-outing. The regional park should be close to the population centers. A regional park may be expected to serve people within an hour's travel time of the park. With the existing highway system, this may be 50 or more miles.

Extra-regional parks are commonly provided by the State and Federal Governments. The primary function of the extra-regional park is to provide facilities for day-outings, tourists, camping, and overnight and longer visits. There is no clear-cut demarcation between the regional and extra-regional parks. A park may serve as a regional facility for the local area and as an extra-regional facility for tourists or visitors from more distant areas. Extra-regional parks for the Kankakee Basin would include all State and Federal parks beyond the Illinois borders as well as most of the Illinois State parks. Recreation facilities at Federal flood control projects which are proposed or under construction, such as Oakley, Lincoln, Helm, Louisville, Shelbyville, and Carlyle Reservoirs, can also be counted as extra-regional park land for the Kankakee Basin population. Similar projects in Indiana, such as Mansfield, Big Pine, Cagles Mill, and Mississinewa Reservoirs, will also provide extra-regional parks.

Because supplying local parks is a local function and because extra-regional parks appear adequate, the problem to be considered is that of regional park adequacy. It has been determined that 10 acres of park land is needed for every 1000 people. It has also been estimated that this requirement will double to 20 acres per 1000 by the year 2000.

Recreation Inventory

It has been previously pointed out that it is not possible to limit water resources planning to a river basin. This is particularly true in the determination of recreation demands on the water resource. The Kankakee Basin is in the unique position of being located at the outer edge of the expanding Chicago Metropolitan Area. Not only is growth of population expected to "spill" into the basin but also a large portion of the outdoor recreation demand is expected to be met in the Kankakee Basin. For the latter reason, the recreation facilities available to the Chicago Area will be discussed at some length.

Chicago Metropolitan Area The proximity of the Chicago Metropolitan Area to the Kankakee Basin dictates the consideration of providing water-oriented recreation facilities for the people of the Chicago Area in the Kankakee Basin. It is generally recognized that the Chicago Area is deficient in outdoor recreation facilities—particularly water-oriented. As of 1960, the six-county Chicago Metropolitan Area (Cook, Du Page, Kane, Lake, McHenry, and Will Counties) had only 2.22 acres of local parks and playgrounds per 1000 population, 7.96 acres per 1000 population of regional parks, and 0.96 acres per 1000 population of extra-regional parks. As was stated before, local parks and playgrounds are a local responsibility and local officials should insure that a sufficient quantity of parks and playgrounds are included in all new additions. It is not required that the 10 acres per 1000 population of extra-regional park lands be provided within the Chicago Area. The problem to be considered here is the provision of regional park lands for the Chicago Area population proximate to this population.

As of 1960, there were nearly 50,000 acres of regional park lands in the six-county area. Table 16 has been prepared using a reasonable population projection and regional park land requirements of 10 acres per 1000 population in 1960 increasing to 20 acres per 1000 population in 2020.

The six-county area contains nearly 2.4 million acres. The anticipated regional park lands required in 2020 constitute over 10% of the six-county area. *Outdoor Recreation in Illinois*[1] gives an estimate of potential outdoor recreation lands available. The Chicago Metropolitan Area contains about 138,000 acres of potential recreation lands of which about 88,000 are flood plain lands. The Division of Waterways in the preparation of *Water for Illinois: A Plan for Action*[2] estimated that there are over 200,000 acres in the Chicago Metropolitan Area susceptible to flooding. Not all floodprone lands are desirable as recreation lands. Due to the great need for recreation lands, all floodprone lands which are suitable for recreation development should be so developed.

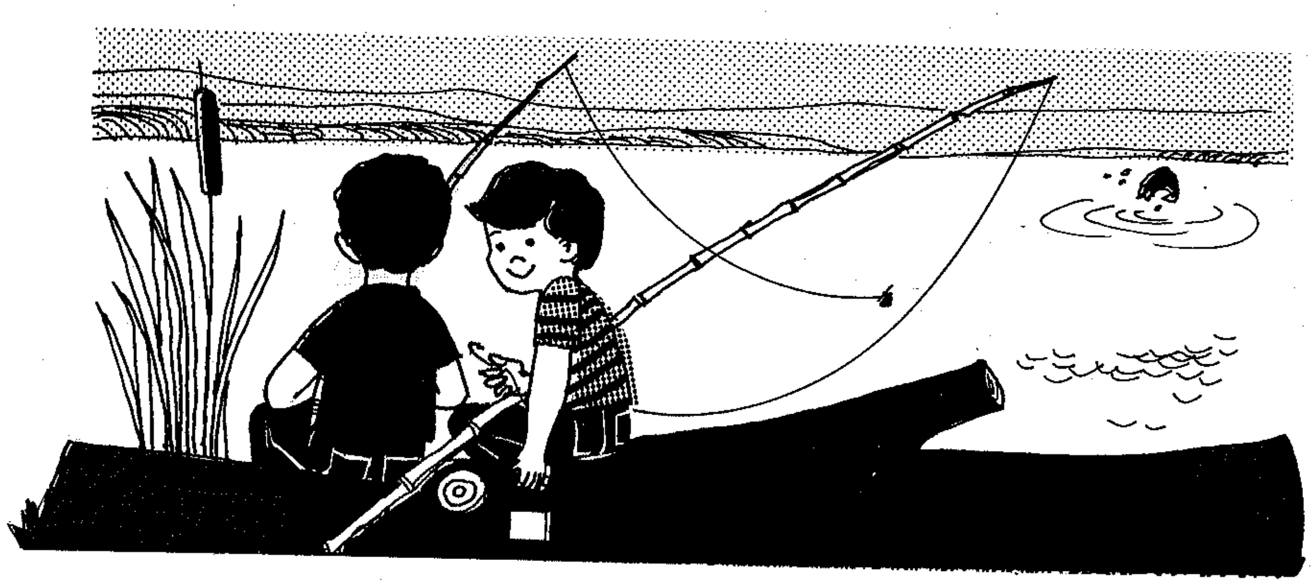
The area of flood plain lands in the Fox, Des Plaines, and Du Page Valleys amounts to over 160,000 acres. Some of these lands are already developed for recreation. Total development of these three valleys for recreation would provide about 60% of the anticipated needs of 2020. It is quite apparent that not only must these lands be developed for recreation but that a large amount (about 120,000 acres) of additional land must also be acquired and developed for recreation.

The Division of Waterways has proposed a plan for the development of the shore of Lake Michigan.[3] This plan calls for the public acquisition of all littoral rights from the Wisconsin State Line to the Indiana State Line; the construction of a breakwater about one-half mile off shore from Waukegan to the Indiana State Line; and the construction of islands within the breakwater

[1] *Outdoor Recreation in Illinois*, Illinois Department of Business and Economic Development, Springfield, 1966.

[2] Ackermann, William C., Editor, *Water for Illinois: A Plan for Action*, Illinois Department of Business and Economic Development (Technical Advisory Committee on Water Resources), Springfield, 1967.

[3] *Development and Improvement of the Land and Water Resources of Lake Michigan and the Principal Waterways of the Chicago Region*, Illinois Division of Waterways, Springfield, 1965 (unpublished).



from Evanston to the Indiana State Line. This plan would provide a large block of public recreation lands (10,000-20,000 acres) proximate to the population of the Chicago Area.

Development of all the above mentioned lands will still leave a considerable deficit of recreation lands (approximately 100,000 acres by 2020). The Kankakee Valley in both Illinois and Indiana is close to the Chicago Metropolitan Area (approximately 60 miles) and is a very desirable and suitable area for recreation development. There are nearly 40,000 acres along the Kankakee River in Illinois which are subject to overflow and should be developed for water-oriented recreation. The Kankakee Marsh in Indiana originally contained about 400,000 acres. About 50,000 acres are now subject to frequent overflow. This land as well as some of the more marginal agricultural lands should be developed for recreation.

Kankakee Basin Consideration of the population projections for the Kankakee Basin and the recreation land requirements previously used leads to the development of Table 17. Existing regional park facilities within the basin include: Kankakee River State Park which contains 2224 acres, Iroquois County Conservation Area which contains 1920 acres, and Des Plaines Conservation Area which contains 2331 acres, part of which is in the basin. (Figure 19)
Both the Iroquois County and Des Plaines Conservation Areas are primarily for hunters and non-intensive recreation uses. Kankakee River State Park has facilities for camping, picnicking, and fishing. The large acreages in the conservation areas are not designed to accommodate a relatively large number of people. Attendance records (1964) show 3000 visits to the Iroquois County Conservation Area, 5275 visits to the Des Plaines Conservation Area, and 502,026 visits to Kankakee River State Park. Over 800,000 visits were made to Kankakee River State Park in 1965 and over 1,000,000 in 1966.

The total area of the three State-owned facilities is 6475 acres. Table 17 shows that the present lands available should meet the requirements for the basin population until after the year 2000. Since nearly two-thirds of the lands are hunting areas, there is likely to be a shortage of intensively developed lands before the year 2000 if only the Kankakee Basin population is considered.

As has been previously pointed out, there will be a large demand for outdoor recreation in the Kankakee Basin due to the proximity of the Chicago Metropolitan Area. The area of land required to meet this demand will be several times the area needed to meet the demands of the Kankakee Basin population.

TABLE NO. 16

Chicago Metropolitan Area Regional Park Land Requirements

Year	Population	Park Lands Required (Acres/1000 pop.)	Total Land Required (Acres)
1960	6,250,000	10	62,500
1980	8,000,000	13.33	106,600
2000	11,000,000	16.67	183,400
2020	14,000,000	20	280,000

TABLE NO. 17

Kankakee River Basin Regional Park Land Requirements

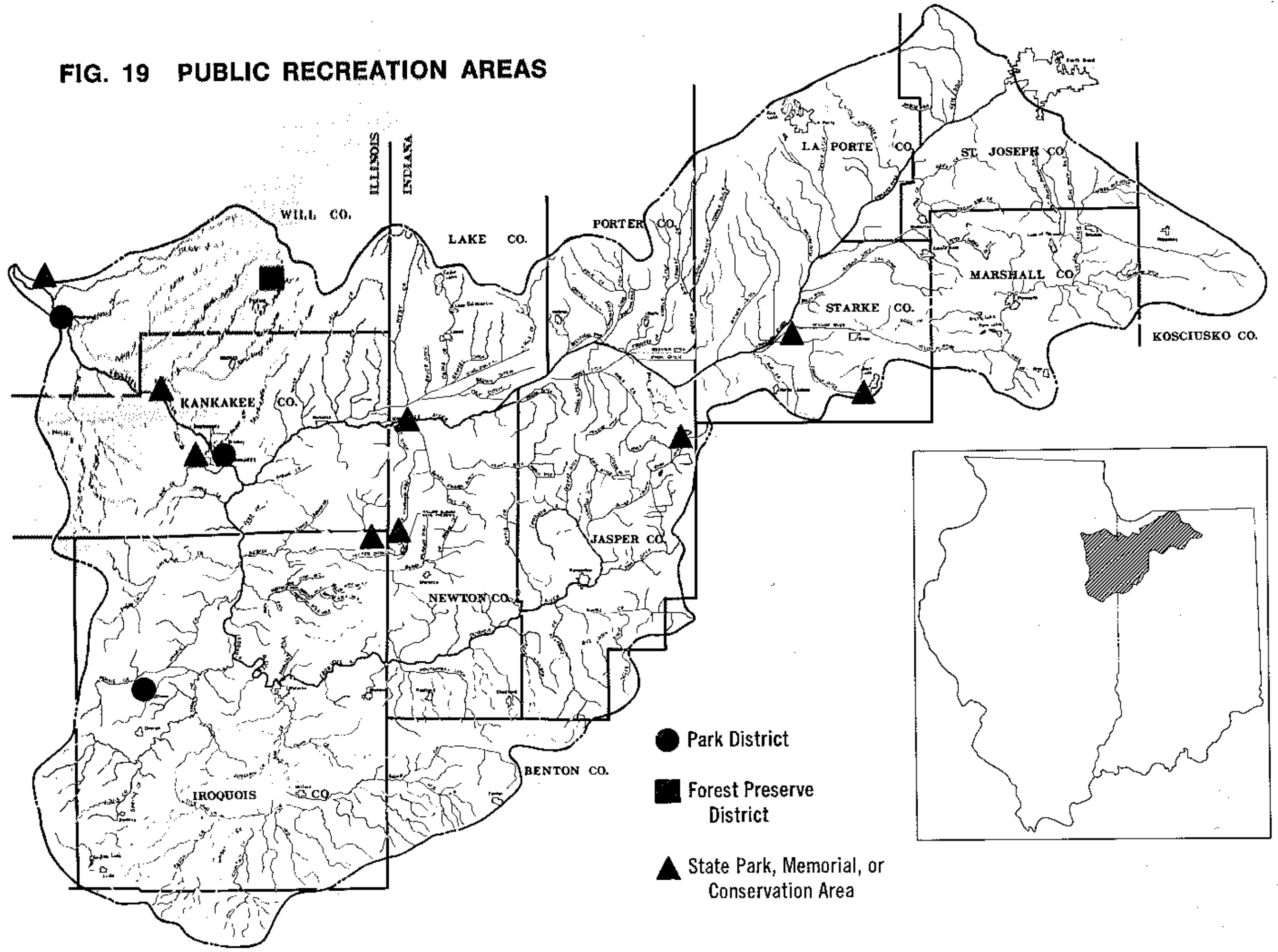
Year	Population	Park Lands Required (Acres/1000 pop.)	Total Land Required (Acres)
1960	147,000	10	1,470
1980	227,000	13.33	3,030
2000	315,000	16,67	5,250
2020	435,000	20	8,700

Plan for Development

The Kankakee River is an excellent stream upon which to construct a recreational waterway and base a regional park. The low flow of the Kankakee is quite good. The lowest measured discharge at Momence is 306 cfs and at Wilmington is 204 cfs. These low flows have a small probability of occurring: about 2% at Momence and less than 1% at Wilmington (3-day duration). The bed of the Kankakee is composed primarily of sand, gravel, and rock with only a few areas of silt and mud. The Kankakee is 159 miles long with 59 miles in Illinois. Near the State Line the slope of the bed is about 0.5 feet per mile. Below Kankakee the slope is over 4 feet per mile. The width of the river varies from about 200 feet to over 800 feet and the depth from about 1 foot at low water to over 20 feet at flood stage.

The present Kankakee Valley is the remnant of the Kankakee Torrent *(PHYSIOGRAPHIC HISTORY)* which existed near the end of the Wisconsin Glacial Age. The Kankakee Torrent eroded through the glacial drift to bedrock forming a large channel. As the flow of glacial water subsided, sand and gravel were deposited causing a narrowing of the channel in some reaches. The bed of the existing channel is essentially the same as it was following the Torrent 10,000 years ago. Because of relatively steady flow, low-sediment concentrations, and bedrock-channel controls, the Kankakee has been unable to effect any major changes

FIG. 19 PUBLIC RECREATION AREAS



in its channel geometry and longitudinal profile since the Torrent. Maps and profiles of the Kankakee have shown no significant changes in the channel, islands, sand bars, or pools over the past 50 years. Noticeable shoaling and bank-cutting were reported along the Kankakee above Momence between 1900 and 1920. This period coincides with major dredging projects in Indiana, but there have been few channel changes since then. It is, thus, concluded that the regime of the Kankakee is stable due primarily to the stream's inability to significantly alter its channel.

The Iroquois River carries a moderate suspended sediment load during high water. Some of this load is dropped where the Iroquois enters the Kankakee at Aroma Park above the Kankakee Dam. Some filling of the Kankakee Pool has occurred in the past and may be expected to continue in the future. A large sand movement into the Kankakee Pool was reported to follow the failure of the Aroma Park Dam.

It is concluded that there will be no unusual problems in constructing and maintaining the proposed recreational waterway which will alter the channel geometry and longitudinal profile.

In order to provide for the recreation needs of the Kankakee Basin and also for a portion of the Chicago Metropolitan Area recreation demand, a recreational waterway and a linear park system along the Kankakee River and a portion of the Iroquois River is proposed. It was previously determined that approximately 100,000 acres of regional park lands will be required by the year 2020 and that a large portion of these lands must be developed in the Kankakee Basin. Somewhere between one-half to three-fourths of these lands will probably be located within the Illinois portion of the basin. There definitely should be park lands developed in eastern Will County as the Chicago Metropolitan population moves into the area. The bulk of the park lands, however, will logically be developed along the Kankakee River which has great recreational potential.

The plan for provision of a recreational waterway and associated land has been developed to enhance the recreational potential of the Kankakee and Iroquois Rivers at a minimum of capital and maintenance expenditures while obtaining needed drainage relief and providing some flood stage reduction. One concept which has been kept in mind throughout the development of the plan is that pleasure boating is incompatible with non-intensive recreation—particularly sports fishing. It is recognized that both uses are needed, necessary,

and perhaps equally important. The possibility of separating these uses was investigated in every reach of the river.

Because of the relatively steep channel gradient below Kankakee, slackwater canalization was the only practical method of providing a navigable waterway. Dams No. 1 and No. 3 only moderately deepen existing natural pools and should have no effect on the fish and wildlife habitat in these reaches. (Figure 20) Dam No. 2 (Wilmington) has existed for many years, and its pool will not be a part of the waterway except through the headrace on the right side of Wilmington Island. The natural riffles below Dams No. 1, No. 2, and No. 3 will be undisturbed and will be preserved exclusively for non-intensive use.

Between the head of Pool No. 3 at Mile 20 and Dam No. 4 at Mile 25.0, the river makes its steepest descent—about 45 feet. This is the reach through Kankakee River State Park which contains scenic rock palisades along the river, Rock Creek Canyon, and fast water. Slackwater navigation through this reach would require 2 or 3 locks and dams, would destroy the aesthetic value of the palisades and Rock Creek Canyon, and would drown the riffles. For this reason, a lateral canal has been chosen to bypass the reach. The canal will be located on top of the terrace opposite Rock Creek and will ascend from the head of Pool No. 3 to Pool No. 4 by three locks. This alinement appears compatible with the park master plan developed by Scruggs and Hammond.[4]

The park will be a focal point for general recreation in the lower valley and will become the objective for cruising boaters from distant points above and below. For this reason, the canal will include widewaters or boat basins between the locks which can be developed for overnight berthing facilities. Such cruising-camping would not be incompatible with the present park development plan.

The pool formed by Dam No. 4 will extend 8.2 miles to the existing Kankakee Dam (No. 5). This pool is relatively straight, broad, and deep and will be used mainly for pleasure boating. Shoreline fishing might be enhanced slightly at the drowned mouths of tributaries.

The pool, formed by the existing Kankakee Dam (No. 5) extends about five miles upstream to Aroma Park. No changes will be made in this reach which is now devoted to pleasure boating. Above Aroma Park, the waterway will be extended by open-channel works—a combination of dredging, dikes, and wing dams. Open-channel works have been chosen for two reasons:

[4]Scruggs and Hammond, *The Development Plan for Kankakee River State Park*, April, 1959.

1) the low river banks through this reach would result in excessive flowage damages if slackwater pools were used, and 2) by routing the navigation channel through island chutes and restricting power boats to the channel by dikes, wing dams, and buoys, the greater part of the river can be preserved for non-intensive uses. Near the head of this reach, a channel will be excavated through rock for about three miles in the vicinity of Momence. This channel has the dual purpose of 1) extending the waterway, and 2) improving drainage outlet conditions and reducing flooding on over 16,000 acres of land in Momence, Yellowhead, and Pembroke Townships. One channel at Momence Island will be maintained as a lagoon and replenished with water at high river stages.

Above the mouth of Yellowhead-Singleton Ditch, Dam No. 6 would control water levels in the remaining reach approximately as they are now. The navigable channel can be extended to the State Line by moderate dredging at shoals and crossing bars. There is a good possibility that pleasure craft could proceed for many miles into Indiana.

The Iroquois River improvement will be accomplished by excavating a channel through the rock control near Sugar Island. The present channel from Sugar Island to Watseka is a long, sluggish pool maintained by the rock control. (Figure 21) The improvement will simply lower this pool to the elevation of Pool No. 5—a reduction of 5 feet. The new channel will be deepened by dredging and will be essentially the same as the existing pool except that it will be at a lower level. This pool lowering will provide very important drainage outlet improvements as well as extend the navigation channel to near Watseka. About 12 miles (one-half) of this channel through the rock control section will be widened an additional 200 feet with a minimum depth of 2 feet. This widening will maintain the existing shoreline fishing, prevent mud flats during low water, and improve the high-water capacity of the channel.

In summary, the Kankakee Recreational Waterway project has been developed for recreational boating and non-intensive water-oriented recreation. It will form the central core of a linear park development which should eventually include 50,000 acres or more of lands and water. As a waterway, it will provide 84 miles of navigable channel between the mouth of the Kankakee River and the State Line and between the mouth of the Iroquois River and Watseka. Of the distance, 66 miles will be in slackwater pools and will be jointly used by all types of water-oriented recreation. Eight miles of river will be exclusively used for fishing, wildlife, and other non-intensive uses. An additional 10 miles of river will be physically divided into pleasure

FIG. 20 PROFILE OF PROPOSED KANKAKEE RIVER RECREATIONAL WATERWAY

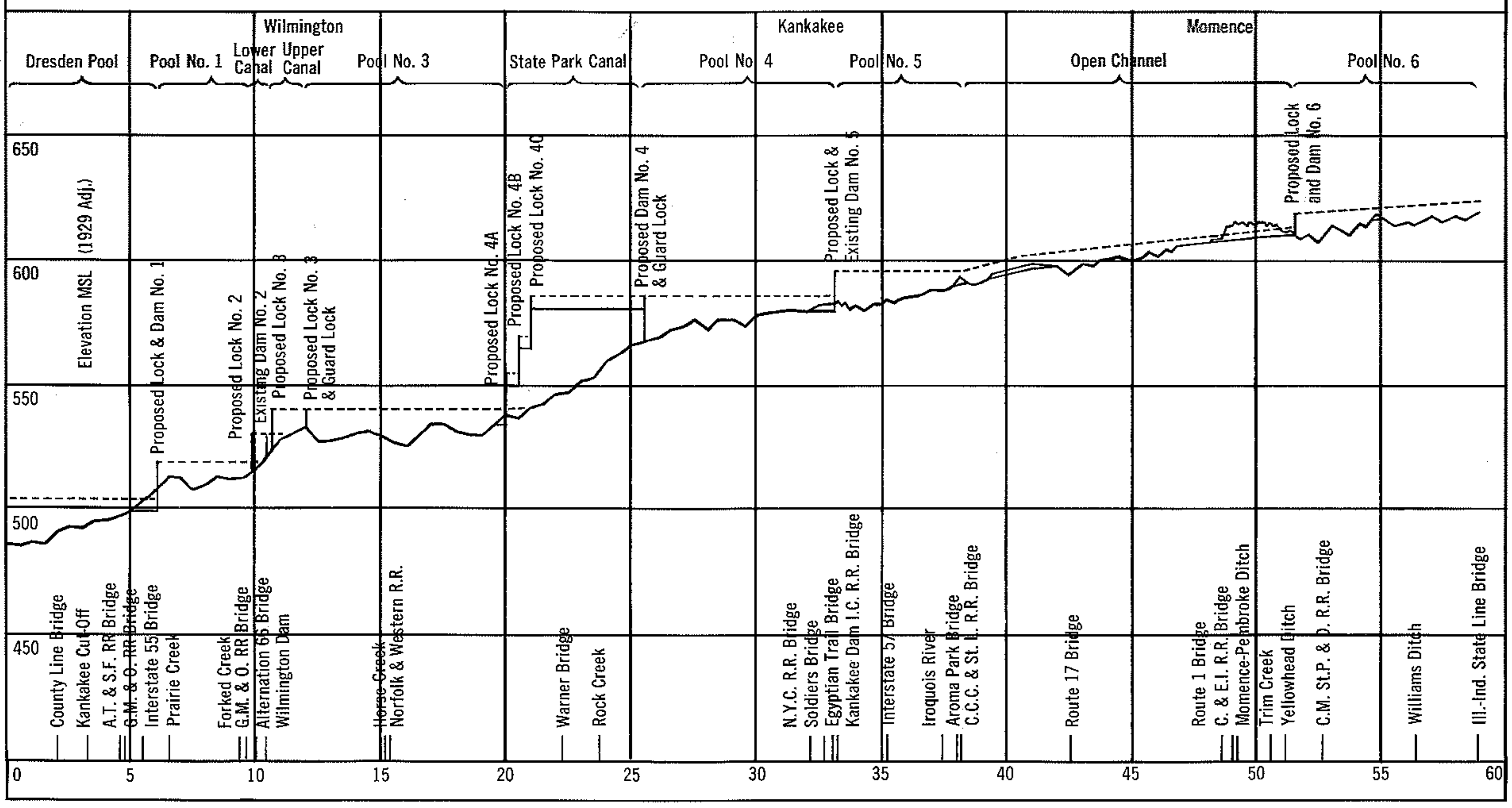
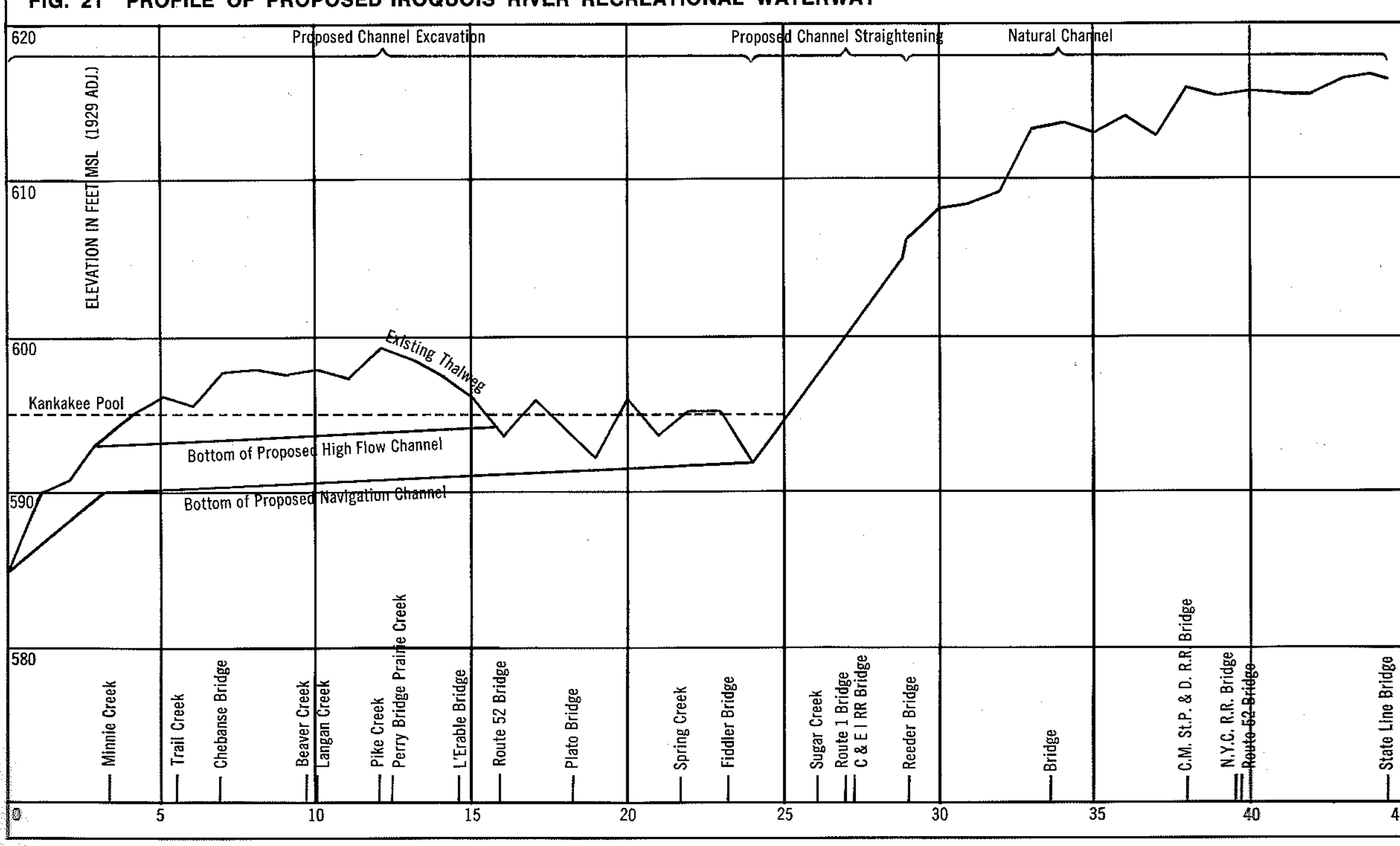


FIG. 21 PROFILE OF PROPOSED IROQUOIS RIVER RECREATIONAL WATERWAY



boating and non-intensive use. Project lands will include about 6,000 acres of bed, banks, and riparian lands as necessary for protection, operation, and maintenance of the waterway. Public access to the waterway will be as open as is consistent with good management. While some sport fishing opportunities may be decreased by conflicts with boating in the pools, the better fishing sites will be preserved intact and the general availability of fishing opportunities for the general public will be increased by having the river in public ownership.

Program Description The general plan described above is here described more specifically. Cost estimates and anticipated benefits are calculated. The actual sequence of development is dependent upon various factors such as available financing, growth of population and recreation demand, and desire for the ancillary drainage benefits. Upon examination of the plan, it appears that the Iroquois deepening should be given first priority. This would provide 20 miles of pleasure-boating channel and drainage relief and flood-stage reduction for 150,000 acres. It then appears logical to start at the lower end of the Kankakee and proceed upstream with the proposed improvements. Lock and Dam No. 1 will provide for increased pleasure boating from the Illinois Waterway as well as provide a pool for withdrawal of water for the Joliet area. As the recreation demand develops, the improvement may be carried upstream to the State Line.

In the lower 20 miles of the Kankakee River, the plan of improvement is essentially the same as that used by the Kankakee Company over 90 years ago. The head of Dresden Island Pool (Elevation 505) on the Illinois Waterway occurs about one mile below the Interstate 55 Bridge at Mile 5.5. A lateral canal starting below the G. M. & O. Railroad Bridge will carry the Dresden Pool level to Lock No. 1 at Mile 6.0. Tentatively, this lock will be a restoration of the old Kankakee Company Lock. Lock No. 1 will have a 15-foot lift to Pool No. 1 (Elevation 520). Dam No. 1 will be a concrete overflow spillway 12 feet high and 750 feet long.

At the head of Pool No. 1, 3.8 miles upstream, Lock No. 2 will have an 11-foot lift to the head race of Pool No. 2 (Elevation 531). The Lock will be the standard 20 x 60-foot design. It will be necessary to increase the vertical clearance at the Alternate 66 Bridge and perform some remedial dredging in the head race.

Lock No. 3 will be restored from the existing Kankakee Company Lock at the head of Wilmington Island. The lock will have a 9-foot lift and will be connected to Pool No. 3 (Elevation 540) by a one-mile long lateral canal. A guard lock or emergency gate will be installed at the head of the canal. Dam No. 3 will be a concrete overflow spillway 6 feet high and 1300 feet long.

Pool No. 3 extends 7.5 miles upstream to the foot of the rapids section in Kankakee River State Park. At this point a lateral canal, 5 miles long, will bypass the river and ascend to Pool No. 4 (Elevation 585) through three locks with a total lift of 45 feet. These locks, 4A, 4B, and 4C, will be the standard 20 x 60-foot design. A guard lock or emergency gate will be installed at the head of the canal. The canal will have a minimum width of 60 feet and a minimum depth of 5 feet, and boat basins will be provided within the park area. Dam No. 4 will be a concrete overflow spillway 17 feet high and 700 feet long.

Pool No. 4 will extend 8.2 miles to the existing Kankakee Dam where Lock No. 5 will be constructed in one bay of the powerhouse structure. This lock will have a 10-foot lift to Pool No. 5 (Elevation 595). An adequate slackwater pool extends 5 miles upstream to the site of the old Aroma Park Dam.

From the ruins of the Aroma Park Dam the channel will be improved 9 miles upstream by a combination of dredging, dikes, and wing dams. In this reach, the navigation channel will pass on the northerly side of existing islands and will be physically separated from the remaining part of the river by dikes and buoys.

At the head of this reach the channel will enter a rock cut with a minimum width of 50 feet and minimum depth of 3 feet at extreme low water. This rock cut will extend through Momence to the mouth of Yellowhead-Singleton Ditch and will have a high water channel 400 feet wide. One channel past Momence Island will be maintained as a lagoon.

Shortly above the mouth of Yellowhead-Singleton Ditch, Lock and Dam No. 6 will be constructed to maintain the existing river level from the dam to the State Line. Lock No. 6 will be the standard 20 x 60-foot design and will have a 5-foot lift at low water. Dam No. 6 will be a concrete overflow spillway 8 feet high and 250 feet long. Minor dredging above the dam will extend the waterway to the State Line.

Tentative cost estimates for waterway improvements on the Kankakee and Iroquois Rivers are given in Tables 18, 19, and 20. These costs include expenditures for drainage and flood control which could not be conveniently separated.

Project Benefits Project benefits have been estimated for those purposes directly attributable to the waterway and its associated improvements. These groups include: drainage and flood control, pleasure boating, fish and wildlife, general recreation, and land value enhancement. Recreational benefits derived from the expansion of the park system to 50,000 acres have not been included other than those directly related to the

waterway. All benefit estimates are intended to be net of any associated or consequent costs and also represent the net benefit increase over existing conditions. The benefits, like the costs, are computed as if the entire project were done at once.

PLEASURE BOATING—This group includes all forms of boating other than fishing, canoeing, and sailing. The pleasure boat traffic is expected to average 90-140 boats per day (in a 200-day navigation season) throughout the waterway system. Traffic is expected to develop almost immediately after project completion. The estimate of boating benefits is based on a unit benefit of $700 per year per equivalent boat season. Additional general recreation benefits have been estimated for picnicking, camping, and other activities directly associated with this boating. The annual benefits are estimated to be $1,642,000 on the Iroquois and $3,780,000 on the Kankakee.

FISH AND WILDLIFE—This group includes all fishing, hunting, trapping, and like activities within the project lands. Benefits have been estimated on a composite figure of 25 man-days per acre per year with a unit value of $4.00 per man-day. The estimated annual benefits are $146,000 on the Iroquois and $600,000 on the Kankakee.

GENERAL RECREATION—This group includes picnicking, camping, hiking, sightseeing, and like activities. The net increase of this activity on the project lands is expected to average 1,250,000 visitor-days annually. The annual benefits, evaluated at $1.00 per visitor-day, are estimated to be $250,000 on the Iroquois and $1,000,000 on the Kankakee.

LAND ENHANCEMENT—This benefit will occur along certain portions of the rivers where agricultural lands will be subdivided for homes and cottages as a direct result of the waterway. It is estimated that 25% of the length of the waterway will be so developed with an average, net appreciation of $9 per front foot. The estimated annual benefits are $25,000 on the Iroquois and $71,000 on the Kankakee.

DRAINAGE AND FLOOD CONTROL—Since the costs associated with drainage and flood control cannot be conveniently separated, the benefits to drainage and flood control are included here. The channel improvement at Sugar Island, Momence, and Watseka will greatly improve drainage outlet conditions, and will reduce the frequency of overland flooding on the land affected. The benefits are based on expected crop yield increases due to improved drainage and crop loss reduction due to overbank flooding. Associated costs for carrying outlet drainage improvements to the upland drainage laterals have been deducted from the gross benefits. The estimated annual benefits are $713,000 on the Iroquois

TABLE NO. 18

Cost Estimate: Kankakee River Improvements

Lands and Damages	6,000 ac.	@	$ 1,000	$ 6,000,000
Dam No. 1				442,000
Dam No. 3				260,000
Dam No. 4				707,000
Dam No. 6				75,000
Locks	8	@	$450,000	3,600,000
Guard Locks	2	@	$300,000	600,000
Channel Excavation (rock)	1,000,000 cy	@	$ 6.00	6,000,000
Canal Section	7.5 mi.	@	$250,000	1,880,000
Open Channelworks	13.5 mi.	@	$ 50,000	675,000
Highway Relocation	2 mi.	@	$ 60,000	120,000
Highway Bridges	6	@	$ 50,000	300,000
				$20,659,000
Engineering and Contingencies				5,165,000
Total Construction Cost				$25,824,000
Annual Operation, Maintenance, & Repair				$ 450,000

TABLE NO. 19

Cost Estimate: Iroquois Channel Improvement

Lands and Damages	1460 ac.	@	$200	$ 292,000
Clearing	1000 ac.	@	$150	$ 150,000
Channel Excavation				
mi. 0.0—mi. 3.0	391,000 cy	@	$4.00	1,562,000
mi. 3.0—mi. 15.5	2,106,500 cy	@	$6.00	12,620,000
mi. 15.5—mi. 24.0	680,200 cy	@	$1.50	1,020,000
mi. 24.0—mi. 29.0	2,830,000 cy	@	$1.50	4,240,000
Bank Protection	11.5 mi.	@	$13,000	150,000
Highway Bridges	2	@	$55,000	110,000
Railroad Bridges	1	@	$162,000	162,000
Minor Drainage Outlets	120	@	$5,000	600,000
Major Drainage Outlets	8	@	$100,000	800,000
				$21,706,000
Engineering and Contingencies				6,505,000
Total Construction Cost				$28,211,000
Annual Operation, Maintenance, & Repair				$ 50,000

TABLE NO. 20

Annual Cost for Combined Projects

Amortization (50 years @ 5%—.05459)	$2,950,000
Operation, Maintenance, & Repair	500,000
Total Annual Cost	$3,450,000

TABLE NO. 21

Summary of Annual Benefits

	Iroquois	Kankakee	Total
Pleasure Boating	$1,642,000	$3,780,000	$5,422,000
Fish and Wildlife	146,000	600,000	746,000
General Recreation	250,000	1,000,000	1,250,000
Land Enhancement	25,000	71,000	96,000
Drainage & Flood Control	713,000	212,000	925,000
Total Benefits	$2,774,000	$5,663,000	$8,437,000

and $212,000 on the Kankakee. Annual project benefits are summarized in Table 21.

Value of the Recreation Plan

The previous discussion on outdoor recreation land needs in northeastern Illinois indicates a rapid increase due to population growth and increasing, individual participation rates. Land needs in the regional park category will approach 280,000 acres by the year 2020. Less than 60,000 acres are now available for public use in county forest preserve districts. The undeveloped potential for regional park lands in the six-county, Chicago Metropolitan Area is estimated to be 138,000 acres. If the development of 20,000 acres of submerged lands in Lake Michigan is included, the maximum potential would be on the order of 160,000 acres. Yet over 180,000 acres of land will be required by 1990 and 280,000 acres by 2020.

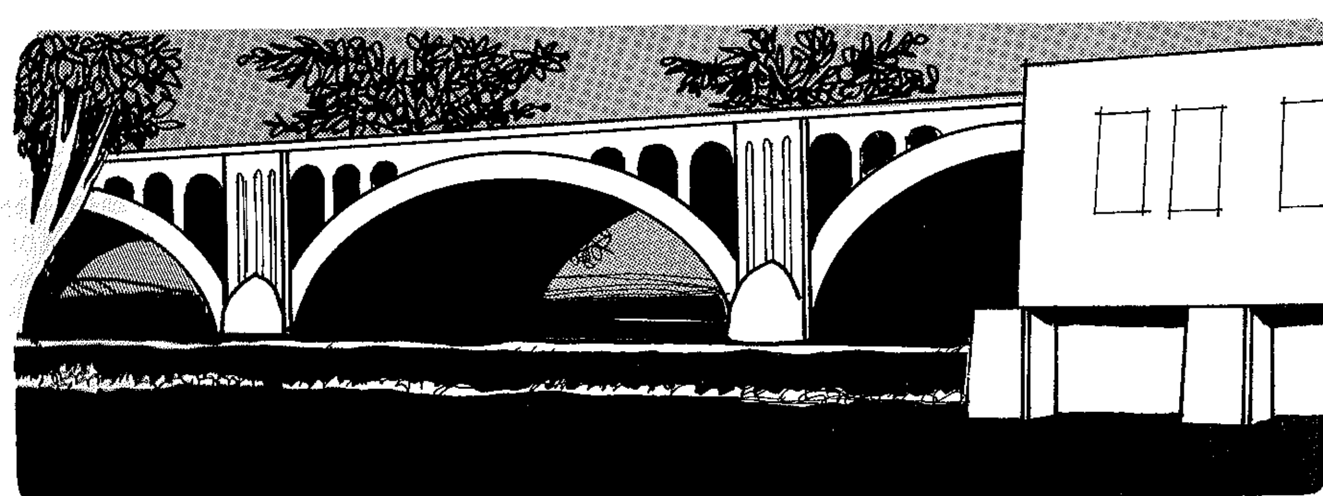
It is evident that 120,000 acres will have to acquired and developed beyond the six-county area. The major resource potentials proximate to the metropolitan area are found in southeastern Wisconsin and in the Kankakee Basin in Illinois and Indiana. Thus, meeting outdoor recreation requirements in the regional park category will require the maximum potential development of all resource areas within and near the Chicago Metropolitan Area: the valleys and flood plain lands of the Little Calumet River, the Chicago River, the Des Plaines River, the Du Page River, the Fox River, the Kankakee River, and their tributaries; the glacial lakes of northeastern Illinois, southeastern Wisconsin, and northern Indiana; the shore and submerged lands of Lake Michigan; abandoned strip-mines, gravel pits, and quarries; kettle moraines, sand dunes, and marshes; and forest lands.

Although a detailed inventory of recreation resources is beyond the scope of this study, it appears that at least 50,000 acres of suitable recreation lands can be found within the Kankakee Basin in Illinois. Large areas are also av_ilable in Indiana. Because of the increasing importance of water-based and water-oriented recreation in the spectrum of outdoor recreation, an objective of this study has been to evolve a plan for the maximum development of the Kankakee and Iroquois Rivers as a central core for a vast (50,000 acres) park system.

The opportunities for developing recreational waterways in Illinois are extremely limited.[5] They are always expensive. It is evident in this study that when the demand is great enough, the benefits derived from a recreational waterway may justify the expense. This is true for the Kankakee and Iroquois Rivers where the estimated benefits are $8,437,000 per year and the estimated costs are $3,450,000 per year. This is particularly fortunate, for the value of a 50,000 acre park system with a waterway will, undoubtedly, greatly exceed its value without the waterway.

[5] *op. cit.*, Ackermann

Thus, the plan proposed in this study will greatly augment opportunities for pleasure boating, sport fishing, and related water activities while providing a desirable setting for driving, riding, hiking, camping, picnicking, and hunting on the associated park lands.



water quality control

Water Pollution

A high standard of water quality is necessary or desirable for almost every beneficial use of water. Yet, almost every use of water alters its quality and tends to cause pollution. Water draining off agricultural land carries with it fertilizers, soil, herbicides, insecticides, barnyard wastes, and numerous forms of decaying animal and vegetable matter. Water draining off streets through storm sewers carries dirt, oil, trash, and decaying leaves. Water entering sanitary sewers from homes and businesses contains human feces, garbage, laundry wastes, floor washings, and a host of household chemicals. The water pollutants added by industries are as varied as the types of plants: ranging from highly toxic, heavy metals to highly organic wastes. Almost every form of natural and human activity causes water pollution.

Pollution arising from the life cycle of plants and animals in the natural environment or from soluble chemicals in soil and rocks is almost impossible to control. But, pollution arising from human activities—in home, farm, or industry—can be controlled. Wherever there is a concentration of human activity there will be a concentration of water pollution unless proper steps are taken to avoid it.

Population, industry, and agricultural production are going to grow in the Kankakee Basin *(INDUSTRY AND TRADE)*. Therefore, the quantity of pollutants entering water during beneficial use is going to increase. The concentration of pollutants is now and will continue to be the highest in the urban population centers such as Kankakee, Watseka, and Momence. Nevertheless, the problem will be important in all the cities, villages, and outlying industries.

If pollution of the ground and surface-water resources of the basin is to be prevented, the pollutants must be removed from water after beneficial use but *before* the water is returned to the streams and aquifers. This objective requires that all raw wastewaters be collected and given appropriate treatment.

Wastewater Treatment

Treatment plants combine mechanical, chemical, or biological processes in order to remove the pollutants. A treatment plant may be a simple home septic tank and tile field which combines a biological process with filtration. Or a plant may be a highly sophisticated chemical and mechanical process required to remove toxic chemicals from an industrial waste.

In cities and villages the wastewaters are generally collected in a sanitary sewer system and carried to a central treatment plant. Plants are designed basically for the removal of solids and bio-degradable wastes by a combination of mechanical and biological processes. These plants are usually incapable of handling toxic, caustic, or acid industrial wastes. Industrial wastes which contain these constituents or an unusually high concentration of bio-degradable material or solids should be given some form of pre-treatment before they are discharged into the sanitary sewers.

As long as a well-managed treatment plant is receiving the quantity and strength of wastewater for which it was designed, it can be expected to produce a high quality effluent. Unfortunately, the design conditions may not always be obtained. Changing conditions may arise from population growth so that the quantities of wastewater handled at the plant increase day by day. Or a plant may receive an unusually high strength waste from a seasonal type industry, such as a cannery. There is also the possibility of the accidental spillage of an acid, caustic, or toxic waste into the sewers which, upon arrival at the treatment plant, upsets the biological treatment process.

Successful pollution control through wastewater treatment depends not only on collecting and conducting wastes to properly designed treatment plants but also depends upon reasonable safeguards to insure that design conditions are not exceeded. Commonly used safeguards include: 1) pre-treatment of all wastes for which the central treatment plant is not designed,

2) a reasonable overload capacity in all treatment processes and equipment, 3) standby or emergency equipment at critical points in the system, 4) fines or scaled service charges to control accidental spillages and temporary system overloads, 5) timely planning and construction of treatment works expansions to meet growing loads, and 6) careful operation, maintenance, and surveillance of all parts of the collection and treatment systems. Thus, the owners of wastewater treatment systems—cities, villages, sanitary districts, industries, and others—must continually apply the best of technical, administrative, and managerial talents in order to insure that pollution control is achieved.

Treatment Plants

There are currently 18 important wastewater treatment plants in the Kankakee Basin (Illinois). (Figure 22) Of this total, 12 are municipal plants, 5 are industrial plants, and one is an institutional plant. Ten small plants serving schools, parks, motels, etc., are not shown on the figure. About 48% of the people in the basin and 88% of the people living in incorporated places are now served by treatment plants. The remaining population is served by individual farm and home septic tanks. Because of the continuing rural-to-urban population shift and because of the expected expansion of urban areas, it is estimated that over 92% of the people in the Kankakee Basin (Illinois) will be served by wastewater treatment plants in the year 2020.

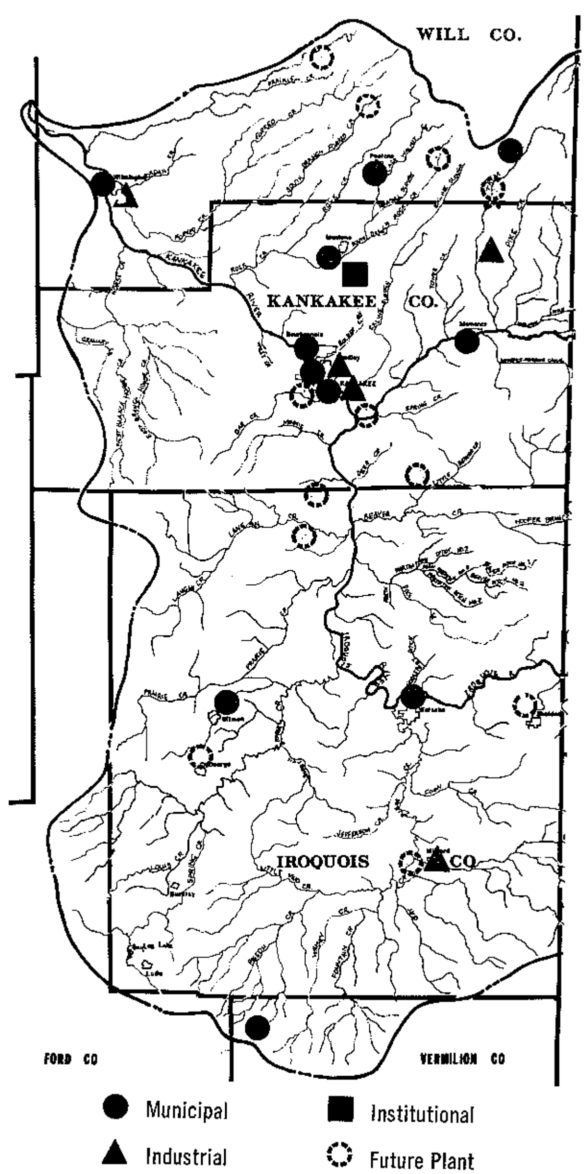
If adequate pre-treatment of industrial wastes can be assured in the future, then the problems of pollution control will center largely on the design and operation of the central, municipal treatment plants. As stated before, the basic function of the central treatment plant is to remove solids and bio-degradable matter from the incoming wastewater. Thus, the adequacy of these plants is best measured by their removal efficiency. No plants, currently available, can remove 100% of the solids and BOD (Biochemical Oxygen Demand). However, under ideal conditions the best plants available can consistently achieve a 95% removal efficiency.

The largest treatment plants are located at Kankakee, Manteno State Hospital, and Bradley. These plants serve a combined population of about 50,000, and the Kankakee plant receives an industrial load of 9200 P.E. (Population Equivalent = 0.17 lbs. BOD/day). By combining secondary treatment in activated sludge or trickling filter units with primary settling, these plants achieve removal efficiencies in excess of 85%. The waste load entering the Kankakee River from the Kankakee, Bradley, and Bourbonnais treatment plants and untreated waste from West Kankakee (4000 PE) were estimated to be 16,600 PE in 1966.

With the technology now available, secondary treatment plants using the trickling filter process can have removal efficiencies between 85 and 90%. Activated sludge plants can have removal efficiencies between 90 and and 95%. As new plants are built in the basin or existing plants are expanded and modified to accommodate growing population, these removal efficiencies can be expected to be achieved.

Since the best secondary treatment processes now available have removal efficiencies between 85 and 95%, it is clear that 5 to 15% of the BOD and solids arriving at the plant are eventually discharged into the receiving streams. Some of the solids will settle in the natural and artificial pools, and the organic matter continues to decompose in the stream and removes oxygen from the water in the process. Where the effluent discharge is not diluted by sufficient streamflow, the oxygen is depleted until fish are suffocated; and the waters become

FIG. 22
WASTEWATER TREATMENT PLANTS



septic. The design of an adequate treatment plant is therefore dependent on the quality of water to be achieved in the stream and on the amount of natural dilution water available.

Stream Quality Standards

The Illinois Sanitary Water Board has regulatory authority over all wastewater collection and treatment systems in the Kankakee Basin (Illinois). The board is charged by law with the duty of preventing pollution in all the waters of the State and can order any pollutors, whether they are individuals, municipalities, special districts, or industries, to construct adequate wastewater treatment facilities. Recent federal legislation requires each state to prepare and enforce stream quality standards in order to participate in the federal, state, and local cooperative pollution control program.

The stream quality standards adopted by the Sanitary Water Board are intended to maintain a reasonable standard of purity consistent with water use for domestic, industrial, fish and wildlife, and recreational purposes. The following requirements apply to the design and operation of treatment plants in the Kankakee Basin:

1. All new construction, major renovation, or expansion of sewage treatment works shall include as a minimum secondary treatment, with additional or tertiary treatment as stream conditions or usage may require.
2. All construction of new sewage treatment works shall include facilities for chlorination of the effluent. Effluents shall be chlorinated during the months of May to October as a minimum period, with continuous daily chlorination throughout the year where required by the Sanitary Water Board.
3. All existing sewage treatment works shall be provided with facilities for chlorination of the effluent, as treatment works are remodeled, improved, expanded, or as stream conditions and usage may require. Effluent shall be chlorinated during the months of May to October as a minimum period with continuous daily chlorination throughout the year where required by the Sanitary Water Board.

Additional criteria are necessary for the protection and maintenance of a well-balanced, warm-water, fish population. These criteria set limits on pH, temperature, and toxic substances and will require the minimum level of dissolved oxygen necessary for fish life—5 mg/l. Limits on coliform bacteria numbers in water used for recreation and municipal water supply will be achieved by disinfection of the treated effluents.

The stream quality criteria will require higher degrees of treatment at most treatment plants in the basin.

Controlling pollution in the small headwater tributaries will undoubtedly require tertiary treatment and will be costly and technically difficult. Nevertheless, achieving the stream quality standards will insure the maximum beneficial use of the waters in the basin for all of the people.

Attaining Stream Quality Standards

The alternatives in attaining stream quality standards are 1) adequate removal of pollutants by wastewater treatment or 2) adequate dilution of pollutants in a treated effluent by natural or augmented streamflow.

It was pointed out previously that the best treatment plants currently available can remove only 95% of the BOD in the wastewater. An intensive national research program is under way to evolve methods to increase removal efficiency. Most methods under study involve adding a third stage to the normal two-stage treatment process. The most promising of these third-stage or tertiary processes include 1) extensions of BOD reduction in polishing lagoons or extended aeration tanks, 2) removal of organic compounds in activated charcoal contact beds, 3) conversion of BOD and nutrients to algae in oxidation ponds, and 4) a variety of chemical and electro-chemical processes for removing suspended and dissolved solids.

Natural dilution water available during low flows is adequate at all points along the Kankakee River, Iroquois River, and Sugar Creek for the present and expected effluents from treatment plants if they are adequately treated and disinfected. However, natural dilution is insignificant in the tributaries and minor headwater streams north and east of the Kankakee River where most of the urban expansion is expected to occur. Opportunities to provide low-flow augmentation from impounding reservoirs on these headwater streams at a reasonable cost are non-existent. In these headwater areas, it is evident that the effluents will constitute the low flow and thus meet the stream quality criteria.

Allowable BOD Loading

The allowable BOD loading of receiving waters is determined by the stream quality criteria requiring a minimum dissolved oxygen (DO) concentration of 5.0 mg/l. Table 22 has been prepared from the general equations of self-purification of streams under two limiting initial conditions: 1) where the initial oxygen deficit is zero, and 2) where the initial oxygen deficit is equal to the critical deficit.

It should be noted that the lowest allowable BOD loading occurs at the somewhat rare combination of high temperature and low level of dissolved oxygen. As a general rule if the BOD loading is not greater than 10 mg/l, the DO level in the receiving water will be greater than 5.0 mg/l and never less than 3.0 mg/l.

TABLE NO. 22

Allowable BOD Loading of Receiving Waters

Self-purification constant, f = 3.0
Min. Dissolved Oxygen, DO = 5.0 mg/l

Temperature	DO Saturation	Critical Deficit	Allowable BOD Loading	
°C	mg/l	mg/l	Max. mg/l	Min. mg/l
0	14.6	9.6	50.0	28.8
10	11.3	6.3	32.8	18.9
20	9.2	4.2	21.8	12.6
30	7.6	2.6	13.5	7.8

TABLE NO. 23

Measured BOD in Receiving Waters, 1965

(In mg/l)

Station	Minimum	Average	Maximum
Wilmington	1.0	3.0	30.0
Momence	1.0	1.0	4.0
State Line (Kankakee)	1.0	2.0	4.0
Chebanse	1.0	2.0	6.0

This allowable loading meets the stream quality criteria for dissolved oxygen.

Allowances must be made for the natural BOD present in the receiving waters at the effluent outfall. Table 23 is a summary of measured BOD levels at several points in the basin as collected by the Illinois Sanitary Water Board. Making allowances for the effect of treatment plant effluents, it appears that the natural BOD of the basin averages 1-2 mg/l with a maximum of about 4 mg/l.

The following equations give the relationship between quantity of effluent, quality of dilution (natural or augmented), concentration of BOD in the effluent, percent of BOD removed in the treatment plant, and strength of wastewater entering the plant:

1) $D = 1/6\,(C_e - 10)E$ where

D = Natural or augmented dilution flow
E = Treated effluent flow
C_e = BOD in effluent in mg/l

and where 2) $C_e = C_i\,(1 - \eta)$ where

C_i = BOD in untreated wastewater
η = BOD removal efficiency of plant

It is obvious from equation (1) that the plant effluent cannot contain more than 10 mg/l of BOD where the natural dilution flow is zero. Thus, a typical municipal plant handling waste with a BOD of 200 mg/l would need to have a removal efficiency of 95%.

Unfortunately many municipal wastewaters run higher than 200 mg/l of BOD. The strength of wastewaters is expected to increase in the future due to growth in food processing industries and increased domestic pollution brought about by increased water use and new household appliances such as garbage disposal units. The strength of wastewaters reaching large municipal plants is expected to range from 250 to 275 mg/l of 5-day BOD. At smaller plants, BOD is expected to range from 195 to 210 mg/l. On occasion, peak loadings far in excess of these figures can be expected at all plants.

Stream Quality Achievement By Treatment

The most severe pollution control problems are expected to occur in the northeastern portions of the basin which will be developed as part of the Chicago Metropolitan urban fringe by the year 2020. In this area, the low flows in the receiving streams are essentially zero. Wastewaters will have to be treated so that the maximum BOD in the effluent does not exceed 10 mg/l. Wherever the strength of raw wastewaters exceeds 200 mg/l, treatment removal efficiencies will have to be greater than 95%. But 95% removal is the best that a modern activated sludge plant can achieve under favorable conditions.

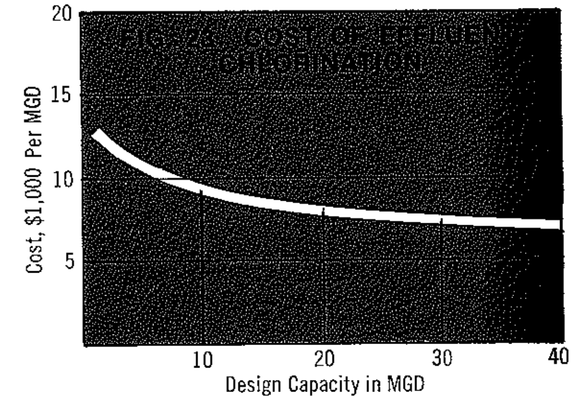
Tertiary treatment will be necessary where removal efficiencies greater than 95% are required. A treatment system which looks promising at this time consists of the following elements:

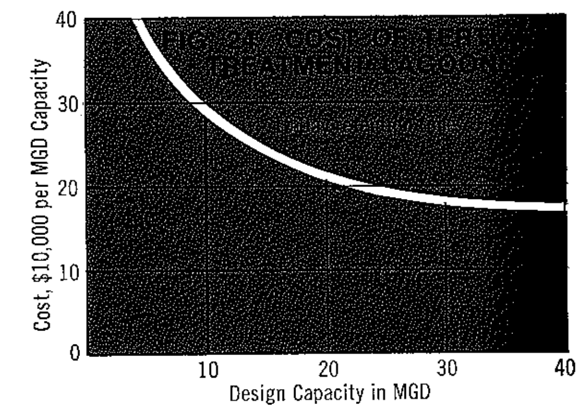
1. Modified activated sludge treatment with a nominal efficiency of 95%,
2. Tertiary polishing lagoons with a 10-day detention time,
3. Chlorination of the lagoon effluent.

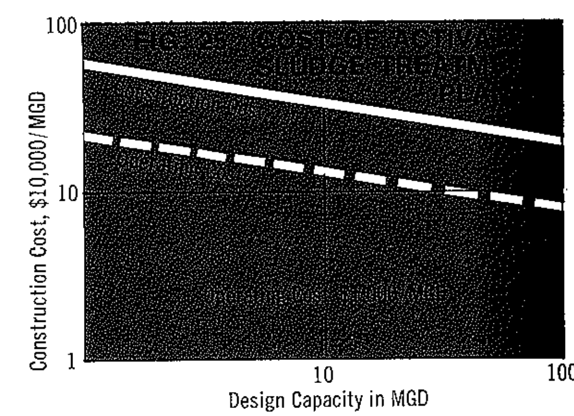
It is expected that this treatment system will achieve at least 97% removal efficiency by 1) equalizing the plant load, 2) additional solids removal, 3) additional BOD removal, and 4) chlorine BOD reduction.

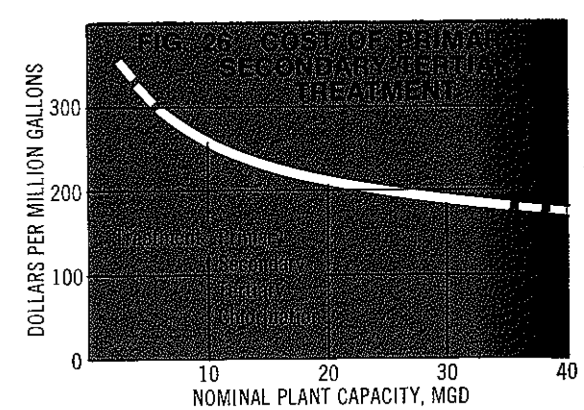
Estimated costs of wastewater treatment with these plants have been prepared using generalized cost statistics for unit processes and amortizing capital costs in 25 years at 5% interest. (Figures 23, 24, 25) Figure 26 shows the cost per million gallons of treating wastewater with the complete primary-secondary-tertiary-chlorination system. These data indicate that the unit costs decline substantially as the treatment plant capacity increases.

There are decided advantages in treating the wastewaters in the future Chicago Metropolitan fringe area in as few plants as possible. First, concentrating treatment in a few plants will take the greatest advantage of scale economies. Second, it is desirable that a minimum number of the tributary streams be used as receiving waters. Third, large treatment plants can be more readily designed to accommodate future expansion by unit increments. These advantages can be obtained by









preparing a comprehensive land-use plan; planning the location of treatment plants, interceptor sewers, lift stations, etc.; and creating one or more sanitary districts to implement the plans.

Other Problems in Water Quality Control

There is a valid question whether or not the proposed recreational waterway will provide the quantity and quality of water recreation assumed in its planning when questions of water quality are considered. (See WATER-ORIENTED RECREATION) The construction of slackwater dams on an open stream which carries pollution loads generally results in a poorer sports fishery than existed in the open stream. This is because the slowing of currents in the pool above a dam results in sedimentation of suspended matter in the water. Some of this suspended matter is bio-degradable waste which forms sludge deposits on the bottom. The anaerobic decomposition of bottom sludge deposits destroys the higher order of bottom dwelling organisms, such as mayfly nymphs. Silt and sludge deposits also destroy fish eggs, particularly when anaerobic decomposition is present. High degrees of wastewater treatment will minimize this problem but probably not eliminate it.

On the positive side, sedimentation of bio-degradable solids tends to improve water quality downstream in the succeeding pools. The worst situation is expected to occur in the pool above the proposed Dam No. 4. This pool, immediately below Kankakee, will receive wastewater effluents from most of the Kankakee urban area. Sports fisheries are expected to be poor. However, disinfection of these effluents with chlorine will insure a high enough water quality for pleasure boating, water skiing, and similar activities.

Water quality in the open-river section below Dam No. 4 and through the Palisades will be improved by previous sedimentation and stabilization. Sports fisheries are expected to be unaffected in this reach. The next pool, created by the proposed Dam No. 3, is simply a deepened version of the existing natural pool. Water quality will be good and fishing conditions should be unaffected.

The pool of proposed Dam No. 1 below Wilmington is also a deepened version of an existing pool. It will receive an additional load of bio-degradable solids from the Wilmington area. Due to the relatively small loads of solids, relatively shallow depths, and short length of the pool, only moderate sedimentation is expected to occur. Sport fisheries should be fair. Conditions in the remainder of the waterway, including the Iroquois branch, should remain essentially unchanged.

The waterway improvements will preserve the sports fishing in those reaches of the river where it is now best. The addition of tailwater fisheries at Dams 1, 3, and 4 will partially offset losses elsewhere. In those pools having the most deleterious effect on fisheries (No. 1 and No. 4), it would have been impossible to reduce the natural conflict between pleasure boating and fishing, so that fishing conditions would have been poor in any event. It is concluded that the quantity and quality of water recreation assumed in the analysis of the recreational waterway can be achieved.

Another problem which requires discussion is the proposal of the Metropolitan Sanitary District of Greater Chicago (MSD) for disposing of sludge from its treatment plants on lands in the Kankakee Basin. The proposal presently contemplates the collection of digested sludge from the district's West-Southwest and Calumet treatment plants, and pumping the sludge to the Kankakee Basin. Disposal would be accomplished by irrigation on strip mined lands in Will County (4000 acres); sandy soils in Custer, Salina, and Essex Townships (15,000 acres); and sandy soils in Pembroke Township (30,000 acres). The district expects that its sludge disposal costs would be reduced from $50 per ton to $15 per ton resulting in an annual cost savings of $9.5 million.

MSD intends to obtain a contract with the College of Agriculture of the University of Illinois to undertake a demonstration project on the agricultural and environmental changes resulting from the use of digested sludge on field crops. While the nutrient value of digested sludge is low, there is a distinct possibility that the addition of sludge to sandy soils of the Alvin, Hagener, Oquawka, Plainfield, and Woodland soils series would improve the soil condition, particularly the water-holding capacity. Other beneficial effects would be reduction in wind erodability and reduction in fertilizer requirements. The combined effects should increase crop yields and reduce planting costs.

The possibility of ground-water pollution must also be studied. In both the Essex and Pembroke areas, relatively shallow sands are underlain by highly fractured dolomites. In portions of the Essex area a highly porous bed of rubble lies between the fractured dolomites and the overlying sands. Any pollution which penetrates through the sand can be expected to travel great distances through the crevices in the bedrock. Both the sands and the underlying dolomite aquifer are used for domestic, farm, and municipal well supplies.

If MSD can establish that the chances of ground-water pollution are negligible and if it is established that sludge improves the condition of the sandy soils, then the proposal will be highly beneficial to the basin and the sanitary district. There would also be the opportunity for municipalities and sanitary districts in the basin to dispose of their sludge in this manner.

Plan for Water Quality Control

The control of water pollution in the Kankakee Basin will be achieved by improved wastewater treatment facilities. The addition of chlorination equipment at all treatment plants will greatly reduce the chances of waterborne infections and will insure a safe water for recreational use. No major technical or financial problems are anticipated in the provision of adequate treatment plants along the Kankakee River, Iroquois River, and Sugar Creek. Some form of tertiary treatment will be required at future treatment plants located on headwater tributaries. Where tertiary treatment is required, costs will be 30 to 50% higher than those for the normal secondary treatment process.

The problems of water quality control in the urban fringe areas can be best overcome by early planning of land use, plant locations, interceptor systems, and by the organization of one or more sanitary districts.

flood damage control

Origin of Flood Damages

Flood damages occur when floodwaters damage valuable property. There are two causes: one is natural, the floodwaters; and the other is artificial, the placement of damageable property in a floodprone environment. The essence of flood damage control is to alter one or both of the causes in order to reduce the resulting damages.

Flooding occurs in the natural floodway or flood plain of a stream. The floodway includes the natural low-water channel and that portion of the valley which is necessary to carry the floodwater discharge. The flood plain includes the floodway and all of the lands adjacent to the stream which are inundated by floodwaters. In mature stream valleys, such as the lower Illinois River, the flood plain is topographically defined by the valley walls (bluffs). But in youthful stream valleys, like those found in the Kankakee Basin, the flood plain has no topographical definition and instead consists of an irregular area beyond the banks of the streams.

On the larger streams in the basin, the Kankakee River, the Iroquois River, and Sugar Creek, the floodways include all of the lands between the high banks (valley walls). With few exceptions, all the bottomlands between the high banks are a necessary part of the floodways. Most of the tributaries of the previously mentioned streams did not have adequate channels or floodways in their natural state even for moderate discharges. Most of these have been widened and deepened by excavation to form drainage outlets.

The largest flood plain areas in the basin are located above and beyond the high banks of the streams wherever these banks are lower than the possible flood stages. This situation occurs in the ancient Lake Watseka area along the Iroquois River and Sugar Creek above Sugar Island, in the Kankakee Marsh area above Momence, and along most of the headwater streams and drainage ditches. The notable exception is found along the Kankakee River between Prairie Creek (6.5 miles above the mouth) and the mouth of the Iroquois (37.5 miles above the mouth) where the banks are higher than flood stage. The temporary storage of floodwater in these flood plain areas has a regulating effect which tends to reduce peak flood discharges.

Most of the damageable property in the Kankakee Basin is located in the flood plain beyond the floodway. However, roads, bridges, cabins, boat docks, and utility lines are often located in the floodway and are occasionally damaged. Flood damage control includes a wide range of alternatives and solutions which will reduce the damaging conflict between property and floodwaters. If no valuable property was located on a flood plain, there would be no flood damages. Or, if the behavior of a stream and its watershed during intense runoff periods was radically altered so that floods could be contained within the normal channel, there would be no flood damages. These two cases define the extremes between which practical solutions can be found. The actual choice of appropriate solutions and alternatives is controlled by public policy, economics, and the choice of an acceptable degree of risk.

Public Policy

The complex body of public policy on flood damage control can be roughly separated into three concepts: disaster, reclamation, and land-use management. In actual practice there are innumerable variations and combinations of these concepts. Nevertheless, the formulation of a flood damage control policy suited to each problem area in the Kankakee Basin can best be approached by understanding these concepts in their simplest form.

Disaster Concept This concept is most clearly stated in the Federal Flood Control Act of 1936 and in the Illinois Flood Control Act of 1945. The verbiage in the Illinois Act is representative of both and reads as follows:

> *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; . . . constitutes a menace to the general welfare of the people of Illinois; . . . that the State of Illinois should improve or participate in the improvement of the rivers and water, including the watersheds thereof, for the purpose of regulating the flood [flows] . . . if the benefits are in excess of the estimated costs and if the general welfare of the People of Illinois are adversely affected.

The intent in the acts is to establish a public responsibility in flood damage control where damages have assumed a disastrous level on existing developments and have adversely affected the general welfare.

The concept is economically sound where: 1) the benefits exceed the costs, 2) the beneficiaries bear an adequate share of the costs, and 3) new flood plain occupancy is not induced beyond the area of protection. Above all, there must be an adverse effect on the general welfare, for this is the origin of the public responsibility. For example, flood protection of flood plain areas which are presently waste lands cannot be considered a public responsibility.

The disaster concept has been frequently applied to urban areas on the flood plains of large rivers, such as East St. Louis, Cairo, or Beardstown. Flood damage control is usually accomplished by structural measures: levees, floodwalls, channel improvements, or flood control reservoirs. In many cases this policy has been inapplicable because it did not meet the economic criteria or the disaster criteria (general welfare). In many more cases the policy has led to new flood damages where the economic efficiency criteria in 1) and 2) above have not been met.

To the extent that new flood plain occupance is subsidized by indemnities or protection at less than cost, greater use of flood plains is encouraged than is warranted by the economies of flood plain location. The effect of subsidy is to start a round of unwarranted investment. Damage potential is needlessly increased. Unnecessary losses accumulate. Then, if the development is to be salvaged, further subsidy is required.[1]

The general public, by bearing all or a major part of the cost of flood protection works and lessening the individuals' damage costs, further subsidizes their use of the flood plain. Principles of economic efficiency and social equity are thereby violated.[2]

[2]*ibid.* Page 15.
[1]Task Force on Federal Flood Control Policy, *A Unified National Program for Managing Flood Losses*, House Document No. 465, 89th Congress, 2nd Session, 1966, Page 16.

Reclamation Concept This concept is best illustrated by the laws and policies pertaining to drainage and levee districts, surface water protection districts (See Illinois Drainage Code, Chapter 42, *Illinois Revised Statutes*), and the local improvement powers given to counties and municipalities. These acts provide the legal power and mechanism for a group of landowners to improve the value of their property by providing improved drainage or protecting the land from overflow. All these works are financed by special assessments on the properties benefited with the proviso that the increase in property value (benefits) must exceed costs.

The reclamation concept has been widely applied throughout Illinois in the improvement of land drainage and the construction of levees in flood plains. The numerous and large drainage projects in the Kankakee Basin have carried over secondary benefits to the general economy. This is precisely why the laws were enacted. The public's contribution to reclamation includes the legal mechanism, special assessment taxing powers, eminent domain powers, and the use of the court system. Occasionally, public roads, buildings, or other properties are directly benefited, and the government pays a proportionate share called the "public benefit."

The reclamation concept breaks down as a useful policy wherever a significant part of the direct benefits attach to persons or properties which cannot be assessed. It also fails if the tangible, direct benefits cannot be proven to exceed the costs. Public benefits, which can be large, cannot be assessed against the State without the authorization of the legislature. Therefore, the reclamation concept works best where a group of landowners having a common problem which has a common solution can agree that the benefits exceed the costs and are willing to levy the assessments.

Land-Use Management Concept This concept minimizes flood damages by restricting, controlling, prohibiting, or prescribing certain types of land use. The legal basis of this concept arises from zoning and building code authority given to counties and municipalities in Illinois. Public land acquisition is another dimension of land-use management; and legal authority for it is given to counties, municipalities, numerous special districts, and several state agencies.

In practice, land-use management is accomplished as a part of a comprehensive zoning plan backed up by subdivision ordinances, building code provisions, and public open-space plans. The objective is to zone and regulate construction on each parcel of flood plain land so that the maximum beneficial use can be obtained while the resulting flood damages or associated development costs are minimized. Public land acquisition is often used as an added device in urban areas.

Land-use management works well only if it is implemented before flood plain lands are developed. It is not a solution to damages incurred by the existing "non-conforming" uses. Other pitfalls arise from 1) overzoning, 2) unreasonable restrictions, 3) faulty definition of flood plain lands, and 4) lack of enforcement. Fortunately, all the pitfalls can be avoided by careful planning and using the combined talents of the city planning, engineering, and legal professions.

Flooding and Damages

Although a detailed inventory has not been made, it appears that over 10% of the lands in the Kankakee Basin are subject to flooding. About 2 to 2.5% of the lands are so frequently flooded as to have formed bottomland soil types. This 2 to 2.5% of the land constitutes the floodways of the larger streams where very little damage property is located.

The average annual damages in known damage areas along the Kankakee, Iroquois, and Sugar Creek are about $500,000. Damages along the numerous tributaries are not known; but judging from the quantity of lands involved, they can be expected to be another $500,000. About two-thirds of the floodable lands are cropland and the remainder is pasture, woods, and waste lands. A very small fraction of floodable lands occurs in built-up urban areas (mainly at Watseka), but the damages are quite high.

Floodable Areas Most of the flooding along the mainstem of the Kankakee River occurs from the rock ledge at Momence to the State Line. Here, about 7100 acres of land are subject to frequent flooding in the Momence-Yellowhead Drainage District (7800 acres) and the Momence-Pembroke Drainage District (11,400 acres). Another 9300 acres of land in these districts suffer blocked drainage from high outlet stages.

There are numerous cabins, cottages, and camps along the river between Momence and the State Line. Most of these structures are located on low, sand hills which border the river and are above high water. Only a few of these structures are occupied continuously. The major problem occurs when the local rural roads are flooded and access to or from these areas is prevented.

Between Momence and Kankakee the overflow areas are not very extensive but occur mainly along the north side of the river where the bank is quite low. Highwater in this reach causes backwater in Spring Creek and obstructs drainage in the Spring Creek and North Wichert Drainage Districts. So far (1967) very few buildings have been located on the flood plain. Most of the new construction is occurring between Kankakee and Aroma Park and, if uncontrolled, could result in heavy flood damages.

Below Kankakee the river is moderately deeply entrenched and the area of overbank flooding is narrow. There are very few buildings or structures within the flood plain in this reach and the steep slopes are largely in pasture or timber. No significant flood damages are known to occur.

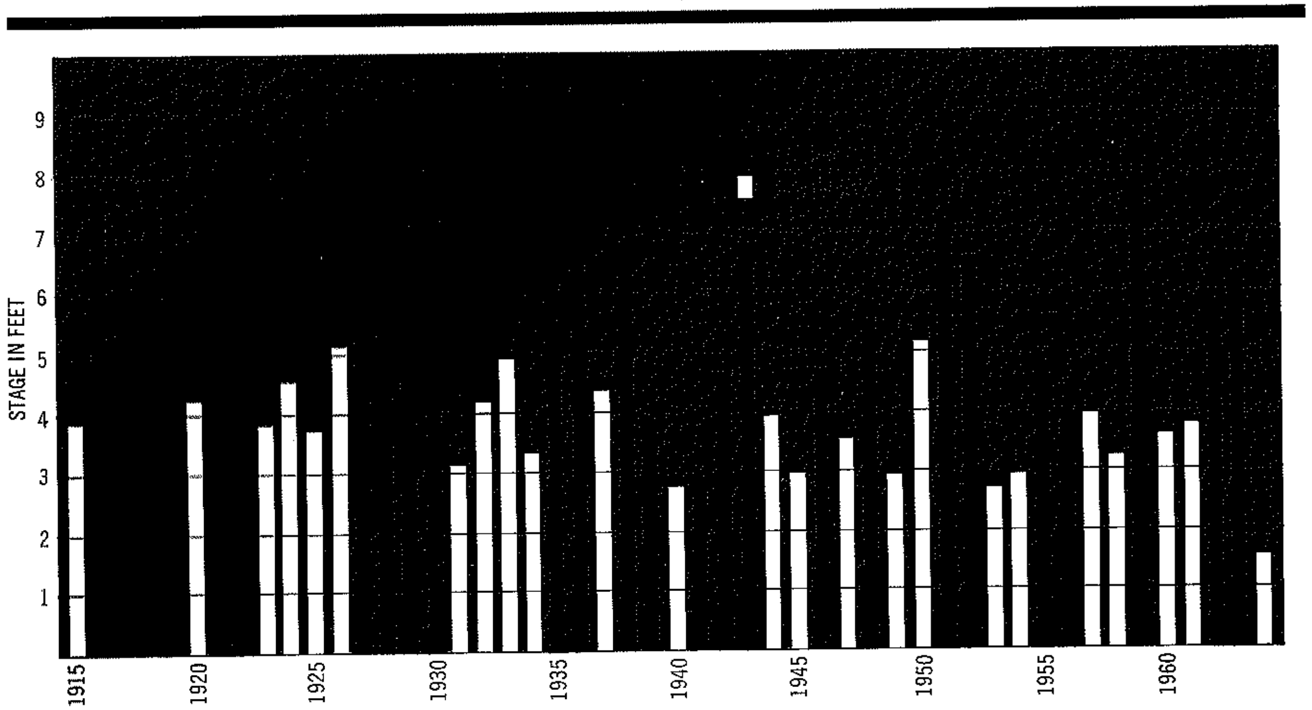
The single, most important area of flooding on the Iroquois occurs between Sugar Island and Watseka in the ancient Lake Watseka area. Here about 50,000 acres of land are subject to flooding and another 100,000 acres suffer blocked drainage as a result of high water. This area is predominantly cropland with a small amount of timber and pasture along the valley. Flood damages have been severe in Watseka, and the city has been virtually isolated by flooding of highways and railroads on three sides along the Iroquois River and Sugar Creek.

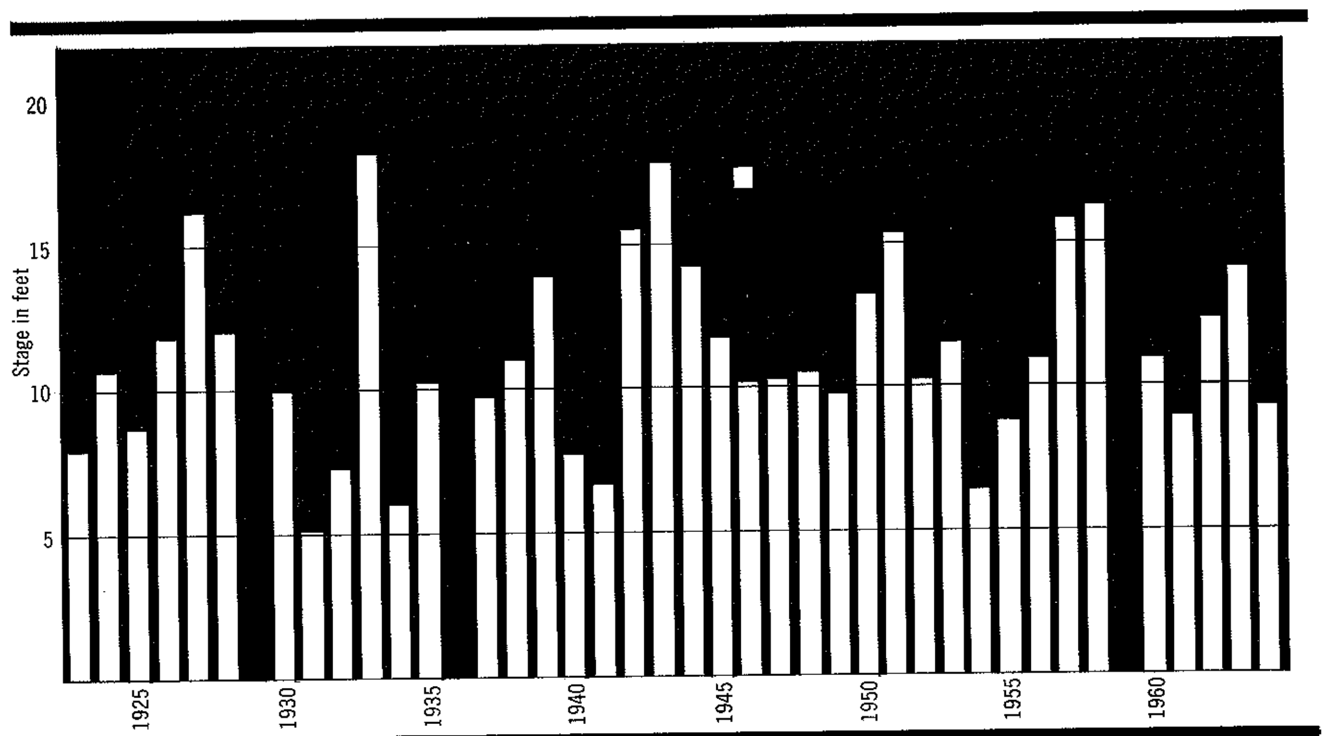
Occasional flooding affects another 55,000 acres of lands along the numerous tributaries of the Iroquois River and Sugar Creek. Fortunately, this flooding occurs on agricultural lands and is usually of short duration so that heavy crop damages do not occur.

Types of Flooding Flooding is always the result of high stages, i.e., high water, but these stages may be caused by high discharges or the damming effect of an ice jam or debris jam. Occasionally high discharges are further complicated by jams so that the resulting stages are very high. High discharges are caused by the natural response of the watershed to runoff caused by rainfall, snowmelt, or both. The magnitude and frequency of high discharges can be conveniently expressed by the annual maximum flood frequency relation such as given in Table 7, HYDROLOGIC DATA. The appropriate discharge for any given probability can be found in the table and converted to a flood stage from the stage-discharge relation for the gaging station. A stage-frequency relation could be constructed for any station in this manner if the chance of high stage caused by ice jams was very small.

High stages are frequently caused by ice jams at several locations in the Kankakee Basin. Because these stages occur in the winter, they do not cause significant crop damages. In urban areas, however, the ice stage causes about the same damages as a high-water stage caused by discharge. Winter flooding of homes and businesses, which causes heating plant failures, is particularly damaging and inconvenient.

Figures 27A through 27F show all the recorded annual peak stages at the primary gaging stations in the basin and whether they were caused by ice jams or by high discharges. It can be readily seen that ice jams are a major cause of peak stages at Momence and Wilmington while they are a relatively minor cause at Chebanse, Iroquois, Milford, and Custer Park.

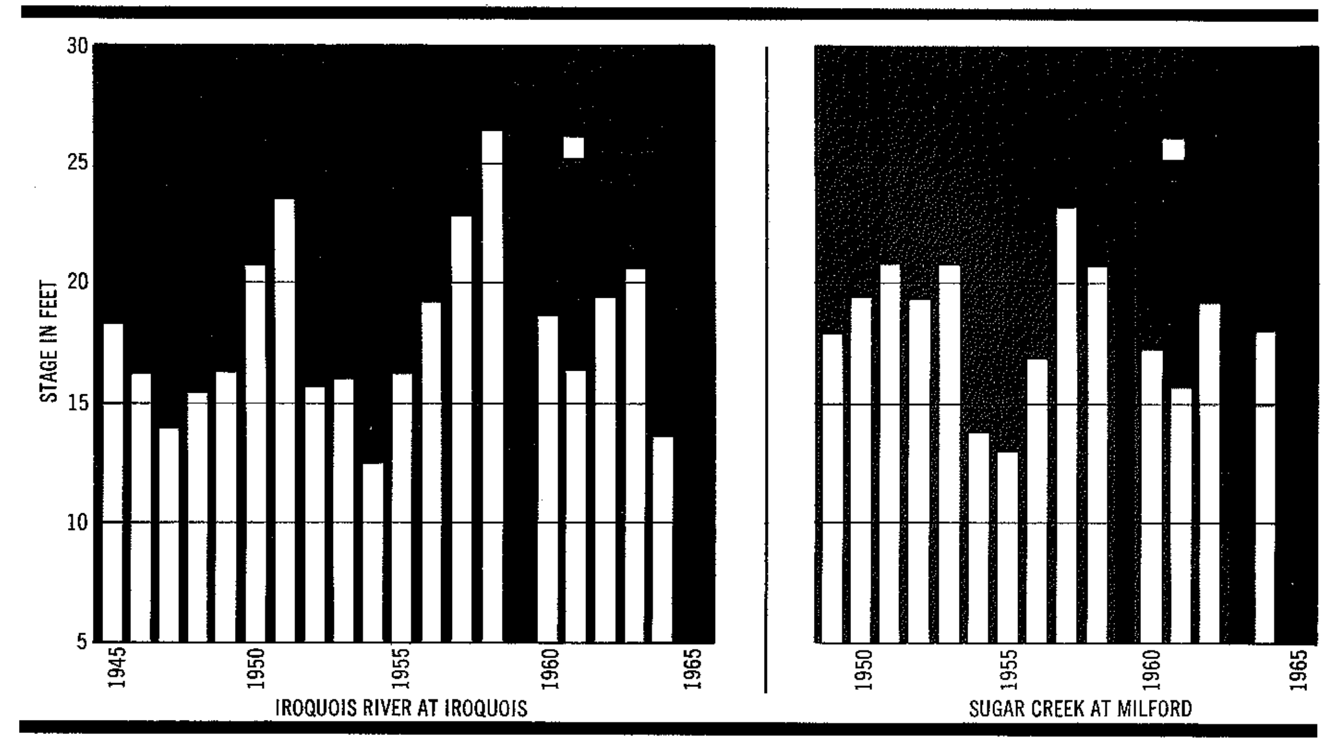


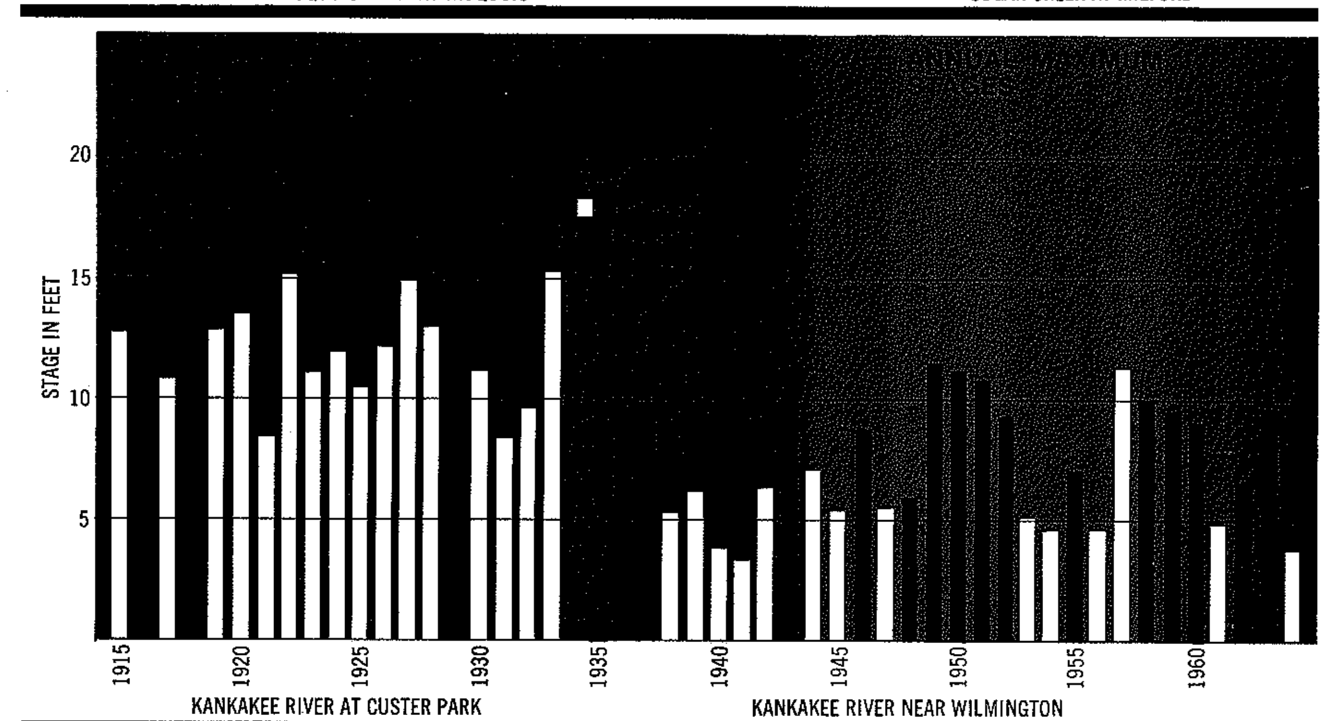


Ice jams occur most frequently at those points on the stream where a relatively steep reach discharges into a flat pool. Nevertheless an ice jam with a stage on the order of the maximum recorded can reasonably be expected to occur at any point on all the streams.

Ice stages of 8 to 12 feet above low water can be expected on the Kankakee River from the head of Dresden Island Pool to the Kankakee Dam. Stages 4 to 8 feet above low water can be expected between Kankakee and the State Line. Ice stages on the Iroquois River can be expected to vary from 18 feet above low water at Sugar Island on the Iroquois to 24 feet at Iroquois and Milford.

At many locations in the Kankakee Basin, the drainage divides are so poorly defined that excessive flows in one watershed may cross the divide and flow into another stream. Damages are caused by the overland flow. This problem has been largely corrected in the upland





areas of the basin by the construction of drainage outlet ditches. The problem of overland flow still occurs in the Momence-Yellowhead and Momence-Pembroke districts. Here, depending on water stages, water flows across the State Line from Indiana at numerous points, flows laterally across the districts to the Kankakee River, or flows from the Kankakee River into the districts and then back to the river via the Yellowhead-Singleton Ditch or the Momence-Pembroke Ditch.

Flood Damages Flood damages are generally classified as urban, agriculture, transportation, and utilities. Utilities in the latter classification do not include distribution and collection systems in urban areas but do include gas, power, and telephone transmission lines, power plants, substations, water treatment plants, wastewater treatment plants, and the like. Urban flood damages include damages on all the typical land uses: residential, commercial, industrial,

53

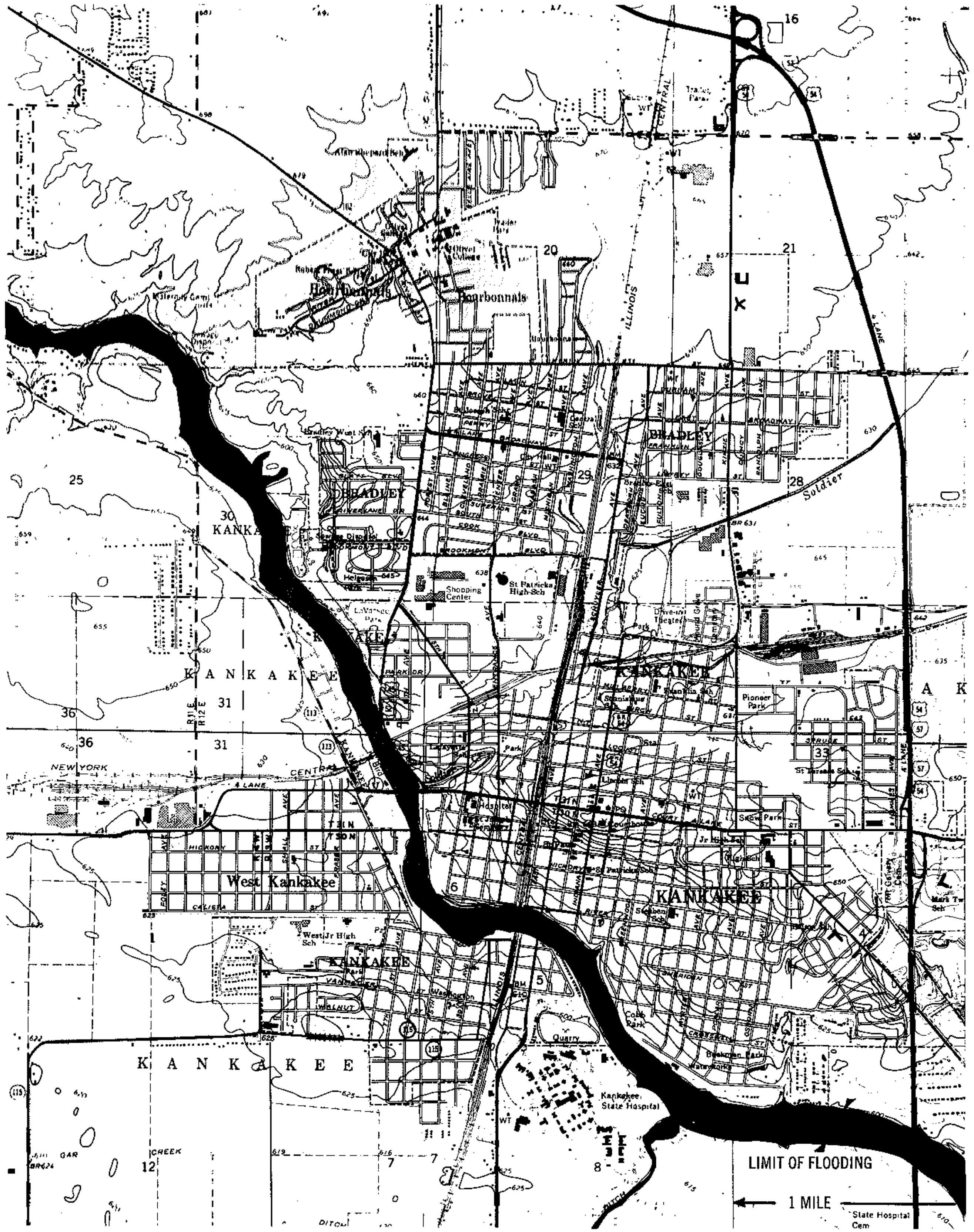


FIG. 28 FLOODING NEAR KANKAKEE

54

FIG. 29 FLOODING NEAR AROMA PARK

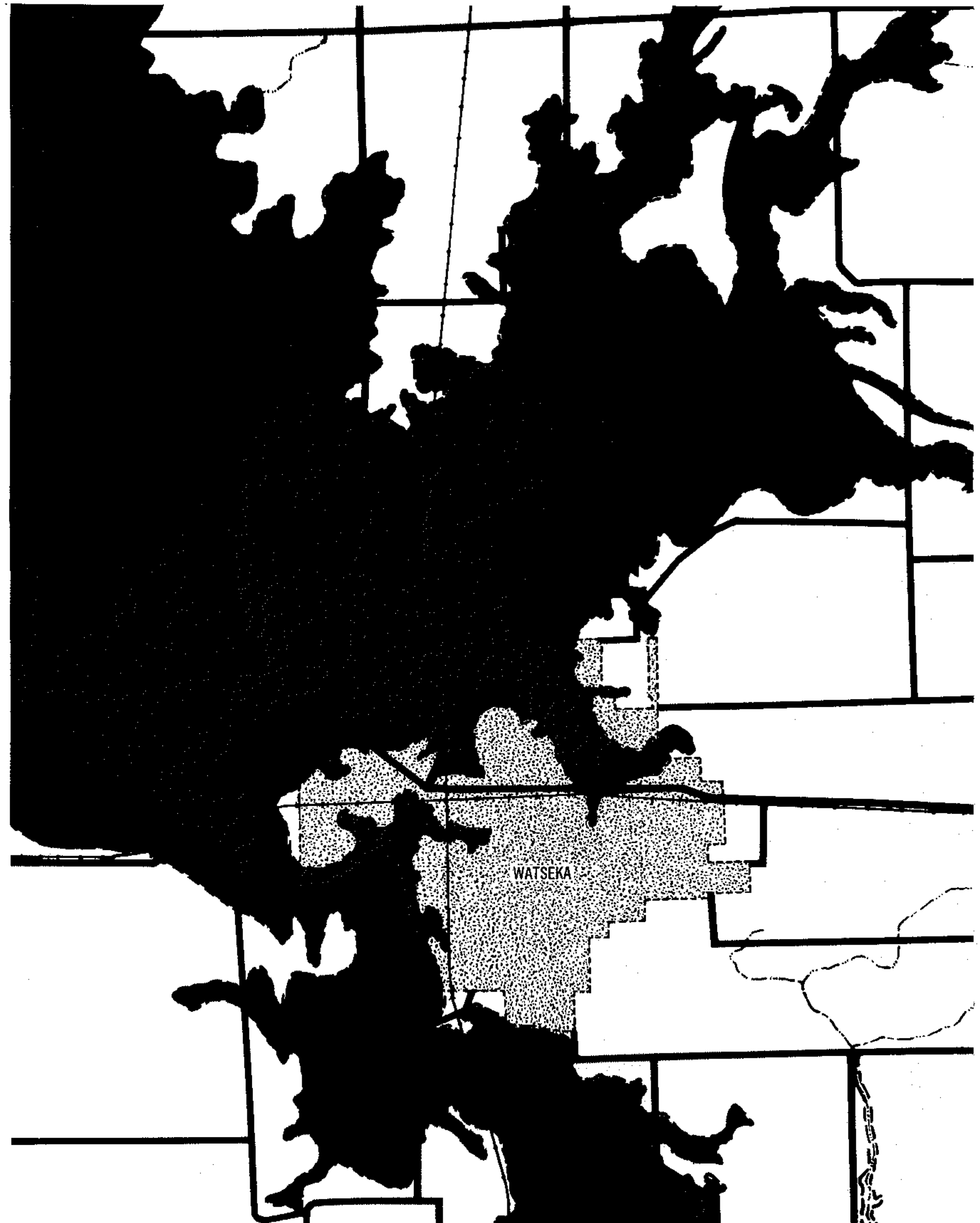


FIG. 30 FLOODING NEAR WATSEKA

institutional, and public. Agricultural damages include losses in growing crops, livestock, stored grain, feed, fertilizer, and damages to buildings, machinery, fences, drainage systems, water supplies, and soil. Transportation damages include traffic losses and damages to structures and equipment.

At this time (1967) urban flood damages are mainly confined to Watseka. Very little encroachment has occurred on the flood plain at Kankakee, Wilmington, Momence, or Milford. Figure 28 shows the floodable area in the vicinity of Kankakee. It can be readily seen that very little flooding occurs on damageable property. A serious local flooding problem existed along Soldier Creek (flooded area not shown), but this has been largely corrected by channel improvements.

Figure 29 shows the floodable area upstream from Kankakee in the vicinity of Aroma Park. Riverfront lots are being subdivided and developed in this area. It is apparent from the map that a conscious effort has been made in some subdivisions to keep buildings above high water. While in other subdivisions, the floodable lands have been carelessly built upon. The origin of urban flood damages can be clearly seen on this map—careless encroachment of buildings into the flood plain. There have undoubtedly been many more encroachments since the base map was made (1960).

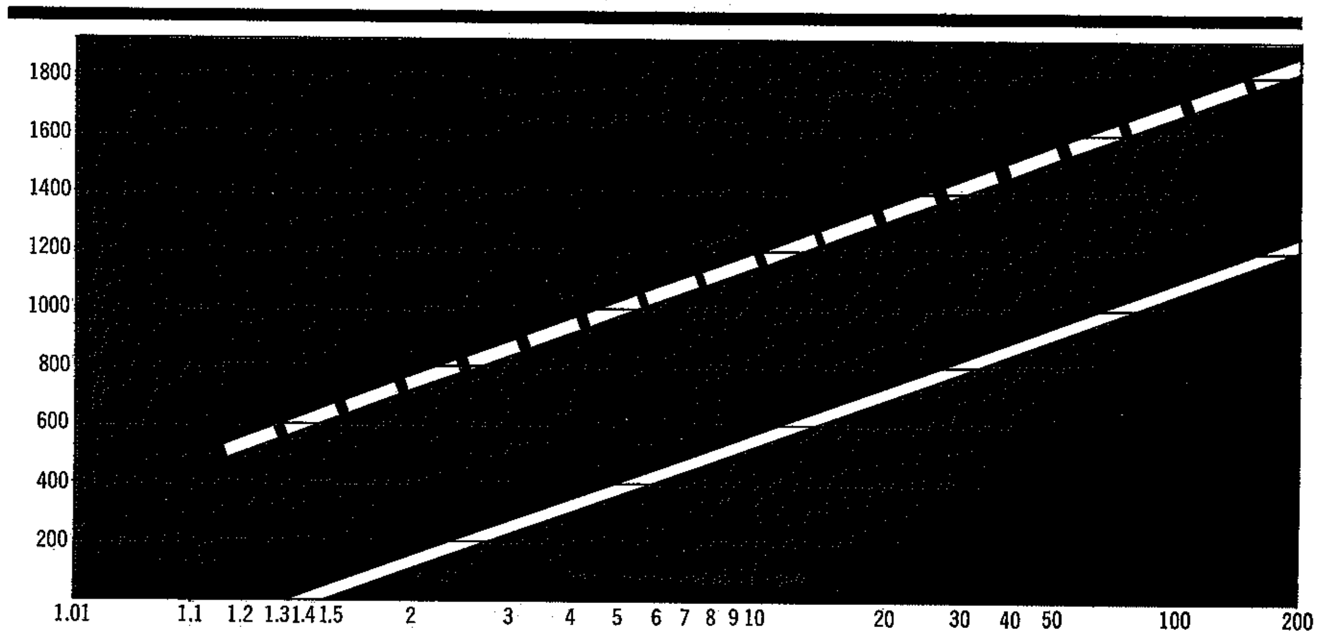
The growing urban fringe of communities in the basin, such as the Aroma Park area, present a serious threat for increasing future flood damages. It is unfortunate but true that there is no practical solution for reducing flood damages on these properties once they have been built upon. In rare instances, it may be economical for an owner to have his building raised or floodproofed, but the cost is usually excessive.

Figure 30 shows the floodable area in the vicinity of Watseka. Considerable development has occurred in the flood plain on the north and southwest sides. Flooding of these areas is not frequent, but when it occurs, it attains disaster proportions. Future building in these areas will only intensify the flood damage problem. It appears possible to protect the damageable areas by a levee, and the proposal will be discussed subsequently.

The efforts to prevent new, future flood damages will have to be concentrated in the urban fringe areas surrounding the communities in the basin and in the Chicago Metropolitan urban fringe which will be well within the basin by the year 2020. The Chicago Metropolitan urban fringe will be a moderately dense suburban type development located roughly between the basin divide in Will County and a line defined by the villages of Manhattan, Peotone, and Grant Park. It is also expected that bands of denser developments will extend southward along Route 54 and Interstate 57 between Peotone and Bradley and along Route 1 between Grant Park and Momence.

This sector of future urban growth lies in the watersheds of Prairie Creek, Forked Creek, Black Walnut Creek, Rock Creek, Exline Slough, Trim Creek, and Pike Creek. The streams presently cause flooding on about 10% of the land area. Urbanization will greatly increase the frequency of flooding on all the affected streams. The increased flooding is due to increased runoff from impervious areas, decreased storage from land grading and drainage, and decreased concentration times due to storm sewers.

Figure 31 shows the present flood frequency curve for the watershed above the gaging station on Prairie Creek



near Frankfort. A second curve on the figure shows the flood frequency relation which would result after complete urbanization. The effect of urbanization can be readily seen. For example, a discharge of 740 cfs has a 4.35% probability of occurring in any year under present conditions. After urbanization this discharge will have a 50% probability, i.e., it will occur on the average every other year. The interpretation that must be made is that urbanization will cause dramatic changes in the runoff response of watersheds resulting in: 1) higher and more frequent flood stages, 2) inadequate bridge and culvert openings, 3) more severe demands on channel and floodway capacities, and 4) increasing flood damages unless proper steps are taken to avoid them.

Transportation and utility systems must unavoidably cross flood plains in order to serve the needs of the people. But, because the public demands a high quality and reliable service, these systems are generally designed to be floodproof where needed. Many rural roads, however, are frequently blocked by high water throughout the basin. These traffic interruptions isolate farms and occasionally towns. The transportation damages in the Kankakee Basin average about $20,000 annually. No major flood damages are known to occur to power lines, telephone lines, or plants and equipment.

Flood damages on agricultural lands currently account for the greater portion of the flood damages in the basin. Most of these agricultural damages are from reduced crop yields which result from delayed planting or direct water damage. In many cases the flooding is complicated by poor drainage which results in even greater damages. Short term flooding of field crops followed by rapid soil drainage generally does not significantly reduce yields except when plants are very young or are ready to harvest.

Flood durations commonly exceed 30 days on the Kankakee above Momence and are very damaging. Flood duration is usually less on the Iroquois between Sugar Island and Watseka. The floods experienced on the numerous tributaries are seldom of long enough duration to cause significant damages.

Even moderate flood stages on the Kankakee above Momence and the Iroquois above Sugar Island cause blocked drainage for many days. This poor drainage often results in crop damages as high as that experienced by prolonged overbank flooding.

Developing A Flood Damage Control Policy

A flood damage control policy for the Kankakee Basin must minimize the effects of flood damages on the present and future economy to the maximum extent allowed by wise land use and economic efficiency. Because the types of flooding and the land uses which are affected vary greatly throughout the basin, it is necessary to formulate a broad and comprehensive policy which is suited for each individual situation.

All of the flood damage control concepts will be needed, and each must be used where it is most applicable. The general applicability is as follows:

1. *Urban Areas with Few Flood Damages*—zoning and building codes supplemented by public land acquisition to eventually reduce existing damages and prevent future damages.
2. *Urban Areas with Major Flood Problems*—structural measures to reduce flooding supplemented by zoning, building codes, and land acquisition to prevent future damages.
3. *Future Urban Areas (Urban Fringe)*—the full spectrum of land-use management including land-use planning, zoning, building codes, and public land acquisition. Reclamation may be economically attractive where flood depths are small.
4. *Transportation and Utilities*—careful location or floodproofing of all primary elements and floodproofing of all secondary systems wherever economical.
5. *Agricultural Lands*—reclamation of lands wherever economical, but farmsteads, buildings, granaries, etc., should be located in flood-free locations.
6. *Recreational Lands*—to the maximum extent possible all floodable lands suitable for recreation should be incorporated into public or private holdings by acquisition or by zoning.

Land-Use Management Concept Land-use management concepts are applicable to all parts of the basin to varying degrees but are most applicable to the yet undeveloped urban fringe areas. The reasons behind land-use management are as follows:

1. Occupancy of floodable lands is seldom economically justified when all the costs (reclamation, damages, disaster relief, etc.) are included and suitable flood-free lands are available.
2. The proportion of floodable lands, about 10%, is not greater than the amount of public and private open space ordinarily required in urban areas.
3. The frequency of flooding can be expected to increase greatly as watersheds are urbanized thus increasing the risks of flooding on properties located in flood plains.
4. Construction, operation, and maintenance costs of public works such as highways, streets, sewers, water systems, storm drainage systems, and also public utilities are much greater for equal service in flood plain areas.
5. Protection of public health and safety require that many uses be prohibited in flood plains and that many more be avoided if possible.

TABLE NO. 24

Permitted Use of Flood Plain Lands In a County Zoning Ordinance

Agriculture
Amphitheater
Arboretum or Botanical Garden
Archery Range
Automobile Parking Lot
Boat Building and Repair
Boat House
Boat Launching Ramp
Boat Rental
Boat Sales
Bulk Materials Storage[1]
Camp, Commercial Recreational
Camp, Day
Camp, Military
Club, Outdoor Recreational
Conservation Club
Country Club
Drive-in-Theater (c)
Extraction of Earth Products (c)
Flower Farm
Game Animal Farm
Golf Course
Golf Driving Range
Grass or Sod Farm
Heliport (c)
Junk Yard
Machinery Storage Yard
Marina
Mink, Fur-bearing Animal Ranch
Mushroom Production
Nursery, Tree or Shrub
Orchard
Park, Commercial Recreational
Park, Public Recreational
Picnic Grove
Piggery
Playground
Public Open Land
Trampoline Center
Truck Farm
Utility Installation (c)

[1]Except flammable liquids or materials which may float.
(c): Conditional Use Permit required.

Zoning is the principal tool for implementing a land-use plan. The first decision in zoning is what uses will be permitted and what uses will be prohibited. Table 24 shows the permitted uses of flood plain lands in one county zoning ordinance in Illinois. In this ordinance there is not a special "flood plain district"; instead the permitted uses must be allowable within the regular zoning district: AG, E, SE, SR, UR-1, UR-2, etc.* Furthermore, the principal building on each tract must be located above the "flood base elevation," i.e., out of the flood plain. It is evident in Table 24 that the permitted uses tend strongly toward agriculture and recreation.

*Typical Zoning Districts

AG	Agricultural	CB	Community Business
E	Estate	HC	Highway Commercial
SE	Suburban Estate	CR	Commercial Recreation
SR	Suburban Residential	CS	Commercial Service
UR-1	Urban Residential	OR	Office and Research
UR-2	Urban Residential	LI	Limited Industrial
UR-3	Urban Residential	GI	General Industrial
RR	Resort Residential	II	Intensive Industrial

The zoning districts must be supplemented by additional provisions which specify the grade of streets, basements, sewers, and other utility lines with respect to the high-water elevation. Flexibility can be obtained by allowing floodproofing, e.g., a basement floor may be below the flood elevation if the walls are designed for the hydrostatic pressure, the lowest opening (windows or doors) is above high water, and a sump pump and force main are connected to the sanitary sewer.

It can be assumed that most future land developments will take place within subdivisions, consequently special care should be taken in drawing subdivision ordinances so that the desirable result is or can be obtained. The first principle is that tracts containing a portion of flood plain lands should be able to be subdivided and developed on a parity with similar subdivisions on non-flooded tracts. The corollaries are that:

1. The subdivider should not be required to dedicate a greater proportion of open space (measured by value) than would be required in similar subdivisions.
2. While it is desirable that lot sizes should be large enough to provide a non-flooded building space, they should not be so large that they are unsalable.
3. Land grading and/or filling to improve lots should be allowed as an alternative, but in no case should fills be allowed to encroach on floodways.

The second principle is that the integrity of the drainage channels and floodways must be maintained with suitable allowances for increased flooding from urbanization. This is usually accomplished by requiring dedication of the channels and floodways which must then be incorporated in the regular maintenance program of the county or municipality. Occasionally, developers desire to convert minor surface drainage courses to covered storm drains in order to increase the amount of usable land. This alternative should be allowed only if the conduit is designed to handle flood discharges based on complete urbanization of the upstream watershed with a hydraulic grade line no higher than the originally specified flood base elevation.

The third principle is that flood plain lands should be allowed to be counted as part of the required open space without any discounting. Wherever the flood plain area is so great that it is impractical to provide the open space on a lot by lot basis, several alternatives should be allowed, such as:

1. A planned urban development where a complex of buildings—duplexes, townhouses, apartments, etc.,—are located on the flood-free portion of the tract and the flood plain area is used as common open space.
2. A more flexible allowance on lot dimensions, so that lot widths can be decreased and depth increased in order to provide a flood-free building site.
3. Where the flood plain area is larger than the required open space, the excess should be acquired by purchase for park purposes or other public open space.

Where the last condition cannot be fulfilled because the local government does not believe there is a need for the public open space or is unwilling to spend the money, then the zoning classification must be revised for it has created an impossible situation. Thus, the open space requirements of the district must be upgraded by shifting from UR-2 to UR-1 or UR-1 to SR or SR to SE or a complete change in concept to CR or AG until a workable result is obtained.

It can be concluded from the previous discussion that flood damage control through land-use management is a practical concept if all the available tools are applied with reason and flexibility. With adequate information on land capability, flood hazards, population trends, economic trends, etc., the local planning agency can prepare a comprehensive land-use plan which will satisfy the requirements of population and industry while avoiding the disastrous effect of flood damages.

Reclamation Concept The reclamation concept is particularly applicable to the agricultural lands in the basin but it may have application in urban land development. The principles are the same for both urban and rural lands and require that:

1. A group of contiguous land tracts must have a flood problem arising from the same source (say overflow from a stream).
2. There must be a suitable solution to the problem (say a levee).
3. The benefits must exceed the costs.
4. There must be a general consensus of the landowners in favor of the project.
5. All the beneficiaries must be willing to pay a fair share of the costs.

Reclamation improvements have been used frequently and successfully wherever the above conditions could be met. The concept weakens when the improvements must be located or extend beyond the benefited lands. The concept is also weakened when additional lands may be benefited by the improvement, but the landowners show no interest in the benefits and are unwilling to be assessed. Special assessment projects are greatly weakened when beneficiaries can, for one reason or another, choose not to pay assessments. Principles of economics and equity are not met when the assessed properties must bear the additional cost of the non-assessable benefits. Because of these weaknesses, very few flood protection projects, other than levee districts, have ever been accomplished in Illinois under the reclamation concept.

Two major improvements in the Kankakee Basin which have been unaccomplished largely because of the above reasons are the removal of the obstructions at the Momence rock ledge and the Sugar Island rock ledge. Both of these improvements would result in widespread benefits for flood stage reduction, improved drainage, and recreational navigation. Agricultural and urban lands and residents and non-residents of the basin would benefit from such improvements. There is a very large "public benefit" involved in these improvements which cannot be assessed on the benefited lands. The successful accomplishment of both projects will require an equitable cost allocation between public and private benefits.

The numerous, ancillary improvements which would be required along with the above projects such as ditch, lateral, or levee improvements, are well within the capability of the drainage districts or municipalities under the reclamation concept.

Disaster Concept The flood problem at Watseka is even more complicated than the previous case because many more beneficiaries are involved. These include: homes and businesses in Watseka, railroad properties, farmland, public properties, and public highways. In this situation there is little question that the disaster concept under the Flood Control Act of 1945 is applicable. In the narrowest sense the disaster concept only applies to the existing damages; it is not applicable to land enhancement beyond the present damage areas. There are, however, distinct opportunities for land enhancement improvements in connection with flood protection for Watseka. These will be discussed subsequently.

The requirements for large tracts of regional park lands in the basin will increase greatly between now (1967) and the year 2020. (See Tables 16 and 17) Most of the flood plain lands along the Kankakee River and the Iroquois River below Watseka are well suited to this use and should be acquired. In addition, the local park and regional park requirements of the urban fringe areas will make it desirable to acquire flood plain lands along the tributaries north of the Kankakee River. This land acquisition for public purposes is an indirect but effective means of flood control. In this sense, it has an additional value. The greatest value will be obtained if this land acquisition is phased with and complements the area-wide comprehensive zoning *plans (supra).* In this manner the optimum development of urban lands can be achieved while providing adequate park lands and open space where it is needed.

Flood Damage Control Plan

The recommended flood damage control plan for the Kankakee Basin consists of the following major elements:

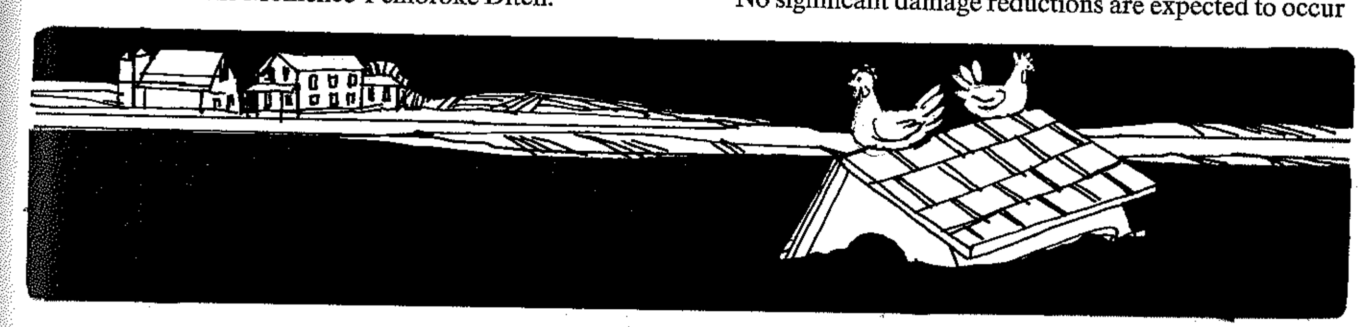
1. Public acquisition of the valley lands of the Kankakee River and Iroquois River (up to Watseka), which would include the channel and floodway lands necessary for construction, operation, and maintenance of a recreational waterway and would preserve the integrity of these streams.
2. Acquisition of additional flood plain lands along both streams to form a major regional park facility for the Kankakee Basin and the Chicago Metropolitan Area.
3. Acquisition of flood plain lands, as required, in the growing urban fringe areas to provide needed open space and to optimize the land development pattern.
4. Lowering of the rock ledge at Momence to provide through recreational navigation, lower floodwater levels, and improve drainage outlet conditions for the Yellowhead-Singleton Ditch and the Momence-Pembroke Ditch.
5. Lowering the rock ledge at Sugar Island with channel deepening and straightening upstream to provide recreational navigation, lower floodwater levels, and improve drainage outlet conditions.
6. Construction of a local protection levee around the City of Watseka to eliminate disastrous flood damages.
7. Implementation of land-use management through zoning and building codes on all lands within the basin subject to flooding.

These recommendations would reduce direct flood damages along the major streams to a small and tolerable amount. Immediate drainage improvements would affect vast areas in the Lake Watseka and Kankakee Marsh regions. Perhaps the greatest benefits, which have not been estimated, would be the future avoidance of flood damages and the ability to further develop land drainage where necessary because of the improved outlet conditions.

Plan Elements *Structural Works*—The drainage and flooding problem above Momence is due not only to overflow from the Kankakee River, which occurs almost annually, but also to the inadequate capacity of the Yellowhead-Singleton Ditch which has a drainage area of 270 square miles. The bankfull capacity of the Yellowhead-Singleton Ditch varies from about 100 cfs at the State Line to 1400 cfs near the mouth. Discharge records at Illinois indicate that the annual probability of bankfull capacity being exceeded varies from 98% at the State Line to 67% at the mouth.

The discharge capacity of the Yellowhead-Singleton Ditch and the Momence-Pembroke Ditch are reduced by high-outlet stages on the Kankakee River. (Figure 32) There is a 54% chance that the Kankakee stage will exceed bankfull for more than a month in any year, and there is a 10% chance that the bankfull stage will be exceeded for more than four months in any year. (Table 25)

The recommended improvement consists of lowering the rock ledge at Momence approximately seven feet and carrying this improvement above the mouth of the Yellowhead-Singleton Ditch were a dam would be constructed to maintain low-water levels upstream. No significant damage reductions are expected to occur



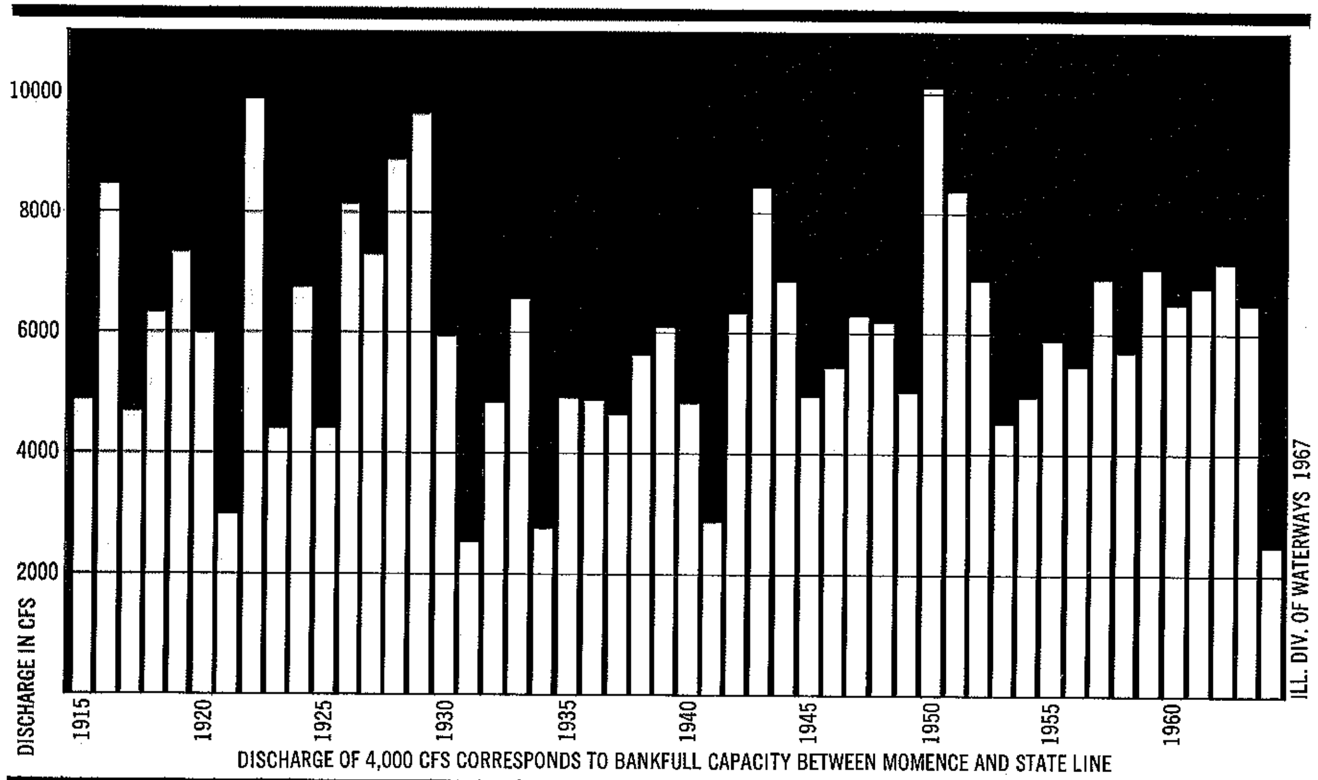


TABLE NO. 25

Duration of Discharges Exceeding Bankfull (4,000 cfs) At Momence
1916-1964

Duration, Days	Number of Times Exceeded
3	44
7	43
15	36
30	27
120	5

above the dam. The lower thalweg elevation on the Kankakee below the dam will have to be carried up the outlet ditches in order to realize the full benefit of the improvement. It is expected that the chances of overbank flooding along the Yellowhead-Singleton Ditch will be reduced to 4 to 5% and similar improvements can be expected on the Momence-Pembroke Ditch.

An additional improvement which would benefit the areas would be to raise the State Line Road above high water in order to keep it open to traffic and to prevent uncontrolled overland flow. If this was combined with the raising of Route 114 and the county road north of the river, the drainage districts would be protected from overflow from the Kankakee; and an all-weather access would be available to the recreation areas along this reach.

The Iroquois improvement consists of lowering the rock ledge at Sugar Island a maximum of 9 feet and extending an improved channel upstream by deepening and some widening to the vicinity of Fiddler Bridge. At low water this channel will provide a small boat channel with depths varying from 5 feet at Sugar Island to about 3 feet at Fiddler Bridge. Above Fiddler Bridge a series of channel cut-offs would reduce the river length by 10.8 miles and increase the thalweg slope*. Stage reduction will vary from about 6 feet near Sugar Island to about 4 feet near Reeder Bridge. Drainage outlet stages will be improved at all points along this reach.

Approximately four miles of levee would be constructed around the north, west, and southwest sides of Watseka*. (Figure 33) Crown elevation would be set with freeboard above the flood of record which when combined with flood stage lowering would give a very high degree of protection.

*This is essentially the project proposed in the 1962 Survey Report: *Flood Control and Drainage Development, Iroquois River*, Illinois Division of Waterways.

The costs for all elements of the plan except the Watseka levee have been given in Table 19. The cost of the Watseka levee is estimated to be $870,000 with annual maintenance costs about $2500 to $5000. Benefits due to reduced flood damages within the levee will be on the order of $60,000 per year (not counting future developments). The channel improvements will provide several possibilities for reclaiming additional lands for urban or agricultural use near Watseka. Figure 34 shows the lands which might be reclaimed by an expanded levee system. The benefit of this type of improvement is essentially land-value enhancement and can be most conveniently carried out under the reclamation concept.

Non-Structural Works—The recommended non-structural works are basically a basin-wide comprehensive zoning plan and basic land acquisition for the recreational waterway. Both must be supplemented by building code and subdivision regulations and additional land acquisition based on a master plan for land use and recreation development.

All the non-structural measures for flood damage control must proceed from the same basic information toward the same goal. The basic information required is land-use and land-capability data. First, all existing land uses must be inventoried and mapped. Second, the suitability of each type of soil and terrain must be evaluated for each possible land use: residential, commercial, industrial, recreational, agricultural, etc. Third, a flood information study is required to determine the extent of possible flooding on all lands. This study must include engineering studies to determine future flood regimes caused by land development.

The goal of the non-structural measures is to insure that future economic growth can take place on lands suited for each use while avoiding unnecessary flood damages. Land-use planning, recreation planning, and flood damage control are all interrelated and must be carefully coordinated.

Implementation of the plan requires numerous government entities which are properly staffed, funded, and coordinated. Unless these conditions are met, there is little hope that flood damage problems can be avoided. Some of the problems which must be anticipated and avoided are as follows:

1. A municipal government prescribes set-back lines along a watercourse. Are the set-back lines based on future flood flows which can be expected from urbanization of the watershed? Are bridge and culvert openings adequate, and are the highway authorities prepared to modify inadequate openings and provide adequate openings in all future structures?

2. A subdivider dedicates a floodway to the local government. Is the floodway adequate for future flood flows which can be expected from urbanization of the watershed? Does the local government have personnel, equipment, and funds for floodway maintenance? Is the floodway accessible for maintenance?

3. A local planning agency recommends public acquisition of a flood plain tract which cannot be economically developed for urban use. Is the park authority prepared to acquire the tract? Can this parcel be incorporated into the park development plan?

4. The Official Plan zones a tract of land, adjacent to the recreational waterway, commercial recreational (CR). The anticipated usage is a commercial marina. Will the State issue a permit for construction of docks? What will be the permitted uses on the floodable portions of the tract? Are there zoning or building code provisions on the storage of flammable liquids (gasoline) or floatable objects (boats) in flood plains? Are public health requirements for potable water, sanitation, and food service adequate for the situation?

5. A park authority has included one of the few sites suitable for developing a recreational lake in its long range plan. Does the Official Plan recognize future water stages in and above the lake particularly with regard to possible flood damages or blocked drainage outlet conditions? Will the dam and spillway be designed for a negligible risk of failure, or is an adequate floodway provided downstream to handle the flood wave from dam failure without disastrous damage?

6. A subdivider-developer has prepared a plan for reclaiming a flood plain tract with a levee. His intention is to build homes of the type allowed within the zoning district, and he requests the zoning board of appeals to remove the building restrictions applicable to flood plain areas. Is the levee designed to provide a negligible risk of flooding? If not, should the restrictions be removed? Did the planning commission consider this flood plain area part of the required open space for the originally anticipated development? If so, does the developer intend to provide compensatory lands? Will the levee cause increased flood stages upstream?

7. A subdivision plan meets all the requirements of the zoning and building codes, but access is over an existing rural road which is frequently flooded. Is the developer or highway authority willing to raise the road grade above high water? Will the objectives of public health, safety, and welfare be achieved if the road is not raised?

8. Part of a built-up urban area is subject to flooding; since no economical means of local protection are available, the area has been zoned to restrict future developments and eventually abate the non-conforming uses. Subsequently a state or federal improvement is constructed which reduces the frequency of flooding but does not eliminate it entirely. Should the restrictions be

63

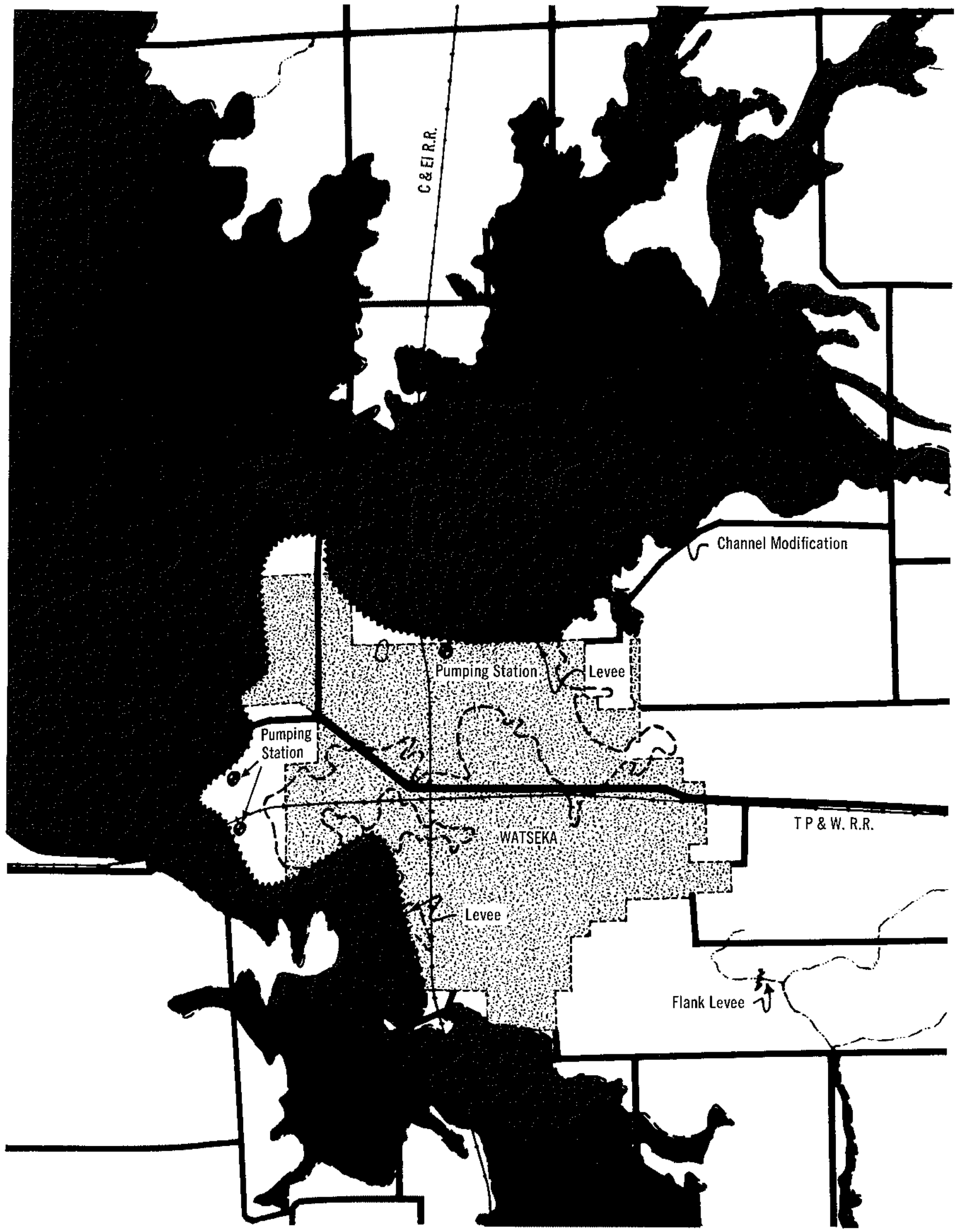


FIG. 33 1962 SURVEY REPORT: WATSEKA FLOOD PROTECTION

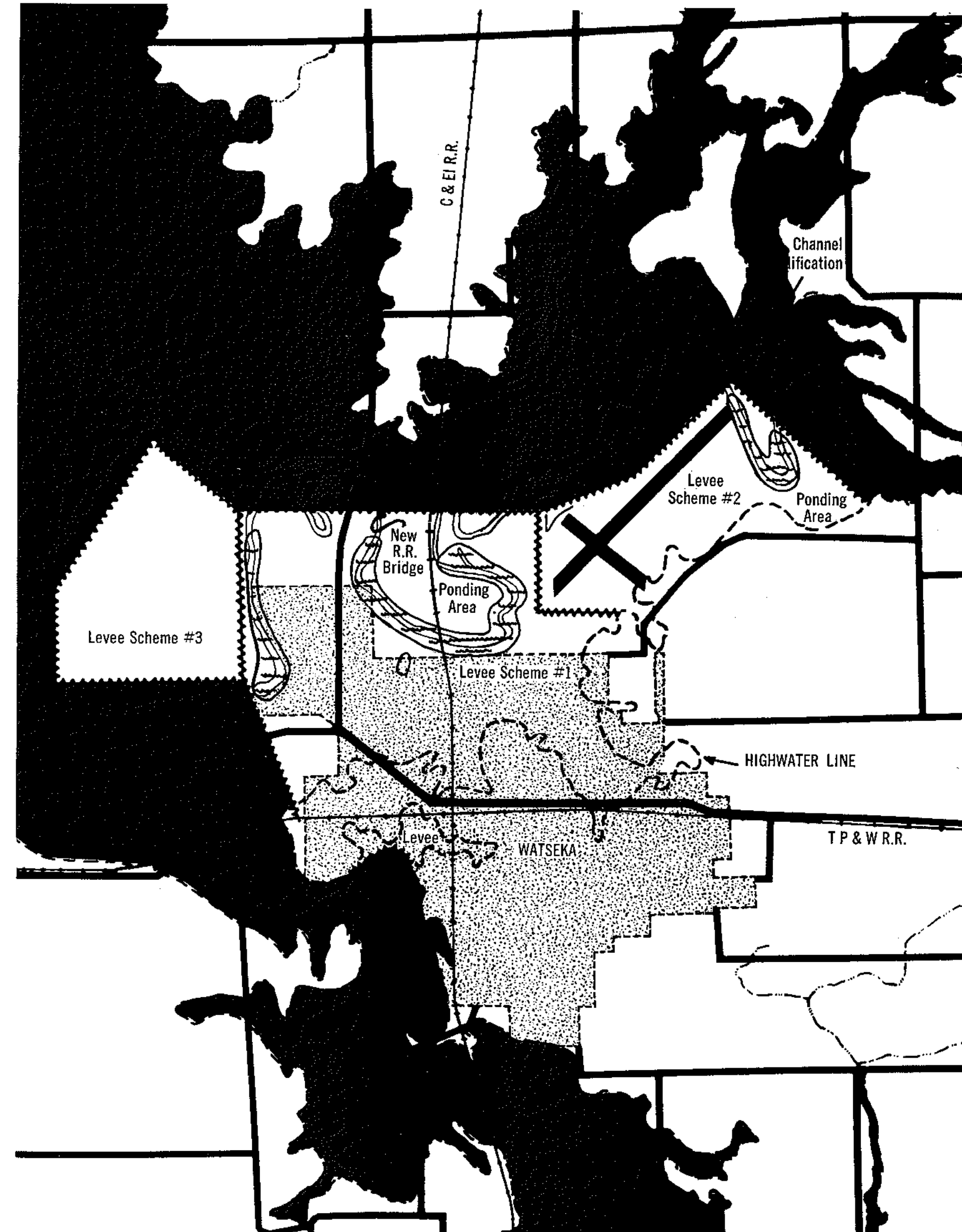


FIG. 34 POSSIBLE FLOOD PROTECTION SCHEMES

64

removed? Should the area be rezoned to a use which is compatible with the new level of risk?

9. A State park development plan in connection with the recreational waterway includes future acquisition of several tracts which include non-flooded upland as well as flood plain. Does the Official Plan preserve these tracts from urban development? Is the park plan duplicated by local park planning? Are adjacent zoning districts compatible with recreation lands?

The preceding examples illustrate the necessity for carefully drawn plans which are coordinated with the activities of many units of government. Regardless of the limited authority, scope, interest, or capability of each government unit in flood damage control, all must share a common and consistent set of policies and objectives. The purpose of state government is the promotion of public health, safety, and general welfare. It is inconceivable that the State has intended to delegate powers to state agencies, local governments, or special districts which are in any way inconsistent with these purposes. It appears that the greatest problems to be overcome in plan implementation are those of cooperation and coordination between government agencies at all levels.

Effects of Plan The effects of a comprehensive [illegible] damage control plan will be far greater in the [illegible] than they are now. The current average annual [illegible] damages, $1,000,000, in the basin now are a [illegible] fraction of what could be expected to occur [illegible] unplanned and unregulated development of the flood plains.

The major effects of the comprehensive flood [illegible] control plan are as follows:

1. Land-use planning will provide for [illegible] population and economic expansion [illegible] minimum of flood damages.
2. The supply of recreational lands and [illegible] space will be conserved to satisfy the [illegible] of present and future populations.
3. Agricultural production will be [illegible] where flood damage reduction and [illegible] drainage improvements are [illegible] feasible. These production increases [illegible] partially compensate losses of [illegible] lands to urban development.
4. More intensive use will be made of [illegible] and flood plain lands than are now [illegible] but the integrity of channels and [illegible] will be maintained.

agricultural drainage

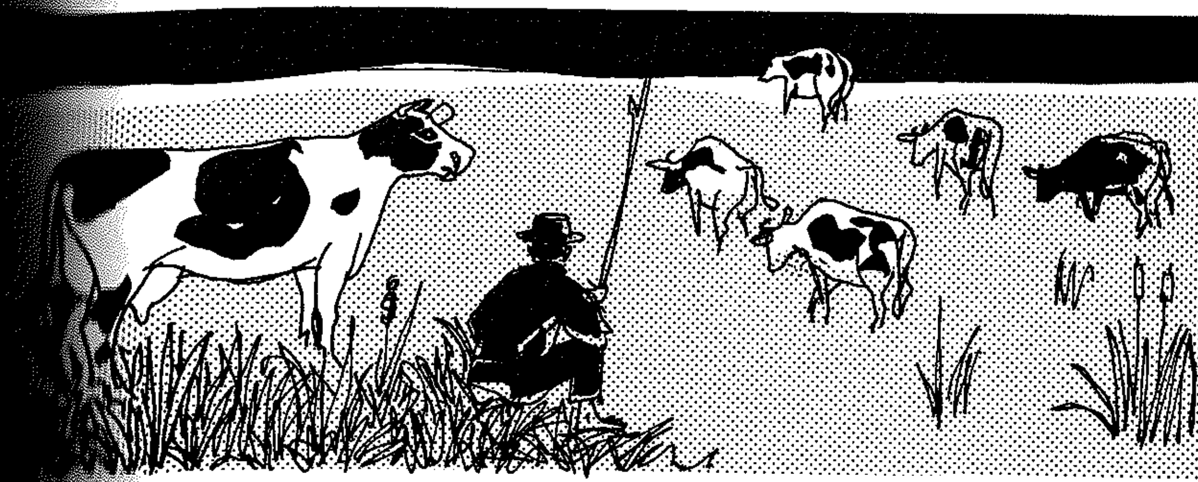
The Drainage Problem

Poor land drainage was an important historical obstacle to agricultural development in the Kankakee Basin. The landscape fashioned by the glaciers and melt-water runoff during the Torrent phase was a broad prairie covered by extensive marshes or swamps. Ponds and lakes occupied the larger depressional areas. The rock ledge at Momence impounded a vast marsh which covered about 400,000 acres. Lesser ponds and marshes were scattered among the sand dunes in southeastern Kankakee County and throughout the headwaters of most of the tributaries of the Kankakee and Iroquois Rivers.

In the marshes and throughout the flat lands of the prairie, the soils were generally too wet for crop planting until late in the season. In the wettest portions [illegible] prairie, crop production was not possible at all [illegible] the areas along the low morainal ridges had [illegible] natural drainage for cultivation. The wet, [illegible] not only impeded agriculture but also the [illegible] of roads. The villages and farms, which were [illegible] on the higher, better drained portions of the [illegible] were largely isolated from each other by the [illegible] roads. Thus, even where crops could be [illegible] marketing opportunities were so poor that the [illegible] growth of the entire region was retarded. [illegible] of better drainage and transportation (railroads [illegible] greatly accelerated the growth in the Kankakee [illegible]

Early Developments

Prior to 1850, the largest tracts of prairie land [illegible]



[illegible] grazing enterprises. These enterprises [illegible] few profitable uses of the wet prairie [illegible] prairie was considered "open range" [illegible] allowed to graze freely and move from [illegible] down into the lower portions of the [illegible] dried out in the summer. Transportation [illegible] since the cattle were driven to market [illegible] when the ground was dry and firm.

[illegible] largely an interim use of the prairie, [illegible] larger enterprises were also in the [illegible] business. That is, they intended [illegible] clearing, sod breaking, minor drainage [illegible] rows, etc., in order to subdivide [illegible] farmers. Another large group of [illegible] business were the railroads— [illegible] Central Railroad which had [illegible] grant from the State.

[illegible] drained portions of the prairie were [illegible] and sold; and the profits were [illegible] ment of other lands. But it soon [illegible] major drainage improvements [illegible] if the majority of the prairie [illegible] ved. The technology of drainage [illegible] ate; people familiar with land [illegible] from Europe; experiments were [illegible] ture of drain tile and the [illegible] ing machinery. Between 1860 [illegible] ical capability of the land [illegible] ir legal and financial capabilities, [illegible] outlet ditches had to be [illegible] properties of several landowners.

[illegible] Drainage Districts

[illegible] large drainage works was [illegible] onstitution of 1870, which [illegible]:

The General Assembly may pass laws permitting the owners of lands to construct drains, ditches, and levees for agricultural, sanitary, or mining purposes across the land 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.

These powers were soon implemented by the Farm Drainage Act and the Levee Act. Many drainage acts or amendments were made in subsequent years, and all the laws were finally assembled in the Illinois Drainage Code in 1955.

Drainage districts are organized by a petition of the landowners before the circuit court. The governing body of a drainage district consists of appointed drainage commissioners who have powers to hire engineers, attorneys, and contractors; devise plans for drainage work; prepare assessment roles; and maintain the drainage works. However, all the proceedings of the drainage district are under the jurisdiction of the court.

Progress In Artificial Drainage

Organized drainage districts were very successful wherever land could be profitably reclaimed by artificial drainage works—that is, where the benefits exceeded the costs. There are now almost 1500 organized drainage districts in Illinois which have reclaimed over 5.5 million acres of land. In the Kankakee Basin about 550,000 acres of land have been artificially drained. These lands constitute over 40% of the total land area in the basin.

removed? Should the area be rezoned to a use which is compatible with the new level of risk?

9. A State park development plan in connection with the recreational waterway includes future acquisition of several tracts which include non-flooded upland as well as flood plain. Does the Official Plan preserve these tracts from urban development? Is the park plan duplicated by local park planning? Are adjacent zoning districts compatible with recreation lands?

The preceding examples illustrate the necessity for carefully drawn plans which are coordinated with the activities of many units of government. Regardless of the limited authority, scope, interest, or capability of each government unit in flood damage control, all must share a common and consistent set of policies and objectives. The purpose of state government is the promotion of public health, safety, and general welfare. It is inconceivable that the State has intended to delegate powers to state agencies, local governments, or special districts which are in any way inconsistent with these purposes. It appears that the greatest problems to be overcome in plan implementation are those of cooperation and coordination between government agencies at all levels.

Effects of Plan The effects of a comprehensive flood damage control plan will be far greater in the future than they are now. The current average annual flood damages, $1,000,000, in the basin now are a small fraction of what could be expected to occur through unplanned and unregulated development of the flood plains.

The major effects of the comprehensive flood damage control plan are as follows:

1. Land-use planning will provide for future population and economic expansion with a minimum of flood damages.
2. The supply of recreational lands and open space will be conserved to satisfy the needs of present and future populations.
3. Agricultural production will be increased where flood damage reduction and associated drainage improvements are economically feasible. These production increases will partially compensate losses of agricultural lands to urban development.
4. More intensive use will be made of floodway and flood plain lands than are now possible, but the integrity of channels and floodways will be maintained.

agricultural drainage

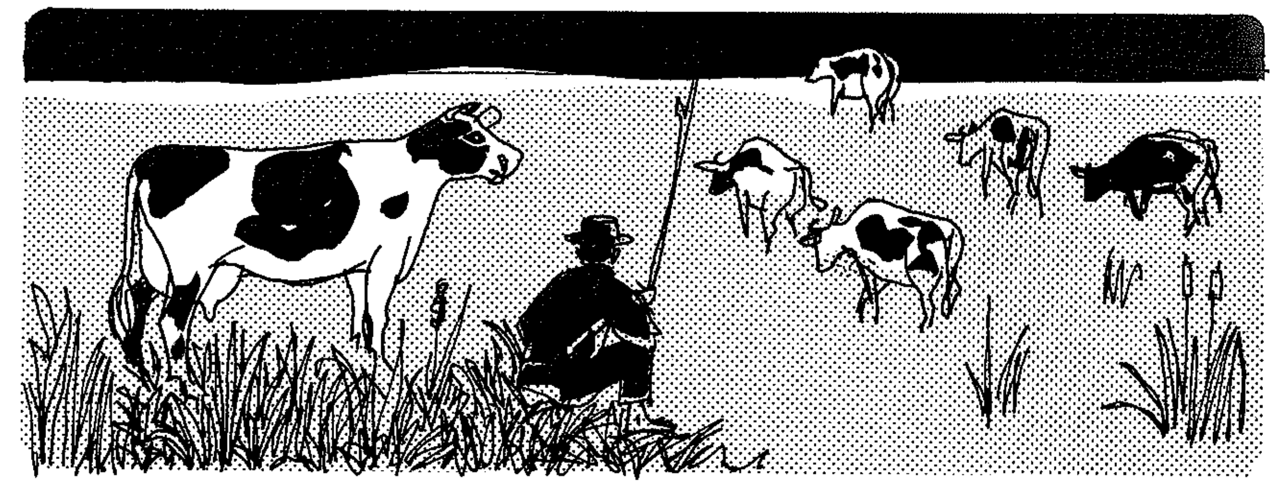
The Drainage Problem

Poor land drainage was an important historical obstacle to agricultural development in the Kankakee Basin. The landscape fashioned by the glaciers and melt-water runoff during the Torrent phase was a broad prairie covered by extensive marshes or swamps. Ponds and lakes occupied the larger depressional areas. The rock ledge at Momence impounded a vast marsh which covered about 400,000 acres. Lesser ponds and marshes were scattered among the sand dunes in southeastern Kankakee County and throughout the headwaters of most of the tributaries of the Kankakee and Iroquois Rivers.

In the marshes and throughout the flat lands of the prairie, the soils were generally too wet for crop planting until late in the season. In the wettest portions of the prairie, crop production was not possible at all. Only the areas along the low morainal ridges had adequate natural drainage for cultivation. The wet, boggy ground not only impeded agriculture but also the construction of roads. The villages and farms, which were located on the higher, better drained portions of the prairie, were largely isolated from each other by the lack of roads. Thus, even where crops could be produced, marketing opportunities were so poor that the economic growth of the entire region was retarded. The advent of better drainage and transportation (railroads) greatly accelerated the growth in the Kankakee Basin.

Early Developments

Prior to 1850, the largest tracts of prairie land were



owned by cattle grazing enterprises. These enterprises were one of the few profitable uses of the wet prairie land. Since the prairie was considered "open range" the cattle were allowed to graze freely and move from the higher ground down into the lower portions of the land as the soil dried out in the summer. Transportation was no problem since the cattle were driven to market in the fall or winter when the ground was dry and firm.

The grazing was largely an interim use of the prairie, since many of the larger enterprises were also in the land development business. That is, they intended to perform land clearing, sod breaking, minor drainage work, plant hedge rows, etc., in order to subdivide the land and sell it to farmers. Another large group of landowners in this business were the railroads—principally the Illinois Central Railroad which had received a large land grant from the State.

The higher, better drained portions of the prairie were the first to be developed and sold; and the profits were applied to the improvement of other lands. But it soon became apparent that major drainage improvements would have to be made if the majority of the prairie lands were to be improved. The technology of drainage work was very inadequate; people familiar with land drainage were brought from Europe; experiments were made with the manufacture of drain tile and the development of excavating machinery. Between 1860 and 1870, the technological capability of the land developers exceeded their legal and financial capabilities, especially where large outlet ditches had to be constructed across the properties of several landowners.

Legal Powers of Drainage Districts

The legal mechanism for large drainage works was finally provided in the Constitution of 1870, which states in Article 4§31 that:

The General Assembly may pass laws permitting the owners of lands to construct drains, ditches, and levees for agricultural, sanitary, or mining purposes across the land 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.

These powers were soon implemented by the Farm Drainage Act and the Levee Act. Many drainage acts or amendments were made in subsequent years, and all the laws were finally assembled in the Illinois Drainage Code in 1955.

Drainage districts are organized by a petition of the landowners before the circuit court. The governing body of a drainage district consists of appointed drainage commissioners who have powers to hire engineers, attorneys, and contractors; devise plans for drainage work; prepare assessment roles; and maintain the drainage works. However, all the proceedings of the drainage district are under the jurisdiction of the court.

Progress In Artificial Drainage

Organized drainage districts were very successful wherever land could be profitably reclaimed by artificial drainage works—that is, where the benefits exceeded the costs. There are now almost 1500 organized drainage districts in Illinois which have reclaimed over 5.5 million acres of land. In the Kankakee Basin about 550,000 acres of land have been artificially drained. These lands constitute over 40% of the total land area in the basin.

TABLE NO. 26

Land In Drainage Projects
(acres)

County	1920	1930	1940	1950	1960
Iroquois	283,159	344,520	363,273	405,437	410,990
Kankakee	125,344	137,214	128,129	133,298	144,198
Will	46,042	64,506	56,306	61,162	71,218

TABLE NO. 27

Status of Drainage Projects, 1960

	Iroquois	Kankakee	Will
Land in County, acres	718,080	435,200	540,800
Land in Farms, acres	674,810	378,632	406,823
%	93.9	87.0	75.2
Land in Drainage Projects, acres	410,990	144,198	71,213
%	57.2	33.1	13.1
Number of Drainage Projects	84	44	35
Average Size of Projects, acres	4,893	3,277	2,035

The majority of drainage work was completed before 1920, but there have been significant improvements since then. Tables 26 and 27 show the progress of drainage works by county statistics from the *Census of Drainage*. Except for the decade 1930-1940, there has been a continued advancement in drainage works. Some drainage districts have been abandoned, either because a successful project could not be accomplished or because the original works secured adequate drainage and have not required subsequent maintenance. There are estimated to be 165 active drainage districts in the basin plus an undetermined number of subdistricts.

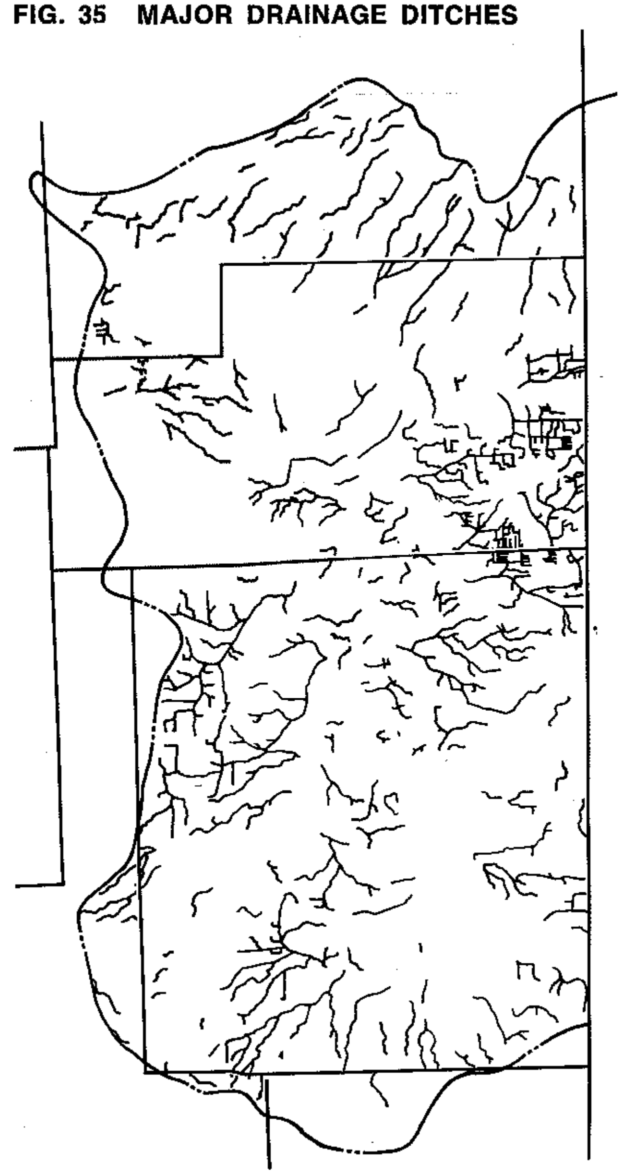
The general pattern of improvements include widening, straightening, and deepening of natural outlet channels and the construction of lateral ditches or tile mains by the drainage districts. Sub-districts have been formed to construct smaller lateral ditches and tile submains. Finally, landowners have constructed field ditches and laid field tiles—all of which are connected to the drainage district outlets.

The major drainage ditches are shown in Figure 35. Tile mains and submains are not shown. It is estimated that drainage districts have constructed over 650 miles of open ditches and over 425 miles of tile mains within the basin. There is a noticeable absence of improvements on the larger streams which serve as outlets for large drainage basins containing many districts.

Economics of Artificial Drainage

The capital investment in artificial drainage works by drainage districts in the Kankakee Basin is about

FIG. 35 MAJOR DRAINAGE DITCHES



$20,000,000 (1965 dollars) or an average investment of $36 per acre drained. To this total must be added the landowners' investment in field tiles and ditches which commonly varies from $100 to $300 per acre where it is needed most but probably averages less than $100 per acre for all lands drained.

The average value of all farmland in the Kankakee Basin exceeded $400 per acre in 1959. This is considerably higher than the state average at that time. Land values have increased over 20% since 1959 indicating that average land values are about $500 per acre (1965 dollars). The best lands in the basin have values on the order of $1000 per acre.

The economic significance of land drainage is apparent when it is realized that the average value of farmlands would not have been more than $300 per acre at current prices if they had not been drained. Thus, the investment in drainage works has been more than compensated by the resulting increased land values. There are, of course, areas in the basin where drainage investments have not been so successful. This is particularly true in the areas of thin, droughty, or erodible soils where the potential productivity is naturally low. Also, in the areas affected by the Momence and Sugar Island rock ledges, drainage has not been improved to its maximum economic potential.

Maintenance of Drainage Systems

Most of the drainage districts are in active operation because of the necessity for continued maintenance and repair of the ditches and tiles. Experience has shown that drainage systems, particularly open ditches, deteriorate rapidly when not maintained. The growth of willows and brush on ditch banks can reduce the carrying capacity of the ditches by 50% in less than 2 years. Maintenance work on tiles is much less than for open ditches. It usually consists of repairs to outlet structures, clearing field inlets, and clearing root growths or soil from within the tile lines.

The *Census of Drainage, 1960,* found that 72 out of the 80 known drainage districts in Iroquois County had performed maintenance work at least once during the period 1950-1959. In the year 1965, 38 drainage districts in Iroquois County levied annual maintenance assessments. District activities are slightly less in Kankakee and Will Counties.

Operation, maintenance, and repair costs incurred by the drainage districts are estimated to be $140,000 per year or about $0.25 per acre drained. Individual landowners spend additional amounts in the maintenance of their own field systems. The low maintenance costs are apparently due to the heavy use of drain tile which have a high initial cost but a low maintenance cost. Periodic clearing of outlet ditches is the major expense.

Status of Drainage

Agricultural drainage is good throughout most of the basin as is indicated by high land values and high crop yields. The drainage works in the upland areas essentially reclaimed the wet prairie and made it suitable for cultivation. The economic success of the original works is beyond question. Subsequent improvements, including farm field tiles, were equally successful and produced significant, tangible benefits. The value of further improvements, where satisfactory drainage is now available, is not at all certain.

Large areas of land are affected by poor outlet conditions caused by the Momence and Sugar Island rock ledges. In the area above Momence, an estimated 16,400 acres of land suffer poor drainage or periodic overflow. The soils are predominately sands and sandy loams which will drain readily if adequate outlets are available. Because these soils have low drought resistance, they can also be overdrained. A complete system of soil-water management is required to achieve maximum production potential.

An estimated 150,000 acres of land suffer poor drainage and periodic overflow along the Iroquois River between Sugar Island and Watseka. Poor outlet conditions at Sugar Island directly affect the capacity of Langans Creek, Beaver Creek, Pike Creek, Spring Creek, Prairie Creek, and numerous smaller tributaries. These streams are the main outlets of over 30 drainage districts which serve over 138,000 acres. Large tracts along the lower portions of these tributaries and along the Iroquois River have never been organized into drainage districts because an adequate drainage outlet could not be obtained and the lands are subject to frequent overflow.

Drainage Outlet Improvements

Major improvements at the Momence and Sugar Island rock ledges are recommended in order to develop drainage in the affected lands to the maximum potential. Both channel improvements at the rock ledges are integral parts of the recreational waterway proposal. Consequently, it is impossible to clearly separate costs due to the waterway from those due to drainage and flood stage reduction. It is clear, however, that the benefits of improved drainage and flood stage reduction would not economically support a single purpose channel improvement. For this reason, it appears that recreation benefits are subsidizing the drainage and flood control benefits to some unknown degree.

Since the relation of benefits to costs for the recreational waterway indicates a justifiable project, it seems unreasonable to deny those drainage and flood stage reduction benefits which could accrue to the project. Therefore, these benefits have been included in the project analysis along with their associated and consequent costs.

The associated and consequent costs are based on the assumption that the lowering of outlet elevations will be carried upstream on outlet and lateral ditches to take maximum advantage of the improved conditions. Along with the ditch improvements, it is expected that modifications will be required at numerous tile outlet structures. Drop structures may also be required on some lateral ditches which would not benefit materially by deepening. It was further assumed that moveable dams, weirs, or gates would be installed in ditches serving sandy soils so that water-table levels could be held near root level during dry seasons. With the improved drainage afforded by the proposed project, there would be little risk in attempting to hold ground-water levels at higher elevations because the moveable checks could be opened when necessary to remove excess water. Benefits from this type of water control were not estimated.

Research In Drainage

Soil-water drainage is only one aspect of water management and conceivably includes practices beyond the simple drainage of wet lands. Where the more obvious problems of drainage have been solved, there is still the question of the feasibility of further improvements. The economic feasibility of drainage improvements depends on the increase in average crop yield which would result. This is an involved problem in science, technology, and economics for which answers are not presently available.

In most areas of the Kankakee Basin, except the Lake Watseka and Kankakee Marsh areas, drainage is considered to be satisfactory. There is the possibility, however, that further crop yield increases could be obtained. Neither the magnitude of these yield increases nor the costs of associated drainage improvements is known.

Research in drainage has concentrated on the theoretical and practical aspects of the design of ditches and tile systems. Few attempts have been made to relate the costs of improvements to increase yields. There are many means to increasing crop production, including further developments in fertilizer, hybrid seeds, plant populations, and irrigation. Nevertheless, those methods which directly improve or augment the land resource cannot be overlooked. In Illinois, these methods would be predominately centered on land drainage but would also include reclamation of bottomlands, strip mined lands, eroded lands, sterile soils, etc.

Although overproduction is the major current problem in agriculture when viewed from the national level, this condition cannot be expected to persist indefinitely. Illinois is already the largest exporter of food products in the United States. It would undoubtedly benefit the most if the United States supplied a greater portion of the world food requirements than it now does. For this reason, it appears wise to explore the technology of drainage as one means of increasing production.

Applied research is needed to relate the economics of drainage to the available technology. Such research is well within the capability of the Agricultural Experiment Station at the University of Illinois. The work should be financially supported by the State in view of the negative attitude of the Federal Government toward programs which would increase production. When this research data is available, it would then be advisable to inventory the entire State and prepare a master plan which would serve as a guide for public and private decision making and investment in drainage projects.

Drainage Plan

The drainage plan proposed in this study consists of two phases: 1) structural improvements at the Momence and Sugar Island rock ledges and 2) water management techniques for sandy soils. The first phase is directly related to the proposed recreational waterway and includes associated improvements on lateral and outlet ditches. Lowering of the rock ledges will lower drainage outlet elevations and increase discharge capability of these controls. Thus, the removal of excess water from the land will be facilitated while stages in the main stream above the controls will be reduced.

The second phase is a recommendation for better water management in the sandy soils. Holding water tables at higher elevations is desirable in droughty soils and essentially riskless when the capability for rapid drainage is available. It has been said many times that the sandy soils in the Kankakee Basin have been overdrained and that they ought to be reverted to marsh for recreational purposes. The potential value of marsh restoration for fish and wildlife habitat and outdoor recreation is not questioned here because of the tremendous unsatisfied demand for this type of land in the northeastern Illinois metropolitan area. However, until the public has taken definite steps toward marsh restoration—at least the formulation of a master plan—it would be unwise to deny the present landowners the maximum beneficial use of their land.

One last point which must be mentioned is the relation of drainage to urban land-use planning. It can never be assumed that a drainage system which is adequate for agriculture will also be adequate for urban land use. In fact, this is almost never the case. Agricultural land drainage requires only that excess water in or on the soil be removed in a reasonable length of time so that plant growth is not impaired. Complete protection against overflow is never required and almost never obtained. Wherever urban land use is proposed, a determination must be made whether a more sophisticated drainage system can be provided at a justifiable cost.

Some lands in the Kankakee Basin will never be suitable for unrestricted urban use. For instance, portions of the lands above Momence and above Sugar Island will still be subject to overflow even with the recommended improvements in operation. The frequency of overflows will be reduced but not eliminated. In other areas there are thin soils lying on bedrock. While farm field tiles would seldom encounter rock in these areas, urban storm drains would be laid at several times the depth of farm tile and run the risk of encountering bedrock with drastically increased costs. Therefore, unrestricted urban land use should only be planned when the feasibility of adequate storm drainage systems is assured and the risk of overflow is negligible.

irrigation

Economics

The profitability of irrigation in humid areas such as the Kankakee Basin depends on soils, climatic conditions, farm management, and current crop prices. If irrigation is to be profitable, the amount of increased crop yield due to irrigation must be of sufficient value that the capital investment is recovered, a reasonable return on the investment is earned, and operating costs due to irrigation are recovered.

Irrigation requires a relatively large investment. Sprinkler systems require pipelines, sprinkler nozzles, and pumps. Gravity systems require extensive land preparation, supply ditches, drains, and perhaps, depending upon the supply source, pumps. Capital investment may be as little as $50 per acre or more than $250 per acre. Average costs will be about $150/acre.

Operating costs will vary with the type of system employed. Generally, a large amount of human labor is required with a gravity system where little electrical-mechanical machinery is used. Sprinkler systems generally require less hand labor and more power machinery. Completely automatic irrigation systems have been devised for both sprinkler and gravity irrigation; the capital investment, however, is very high.

Operating costs will increase with increased water application. The cost of applying an acre-inch of water may vary from $2.00 to $16.00 with an average of about $6.00 per acre-inch. Approximately $2.50 per acre-inch is the average operating cost while $3.50 per acre-inch is the average fixed cost.

As was stated before, the net return from an irrigation system must provide a reasonable return on the capital investment in irrigation equipment. There are three ways in which this condition may be met in the humid areas: 1) the value of the crops must be high in relation to costs, 2) rainfall must be insufficient, or 3) soils must be droughty.

If the percentage increase in yield due to irrigation is the same for different crops and the operating cost for planting and harvesting the different crops is the same, then the higher valued crop is the more attractive, economically, to irrigate. Gladioli, a high value crop, are being profitably irrigated in the Kankakee Basin. If rainfall is consistently insufficient for near maximum yields, then irrigation may be profitable since a return due to irrigation may be had in nearly every year. However, this situation does not prevail in the Kankakee Basin. If soils are droughty and yields are consistently low due to the low water-holding capacity of the soil, then crop yield increases may warrant the investment in irrigation equipment. Approximately 25% of the soil in the Kankakee Basin is considered droughty.

Along with all the above conditions is the requirement that the irrigator be a good manager of his labor and capital. Even in the arid west where irrigation has been proven to be profitable, farmers do fail because of poor farm management.

Soils

The soils of the Kankakee Basin have been described in PHYSICAL GEOGRAPHY. Nearly 500 square miles of the Illinois portion of the Kankakee Basin have sandy soils. These sandy soils comprise nearly one-fourth of the area. These soils are droughty to slightly droughty. Water-holding capacities vary from about .06 inch per inch of soil to about .12 inch per inch in sandy soils. The heavier textured soils have water-holding capacities up to .22 inch per inch. About 50% of the soils in the basin have capacities of about .18 inch per inch. If a root depth of 4 feet is assumed, then the lightest soil will have about 3 inches of water and the heaviest soil will have about 10 inches at field capacity. Generally, plant distress will occur when the evapo-transpiration rate is high and the soil moisture is lowered to about 25% of field capacity. Assuming an evapo-transpiration rate of .2 inch per day, the light soils will support plant growth for about 11 days and the heavy soils will support plant growth for about 37 days with no rainfall. There is a fair possibility that irrigation could be profitable for field crops as well as specialty crops on most of the sandy soils.

Climate

The Kankakee Basin is located in an area where the average rainfall is sufficient for good crop production. (See HYDROLOGIC DATA section) The average growing season precipitation is 22 inches. Some of the dormant season precipitation (14 inches) will replenish the ground-water in the root zone. Of the 36 inches average annual precipitation, approximately 10 inches appear as stream flow. An undetermined amount may be lost through ground-water flow beyond the basin, but the major portion goes back to the atmosphere by evaporation or plant transpiration. In an average year, the amount available for plant transpiration is sufficient for good crop production. There is about a 50% chance of receiving one-half inch rainfall during a one-week period during the growing season and about a 75% chance of receiving one-half inch rainfall during a two-week period.

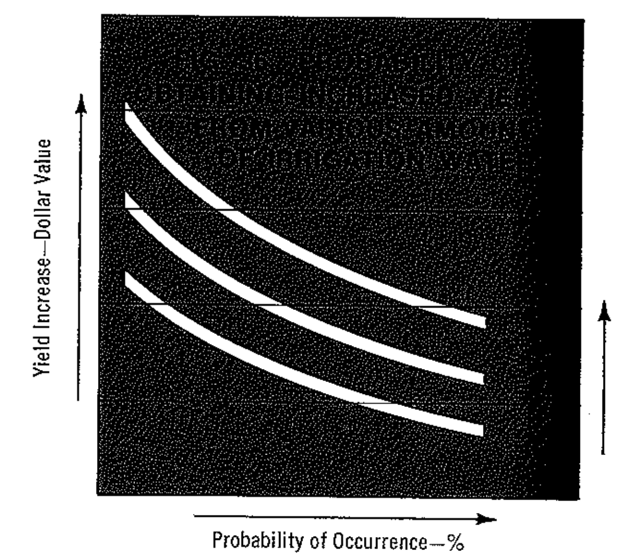
Analysis

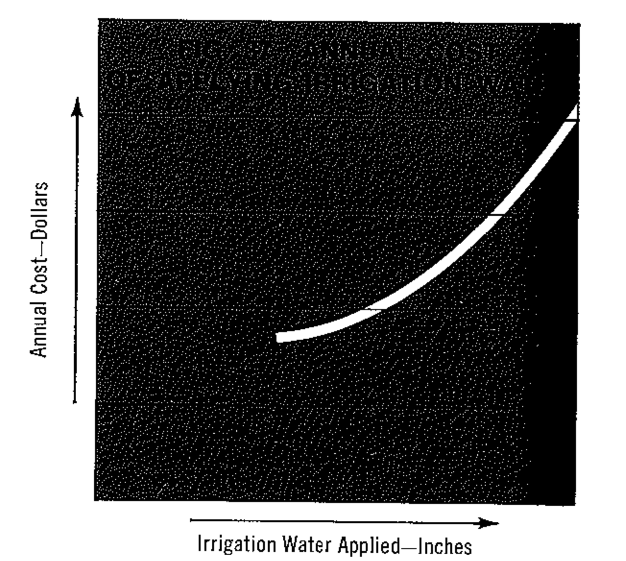
Ideally, in order to determine the economic feasibility of irrigation, it is necessary to know: 1) the price the farmer will receive from the sale of his crops, 2) the price the farmer will pay for seed, fertilizer, planting, and harvesting, 3) the increase in crop yield from each increment of water added (moisture-yield function), 4) the probability with which various droughts will occur, and 5) the cost of owning and operating an irrigation system. Of the above items, all can be determined with some degree of confidence except the moisture-yield function. No well-defined relationship has been developed which will specify the yield of a crop if the soil type, plant population, management level, and climatological data are given. If a moisture-yield function were available, a yield increase-probability function could be developed for various increments of irrigation water. The net expected return could then be computed, and the economic feasibility of an irrigation project could be determined.

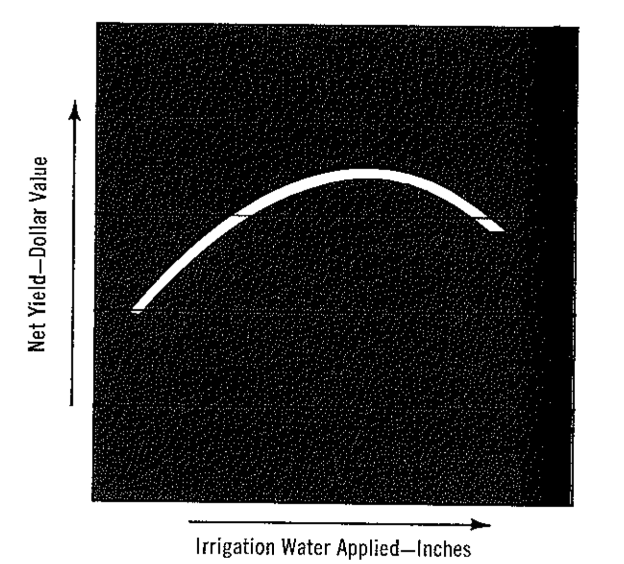
Typically, if a moisture-yield function were available, the analysis would begin with the assumption of a given amount of irrigation water available. For a given crop on a given soil type with a given management level, the historic recorded rainfall can be applied. A water balance must be maintained. An assumption must be made concerning the daily evaporation and transpiration. The water-holding capacity and infiltration capacity of the given soil will be known. As the rainfall is applied, the infiltration may be computed and the runoff determined. During periods of deficient rainfall, when the soil moisture becomes insufficient to meet the evapo-transpiration demands, the irrigation water is applied. For the given irrigation water available, the increase in yield may be computed for each year. It is now possible to assign a probability of occurrence to each of the yield increases. The above procedure may be repeated for various quantities of irrigation water. From this data, a graph may be constructed which would have the general characteristics of Figure 36.

The cost of obtaining and applying the various increments of irrigation water must be computed. A typical cost function would appear as Figure 37. The average annual value of the yield increases for the various irrigation increments may be determined from Figure 36. The difference between the value of the annual yield increase and the annual cost would be the net return. A graphical representation of the net yield versus the irrigation application is shown in Figure 38.

Similar computations should be performed using various management levels. A set of graphs similar to Figure 36 will result. A set of net yield versus irrigation water applied graphs can be constructed. It will then be apparent which management level to use and how much irrigation water must be available.







A similar procedure may be performed for various crops and the complete procedure must be repeated for each major soil type. Although Figure 38 indicates a net gain from irrigation, it is likely that a net loss can result. When sufficient experimental data becomes available to accurately determine a moisture-yield function, it will be possible to assign numerical values to the various items and thereby determine under which circumstances irrigation is economically attractive.

Several generalizations concerning the economic feasibility of irrigation can be made. Inspection of Figure 36 shows that anything that tends to shift the irrigation water lines upward will increase the value of irrigation. The most obvious item which will cause this shift is higher unit prices for the crop. Another factor affecting position of the lines is climate. Yields can be increased more by irrigation if a dry climate prevails rather than a wet one. Soil type will also affect the lines. Droughty soils have a greater probability of requiring irrigation than heavier soils; the probability of increasing yields with irrigation is, therefore, greater.

Irrigation has been practiced for over 40 years in Kankakee County. The principal irrigators grow gladioli in the area around St. Anne. The sandy soils are droughty and tend to require additional water during short dry periods. The high value of the crop makes irrigation economically attractive. The sandy or droughty soils in the east part of the basin coupled with a market in the Chicago Metropolitan Area for specialty crops such as flowers, nursery stock, and vegetables should provide the incentive for increased irrigation in the future.

The irrigation presently being done in the St. Anne area is by sprinklers with water from wells. Wells are generally drilled into the shallow dolomite. The capacity and yields from the dolomite aquifer (Figures 14 and 16, *GROUND-WATER RESOURCES)* will generally be found to be adequate for most irrigation enterprises.

The irrigation of high value crops on sandy soils appears to be economically feasible. More applied research is required in the field of irrigation economies in order to more accurately determine the profitability of irrigating various crops on various soils.

summary of findings and recommendations

The purpose of this report has been to study the water resources of the Kankakee Basin and its relation to: the land, the people, and the regional economy. To accomplish this purpose, the study has progressed from a discussion of the physical geography of the Basin though a discussion of the population and economic base and their probable growth in order to assess the new or changing demands which will be made on the land and related water resources.

Scope and Depth of Study

The scope of the study included all of the major aspects of water use and water management which will or can be affected by changing conditions in the future. Each major topic has been studied in sufficient depth to identify new needs, changing demands, and define a plan of action. Wherever several likely alternatives were available for the solution of identified problems, they have been discussed in sufficient depth to identify the most desirable alternative.

The conclusions and recommendations are based on the information available and on the assumptions which have been stated. Their continued validity is dependent on whether or not the basic information and derived relationships truly represent the present and anticipated future conditions. Recognizing these limitations, the major findings and recommendations are summarized below.

Findings and Recommendations

Urbanization and Population Growth The population of the Kankakee Basin is expected to increase from 147,000 (1960) to 435,000 in the year 2020. To the north of the basin, the six-county Chicago Metropolitan Area is expected to grow from 6,250,000 (1960) to 14,000,000 in the year 2020. The population growth will occur almost entirely within the large urban areas, such as Kankakee. The expansion of the Chicago urban area into the northeast portion of the basin will result in rapid urbanization in this area. Rural farm population will continue to decrease and smaller rural communities will experience little growth.

Municipal and Industrial Water Supply Water supply requirements will increase rapidly in the urban areas of the basin through the combined effects of population growth, increasing per capita domestic use, and industrialization. The present sources of water supply, Kankakee River for the Kankakee urban area, and ground-water aquifers for other communities in the basin are expected to be adequate for future demands. Joliet is expected to utilize the Kankakee River as a water supply source before 1990. Water supplies for the anticipated urban fringe area in the northeast portion of the basin can be obtained from shallow dolomite aquifers providing wells are properly constructed, developed, and spaced.

Water Quality Control The use of the streams for recreation and municipal water supply will require high standards of water quality. The natural water quality in the basin is good and can be maintained by adequate treatment of municipal and industrial wastes. Effluent disinfection will be required at all wastewater treatment plants during the recreation season and may be required at other times to protect water supply sources. The natural low flow in the Kankakee and Iroquois Rivers will provide adequate dilution for effluents from secondary treatment plants. Tertiary treatment will be required in the urban fringe areas along the headwater tributaries where the natural low flow is insufficient for dilution. This tertiary treatment will probably increase costs 30 to 50% over secondary treatment.

Water-Oriented Recreation The greatest demand for recreation lands and facilities will originate outside the basin in the Chicago Metropolitan Area. The study indicates that a major park system containing at least 50,000 acres of land should be developed in the basin by the year 2020. It is recommended that the Kankakee River and Iroquois River below Watseka be developed as a recreational waterway to accommodate pleasure boating, fishing, and related activities. (Figure 39) The waterway would form the core of the park system and consist of 84 miles of navigable channel and 6000 acres of water and riparian lands. The construction cost of $44,000,000 and annual operation and maintenance cost of $500,000 will provide annual benefits of over $8,000,000. Approximately $1,000,000 of the annual benefits are attributable to improved drainage and flood damage reduction.

Flood Damage Control Annual flood damages are presently on the order of $1,000,000. About half of these damages occur on agricultural lands in widely scattered areas along tributary streams. The remaining damages are largely concentrated in three areas:
1) the Kankakee River flood plain above Momence,
2) the Iroquois flood plain above Sugar Island, and
3) the Watseka area. Channel dredging, straightening, and the lowering of the rock ledges at Momence and Sugar Island will reduce overbank flooding on the affected agricultural lands. A levee is recommended to protect the developed area of Watseka. It is recommended that flood damage control through land-use management be implemented in all areas of the basin subject to urbanization. The recommended structural and non-structural measures will reduce present damages to one-half and will minimize future damage growth.

Agricultural Drainage About 550,000 acres of land in the basin have been artificially drained and are suitable for cultivation. Drainage has been very successful wherever good soils were located and adequate outlets could be obtained. Approximately 116,000 acres of lands suffer poor outlet conditions due to the Momence and Sugar Island rock ledges. The proposed channel improvements for the recreational waterway will greatly improve drainage on these lands. Improved drainage of the sandy soils will allow methods of soil-water management which are presently too risky.

Irrigation Approximately 25% of the lands in the basin have droughty soils. Crop production on these lands can be increased by irrigation if the increased returns justify the costs. It appears now that irrigation is economically sound for high-value specialty crops, and the demand for these crops is expected to increase as the Chicago Metropolitan Area expands towards the basin. Future improvements in drainage, soil-water management, and irrigation are expected to increase agricultural output despite losses of land to urbanization.

In conclusion, the major demands on water resources in the Kankakee Basin will occur from the expansion of industry and urban population both within and outside of the Basin. The demands on water supplies, wastewater treatment plants, and recreation facilities can be met by timely planning and construction. The threat of urban flood damages can be essentially eliminated by careful application of land-use management principles through zoning, subdivision regulations, and building code provisions. Although many farms will eventually be displaced by recreational and urban land uses, improvements in drainage, soil-water management, and flood damage control will preserve agricultural output. All these elements will insure healthy and continued economic growth.

FIG. 39 GENERAL PLAN