SURFACE-WATER HYDROLOGY

The surface-water resources of the Kankakee River Basin include the mainstem Kankakee River; its principal tributaries, the Yellow and Iroquois Rivers; an extensive network of smaller tributary streams and ditches; several large natural and man-made lakes; scores of smaller lakes and perhaps hundreds of ponds and man-made excavations; and scattered remnants of *marshes, swamps* and other wetlands.

These surface-water features constitute a significant part of the hydrologic cycle (figure 2), a continual movement of water between the atmosphere and earth. The hydrology of streams, lakes and wetlands is closely related not only to precipitation, but also to topographic, *geomorphic* and hydrogeologic conditions.

HISTORICAL PERSPECTIVE

The hydrology of the Kankakee River Basin has undergone significant changes since the region was first settled in the early 1800s. Drainage of the Grand Kankakee Marsh and *channelization* of the Kankakee River dramatically altered the hydrology of the main river valley. Moreover, the combined impacts of tiling, ditching and related drainage activities further modified local and regional hydrology in areas adjoining the main valley and in many areas of the Yellow and Iroquois River subbasins.

A historical overview of major drainage and flood protection projects provides a broad perspective for assessing potential constraints and impacts of future water and land development. Although many books and reports have been published concerning the history, navigability and channelization of the Kankakee River, only a few major references are cited in this discussion.

The following summary of early history was derived primarily from reports by Campbell (1882), Doggett (1933), Meyer (1936), and U.S. Army Corps of Engineers (1944). Other significant historical accounts are provided by Ball (1900), U.S. Department of Agriculture (1909), Andrews and Andrews [1915], U.S. House of Representatives (1916, 1931), U.S. Army Corps of Engineers (1941), State of Illinois (1954), Conway (1964), and Houde and Klasey (1968). Reports by Bhowmik and others (1980) and Machan (1986) also contain historical summaries.

Early and recent history

The Kankakee River of today bears little resemblance to the naturally meandering river which once traversed the marshy valley lowlands. In its natural state, the Kankakee River upstream of Momence, Illinois followed a sinuous 250-mile course through the wide, 90-mile-long river valley. The natural Kankakee River upstream of Momence had about 2000 bends (Kankakee Valley Draining Company, 1871b) and an average channel slope of about 4 or 5 inches per mile.

The meandering nature of the Kankakee River was produced by many basin characteristics, including: 1) the nearly flat gradient of the geomorphically oversized river valley; 2) the loose, sandy sediments of the valley floor; 3) the presence of wetland vegetation; and 4) the frequent occurrence of floods. These and other factors, such as the high *water table*, also combined to produce a maze of *sloughs* and *oxbows* along the river corridor (Meyer, 1936).

A vast marsh and wooded swamp occupied most of the Kankakee River valley and adjoining lowlands. The area often termed the Grand Kankakee Marsh referred to the marsh-swamp-dune complex which extended from the river's headwaters near South Bend, Indiana to the outcropping limestone ledge in the riverbed near Momence, Illinois, located about 7 miles west of the state line. Figure 21 shows the approximate extent of the marsh in Indiana prior to the massive drainage and channelization projects of the late 1800s and early 1900s.

According to many historic acounts, the Grand Marsh covered more than 400,000 acres, or 625 square miles. The main body of the Grand Marsh was from 3 to 10 miles wide, and smaller arms extended 5 to 10 miles farther out into many tributary valleys and low-lying areas of the floodplain. Isolated dunes and sand ridges, some up to 30 feet high, dotted the interior of the vast marsh, appearing as wooded islands in a sea of aquatic sedges and grasses, marsh hay, wild rice, cattails, and other wetland plants.

A strip of swamp timber bordered the river downstream of the former English Lake (figure 21). Dominant tree species included silver maple, black ash, white ash, and elm. The swampy river corridor averaged about one-half to one mile in width, and reached its maximum width of nearly 3 miles in northern Jasper

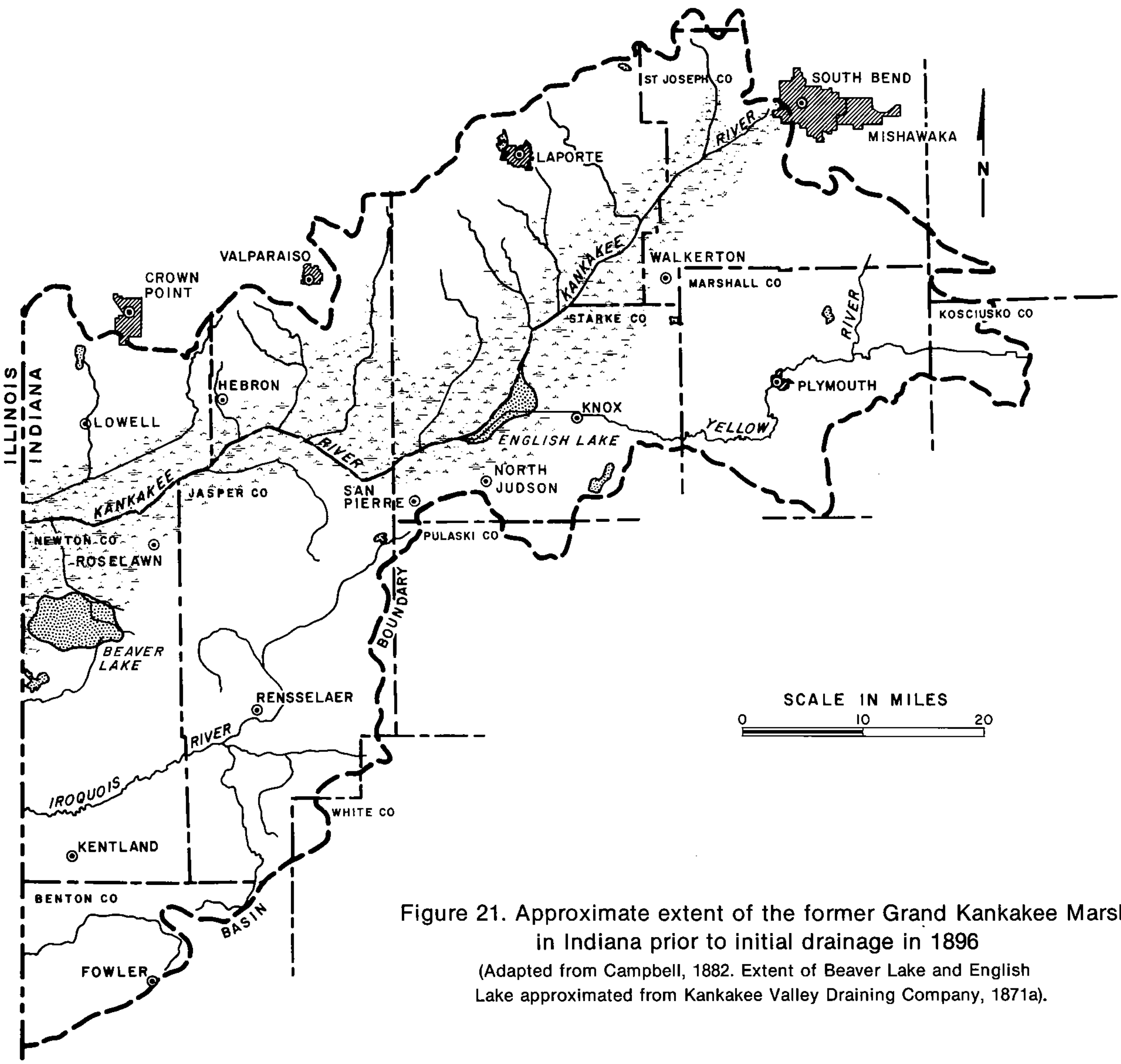

Figure 21. Approximate extent of the former Grand Kankakee Marsh in Indiana prior to initial drainage in 1896
(Adapted from Campbell, 1882. Extent of Beaver Lake and English Lake approximated from Kankakee Valley Draining Company, 1871a).

County, southwest Porter County and southeast Lake County.

For 8 to 9 months of the year, about 1 to 4 feet of water covered a 3- to 5-mile-wide area on either side of the river. The sluggish river and its adjoining marshes thus assumed many characteristics of a wide, shallow lake.

The Grand Kankakee Marsh teemed with wildlife. The Kankakee River and its adjoining open-water areas supported a large number of game fish, including largemouth and smallmouth bass, northern and walleye pike, pickerel and catfish. Millions of waterfowl used portions of the marsh for resting, feeding and nesting. The diversified habitat of the marsh attracted fur-bearing animals such as muskrat, mink, beaver, fox, weasel and raccoon. Squirrel, rabbit, quail, prairie chicken, woodcock, white-tailed deer and other game animals inhabitated the dunes, sand ridges and other uplands. Woodland and wetland habitats also supported a variety of non-game mammals, birds and other animals.

The natural abundance of the marsh's flora and fauna provided a haven for the Pottawatomi and other native Indian tribes. French explorers, voyageurs and missionaries traveled on the Kankakee River as early as the 1670s (Baker, 1929). During the 17th and 18th centuries, hunters and trappers established temporary settlements along the river.

Treaties in 1832 and 1836 ended the Pottawatomi's occupancy of the Kankakee River valley and transferred the tribe to a reservation in Kansas. The first white frontiersmen subsequently entered the valley, seasonally or temporarily occupying uplands bordering the river's marshes and the low dunes and sand ridges within the marsh. By the 1850s and 1860s, farmers, loggers, cattle stockmen and other settlers had replaced the migratory hunters and trappers, and had established permanent settlements throughout the valley.

The Kankakee River was commonly used for transportation, particularly in its lower reaches, and the clear river water provided a valuable source for ice harvesting. At Momence and several other locations in Illinois, the river was used to power grist mills and saw mills. The river also provided many recreational opportunities, including fishing, swimming, boating and ice skating.

By the middle 1800s, the Grand Kankakee Marsh had become widely known as a "sportsman's paradise." Hunting lodges were built along the river corridor by sportsmen's clubs based in the Great Lakes region and the East Coast. The river and its associated marshes attracted U.S. presidents and even European nobility who sought hunting and fishing opportunities.

Although sportsmen, naturalists and other outdoorsmen valued the Kankakee River's vast marshlands, many landowners needed well-drained land for agricultural production and other development. As the population increased in the valley, marshlands began to be converted into tracts of drained farmland.

Early attempts to drain portions of the Grand Kankakee Marsh for agricultural development took many forms and met with varying degrees of success. Pioneer farmers in the early to middle 1800s drained small tracts of land by digging ditches, first by hand and later with the help of oxen and horses.

In 1852, the Governor of Indiana proposed draining the Kankakee's marshes to create new agricultural lands. Early attempts to drain an elevated portion of the Grand Marsh known as the Beaver Lake District met with limited success, however, and early agricultural efforts in the area failed. In later decades, however, the large, shallow lake (figure 21) and most of the surrounding marshes were totally drained.

The expansion of state drainage statutes in 1869 and 1871 and the invention of the steam dredge paved the way for large-scale drainage projects in the Kankakee River Basin. Construction of Singleton Ditch in the 1880s was the first of many large ditching and dredging projects completed under Indiana drainage statutes.

In 1889 and 1891, the Indiana legislature appropriated funds to lower the limestone ledge that outcrops in a 2-mile reach of the Kankakee River bed near Momence, Illinois. In 1893, the ledge was partially excavated, and the channel was widened and deepened in an effort to facilitate drainage upstream in Indiana.

Channelization of the mainstem Kankakee River began in 1896, nearly 30 years after it had been first proposed by a private draining company (Kankakee Valley Draining Company, 1869). Although construction of a 7-mile ditch near South Bend was conducted by private interests, the remaining channelization work was completed under state drainage statutes.

By 1917, the entire length of the Kankakee River in Indiana had been channelized. The sinuous, 250-mile-long river had been converted to a series of seven relatively straight dredged ditches extending about 82 miles from near South Bend downstream to the Indiana-Illinois state line. The river's flow was now confined to a well-defined channel bordered in many places by high spoil banks which topped the natural streambanks.

Moreover, the Kankakee River channelization projects and the subsequent construction of lateral and subsidiary ditches throughout the river valley had converted most of the 625-square-mile Grand Kankakee Marsh to agricultural development, and had increased drainage on more than 900 square miles of marginal land bordering the marsh. By the early 1900s, only about 39 square miles (6 percent) of the original marsh remained in Indiana.

The hydrologic effects of the channelization and drainage projects have long been a topic of debate among engineers, hydrologists, sportsmen, conservationists, farmers, government officials, and others interested in the basin's water resources. Although a lack of historical data prevents a quantitative analysis of stream-flow modifications incident to the drainage projects, interpretations can be made on the basis of hydrologic principles and a recognition of watershed features (see box on next page).

Hydrologic effects of drainage projects

Prior to the channelization, dredging and ditching projects of the late 1800s and early 1900s, soils in the Kankakee River valley were seasonally saturated as a result of the region's high water table. Water often was ponded in surface depressions by runoff and ground-water seepage from tributary basins.

During storm events, the water depth on the valley floor and its bordering marshlands would have increased as the water table rose and tributary runoff was stored in the low-lying areas of the Kankakee River corridor. *Overland flow* would have been obstructed on the floodplain and its bordering marshes by slight topographic rises and dense vegetation, helping to reduce floodwater velocities and attenuate flood peaks.

Following the extensive ditching and dredging projects, the water table was lowered in the Kankakee River valley, and the once-saturated soils were drained. Under certain hydrologic conditions, the unsaturated soils and drained surface depressions could provide temporary storage of precipitation during storm events and perhaps during the early stages of floods. This available storage could therefore contribute in some cases to the further attenuation of flood flows along the Kankakee River.

Once the drained soils become saturated, however, ditches and tile systems transport excess water to drainage outlets, and ultimately to the mainstem Kankakee River. The improved runoff efficiency and the confinement of floodwaters between spoil banks along the straightened Kankakee River can serve to increase flood stages, floodwater velocities and peak flows.

Because stream gages near Shelby, Indiana and Momence, Illinois were not installed until the massive drainage and channelization work was nearly complete, no studies can be conducted to determine actual differences in flood-flow characteristics under pre- and post-channelization conditions. Moreover, any speculations regarding flow modifications are complicated by the unique combination of topographic, geomorphic and hydrologic features of the Kankakee River valley.

As discussed in a later subsection of this chapter entitled ***Flood Flows***, the valley's nearly flat gradient and the availability of an unusually large amount of overbank storage are among the factors which help attenuate flood peaks on the mainstem Kankakee River. According to an investigation by Dodson, Kinney and Lindblom (1968), the frequency and duration of overbank flooding probably did not change significantly following the channelization and ditching projects. However, their report did not describe potential changes in either flood stage or discharge.

A report by the Kankakee River Basin Commission (1989) noted a long-term historical increase in **annual peak flows** at the Davis and Shelby gages during the post-channelization period 1926-86. A report by the Illinois Water Survey (Bhowmik and others, 1980) similarly concluded that 3-year *moving averages* of annual peak flows at the Shelby gage in Indiana and the Momence gage in Illinois showed an increasing trend during the post- channelization period 1931-79. Moving averages of **annual average flows** at the Momence and Wilmington gages in Illinois also showed an increasing trend. No discernible trends could be identified for other gaging stations on the Kankakee and Iroquois Rivers.

It must be emphasized that these analyses did not include the 10 years immediately following completion of the channelization and drainage projects. Because alterations in stream-flow characteristics would be expected to stabilize shortly after the projects had been completed, the observed trends in peak and annual average flows may be the result of continuing natural and man-made changes in the basin.

Changes in precipitation patterns are among the natural factors that may increase peak flows in a given drainage basin. The investigation by Bhowmik and others did not detect any trends in annual precipitation within the Kankakee River Basin as a whole during the period 1931-79. However, because the interactions between precipitation and stream flow are so complex, Bhowmik's analysis of annual precipitation seems inadequate without a further investigation of local and regional storm patterns. A more thorough precipitation analysis might have revealed changes or peculiarities in the frequency, intensity or spatial distribution of flood-producing storm events.

Man-made factors that may be responsible for the increasing trend in peak and average flows along some reaches of the Kankakee River include the ongoing drainage and pumping projects in tributary watersheds and in the main valley. Another potential factor is the construction, enlargement, and improvement of private levees and dikes. Increased pumping and the

In the decades following the Kankakee River channelization and other major ditching projects, drainage work continued on a smaller scale to further enhance agricultural production and help reduce flooding. Many projects in tributary basins were conducted through local drainage boards.

The density of drainage ditches has been partially determined by topography, soils, and the value of farmland. In some parts of the main valley, dredge ditches have been constructed on each section line. Some areas of prime farmland have even denser drainage networks. Pumping stations often are used to facilitate agricultural drainage.

In general, the construction of drainage networks has allowed the successful cultivation of many crops, and the Kankakee River Basin continues to be one of the most agriculturally productive areas of Indiana. However, some small, mucky depressions and low-lying areas along a few streams still remain inadequately drained for profitable agriculture. These poorly drained tracts may be better suited to alternative uses such as wildlife habitat.

Levees and flood control

Flood protection along the Kankakee River historically has been provided to some extent by banks of dredge spoil from early channelization and ditching projects. Additional flood protection has been provided by the Williams and Brown Levees in southern Lake County, and by smaller levees along residential and resort communities located along lower reaches of the river.

Large areas of farmland in tributary basins are partially protected against flooding by agricultural dikes addition of levees can increase the volume of surface runoff while decreasing the amount of available storage. It is also possible that peak and average flows are merely approaching their maximum levels in a periodic cycle, and may exhibit a decreasing trend in coming decades.

An analysis of potential changes in **low-flow characteristics** in the Kankakee River Basin was conducted by Bhowmik and others (1980). Contrary to some expectations, no discernible trend was detected.

In general, draining the soil profile and removing expanses of wetland storage along a river such as the Kankakee would have been expected to reduce low flows. Increasing the efficiency of surface drainage also would have been expected to reduce low flows by reducing the amount of water available to stream systems on a short-term basis as *bank storage*. Moreover, lowering of the local water table in a basin by ditching, tiling and dredging would have been expected to reduce the amount of ground water available for sustained seepage to streams during prolonged dry spells.

The absence of any noticeable changes in low flows in the Kankakee River Basin may be the result of the high degree of ground-water discharge to the river and some of its major tributaries. Other factors might include the hydrologic properties of soils and underlying geologic materials, or changes in flow characteristics of the river itself.

Because drainage modifications within the Kankakee River's tributary watersheds can be complex, and because discharge data typically are unavailable, no conclusions can be drawn concerning flow trends on tributary streams and ditches. Localized flow changes along these watercourses will largely depend on geomorphic factors and on manmade activities such as surface-water and ground-water pumpage, the operation of *water-table control structures*, diversions, and discharge of wastewater effluent.

Changes in **sediment-transport** characteristics downstream of the channelized reaches have been difficult to quantify (see Gross and Berg, 1981). Documented statements typically have been of a qualitative or subjective nature.

A study by the U.S. Army Corps of Engineers (U.S. House of Representatives, 1931) noted that channelization of the Kankakee River in Indiana increased the flow so that, at least initially, more sand and silt were being carried downstream into Illinois upstream of Momence, depositing among trees and creating sand bars in the riverbed. Although not mentioned in the 1931 report, the river's increased sediment load following channelization also could be attributed to 1) the loose, sandy nature of the soils, 2) caving of unstable sandy streambanks, 3) sloughing of spoil banks, 4) streambed scour, and 5) sedimentation from eroding cropland.

Sedimentation in the mainstem and tributary ditches created an ongoing need for ditch reconstructions and channel-cleaning activities in the decades following the major ditching and dredging projects. Between 1906 and 1915, for example, many shoals had formed in the first five segments of the straightened Kankakee River, thereby reducing the river's depth in places (U.S. House of Representatives, 1916).

In 1925, about 23 miles of the Kankakee River upstream of Dunns Bridge were redredged, but there continued to be evidence of considerable sedimentation (Frazier and Sapirie, 1934). More than 3 feet of sediment was reported to have accumulated above the original bottom grade of the channelized Kankakee River at some points in its middle to lower reaches (Doggett, 1933). Doggett's report also noted that some tributary drainage ditches had shoaled to half their original depth, and in some places were overgrown with weeds and other aquatic plants.

A report by the U.S. Army Corps of Engineers (1941) noted that large quantities of sand had been deposited between the state line and Momence, Illinois, thus reducing low-flow depths to less than 1 foot. However, the rate of siltation between the state line and Momence was reported to have decreased, perhaps indicating that the straightened channel in Indiana was stabilizing.

A report by the Illinois State Water Survey (Gross and Berg, 1981) concluded that sedimentation resulting in sand bars, *spit* extensions, and island growth had attained some stability by the early 1950s. Increasing stabilization of *accretionary* sand deposits during the period 1954-73 attested to the stabilizing condition of the Kankakee River. Moreover, the geometric form of the channelized Kankakee River appeared to be nearly stable, based upon the virtual absence of post-channelization river meandering.

and spoil-bank levees formed by dredge material (spoil) from ditching and channel maintenance projects. Ditch-and-levee systems often are supplemented by pumping stations intended to deliver excess water to major drainageways.

Although continuous ridges of spoil banks can act as levees, the degree of flood protection can be quite variable, particularly in areas bordered by agricultural dikes. Spoil-bank dikes and levees vary greatly in height and cross section because of the haphazard placement of dredge material and because the levees usually have been constructed without coordination among local groups.

In many places, spoil-bank levees are interrupted by drainage ditches and abandoned stream channels. Moreover, the sandy, debris-laden dredge spoil is highly susceptible to seepage and erosion. These factors, combined with limited local maintenance and clogged drainage ditches, can result in the failure of spoil-bank levees during floods.

The repair of levees and spoil banks has been one method for reducing flood damage along the Kankakee River. During the 1950s and 1960s, for example, the U.S. Army Corps of Engineers financed or supervised a number of levee inspection and repair projects in Lake and Newton Counties. However, subsequent reports (U.S. Army Corps of Engineers, 1979, 1984) noted that a general lack of maintenance continues to reduce the effectiveness of levees and spoil banks for flood protection.

Developments since 1970

Because of recurring flood problems in the Kankakee River Basin and local concern over water- and land-related resources, a joint federal-state study of the region was conducted in the early 1970s. The study was led by the U.S. Department of Agriculture's Soil Conservation Service, but involved six other agencies, including the Indiana Department of Natural Resources and the U.S. Geological Survey.

The investigation addressed resource-related problems whose solutions would require a cooperative effort among government agencies and basin residents. The final report of the investigation (U.S. Department of Agriculture, 1976) contained five planning alternatives for land and water development. A combination of plan elements was formulated as a 13-point suggested plan.

Major features of the plan included the following: 1) proposed channel work for flood control and drainage on 26 miles of the upper Kankakee River mainstem and more than 240 miles of 13 tributaries, with levees (and no channel work) along 49 miles of the Kankakee River from U.S. Highway 30 in LaPorte and Starke Counties downstream to U.S. Highway 41 in Lake and Newton Counties; 2) amendments or adoption of floodplain zoning ordinances and building codes to allow eligibility for flood insurance; 3) an accelerated land-treatment program to help facilitate on-farm drainage, reduce soil erosion, and increase agricultural production efficiency; 4) implementation of land-use changes to help ensure sustained agricultural capabilities; 5) proper management and conservation of fish, wildlife, woodland and wetland habitat; and 6) development of recreational areas, trails and water-access sites.

Although not directly implemented, the suggested plan elements were used as a guide by the Kankakee River Basin Commission, which was formed in 1977 by the Indiana General Assembly. The main purpose of the 24-member commission is to address water-resource development issues, including flood-control and drainage problems, in an eight-county area along the Kankakee River and its major tributary in Indiana, the Yellow River.

The Kankakee River Basin Commission received an appropriation in 1979 from the Indiana General Assembly to clear and snag debris from the Kankakee and Yellow Rivers, and to improve damaged or inadequate dikes and levees. Spoil-bank levees near Shelby were repaired, and some minor clearing and snagging was completed on a short stretch of the Yellow River. However, the U.S. Army Corps of Engineers denied the commission a permit to clear and snag the mainstem Kankakee River on the grounds that increased floodwater velocities, increased sediment loads, and environmental damage downstream of the project would outweigh flood protection benefits in the project area. Reports by the U.S. Army Corps of Engineers (1982a, b) contain environmental assessments of the proposed project.

Following such attempts to conduct channel maintenance, the commission adopted a new set of guidelines (Kankakee River Basin Commission, 1983). The guideline resolution incorporated comments from representatives of the agricultural community, environmental organizations and state government.

Since 1983, the commission has cooperated with various organizations in developing a master plan which proposes four basic elements for implementation in the coming decades, namely: 1) flood control and protection along the Kankakee River through the development of a widely spaced levee system; 2) improvement of agricultural drainage in 39 tributary basins; 3) improved land-treatment practices and suggested land-use alternatives for some agricultural lands; and 4) enhancement of natural areas, wildlife habitats and recreation facilities (Kankakee River Basin Commission, 1989).

The proposed levees described in the master plan would be located on both sides of the Kankakee River. The levee system would extend for a length of about 60 miles, from U.S. Highway 30 in LaPorte and Starke Counties downstream to the Indiana-Illinois state line.

Unlike conventional levees, which are constructed on or near the riverbank, the proposed levees would be set back from the river at varying distances to allow *overbank* storage of floodwater in low-lying lands between the levees. The proposed levee system would provide flood protection for nearly 110 square miles (70,000 acres) of floodprone land while containing waters from a *100-year flood* event on approximately 48 square miles (30,714 acres) of land between the levees.

A computer model developed by the Soil Conservation Service and the IDNR Division of Water has been used to establish the approximate location and height of the proposed setback levees. The levees would be located as close to the river as 150 feet and as far back as 2 miles, depending on local topography, land-use practices, and the hydrologic requirements for storing floodwaters.

Proposed levee heights would vary from 2 to 11 feet depending on local grade elevations and the proposed floodwater-storage requirements. Levees are not being planned in areas where sufficiently high ground is located at or near the proposed levee alignment.

Reconstruction of Williams Levee, which is considered as the first phase of the wide levee plan, was completed in Lake County in 1988. A tributary pumping project, known as the Bailey-Cox-Newtson Watershed Project, was completed in Starke County in 1984, and will be incorporated into the wide-levee plan if it is implemented.

If constructed, the proposed levee system should improve agricultural drainage on nearly 700 square miles (447,805 acres) throughout 39 tributary drainage basins. The drainage would be accomplished through the use of tributary control gates, pumping stations, and levees along the tributaries back to high ground.

The proposed project also would provide opportunities for additional recreational development and the potential enhancement of fish, wildlife, woodland and wetland habitats along some segments of the river corridor. These goals would be accomplished primarily through management practices, acquisition, and land-use changes on selected lands lying between the proposed levees (Kankakee River Basin Commission, 1989).

As of July 1990, elements of the Kankakee River master plan are under review by the Kankakee River Basin Commission and the Indiana Department of Natural Resources. Individual projects compatible with the setback-levee concept are possible, but the future of the proposed levee system remains uncertain.

SURFACE-WATER RESOURCES

Streams of the Kankakee River Basin not only supply large quantities of water for withdrawal uses such as irrigation and public supply, but also provide water for non-withdrawal uses such as instream recreation. Wetlands and lakes typically are not considered as potential water-supply sources, but their occurrence and regulation directly affect land use and its associated water resources development.

Wetlands

Wetlands are a major hydrologic feature of the Kankakee River Basin. In general terms, wetlands occur where the ground-water table is usually at or near the ground surface, or where the land is at least periodically covered by shallow water. Because the water's presence creates a unique environment, wetlands support plants and animals specifically adapted for life in water or saturated soil.

Wetland types in Indiana can be grouped according to the classification scheme used by the U.S. Fish and Wildlife Service (Cowardin and others, 1979; Cowardin, 1982; U.S Fish and Wildlife Service, 1986). The structure of this classification is hierarchical, progressing from the most general levels of systems and subsystems to the more specific levels of classes and subclasses. The latter two levels in the hierarchy can be further subdivided according to water regime (duration and frequency of flooding), water chemistry, soil type, and dominant plants or animals.

Wetlands in Indiana belong to three of the five major wetland systems identified by Cowardin and others (1979). **Lacustrine** wetlands include permanently flooded lakes or reservoirs of at least 20 acres, and smaller impoundments whose maximum depths exceed 6.6 feet at low water. **Riverine** wetlands are contained within a natural or artificial channel that at least periodically carries flowing water. **Palustrine** wetlands are associated with areas and/or shallow bodies of water which usually are dominated by wetland plants. Palustrine wetlands include not only vegetated wetlands commonly called *marshes, swamps, bogs, sloughs,* or *fens,* but also isolated catchments, small ponds, islands in lakes or rivers, and parts of river floodplains. Palustrine wetlands also may include farmland that would support *hydrophytes* if the land were not tilled, planted to crops, or partially drained.

A comprehensive inventory of Indiana's wetlands was initiated in 1981 by the U.S. Fish and Wildlife Service as part of its National Wetlands Inventory. The inventory process involves identifying and classifying wetlands from high-altitude aerial photographs, then transforming the photographs into detailed maps (1:24,000 scale). The location and classification of each wetland then is digitized and stored in a computer. The computerized data will be accessible for analysis through the use of a geographic information system.

The Indiana Department of Natural Resources, Division of Fish and Wildlife entered a cost-share agreement with the U.S. Fish and Wildlife Service in 1985 for mapping and digitizing Indiana's wetlands. The statewide aerial photography was completed in 1988, and the mapping and digitizing was completed in 1990.

Because preliminary data on Indiana's wetlands were needed during the inventory's early stages for ongoing wetland conservation efforts, the Division of Fish and Wildlife initiated two studies between 1984 and 1986 to determine the abundance of wetlands in northern Indiana (Rolley and New, 1987) and east-central Indiana (figure 22). Wetland acreages were estimated using draft wetland maps and enlargements of interpreted aerial photographs from the U.S. Fish and Wildlife Service's National Wetlands Inventory. The estimates were extrapolated from a random sample of about 3 percent of the 1-square-mile sections occuring within the study regions.

In another investigation conducted by the Indiana Department of Natural Resources (1988c), the degree of wetland loss by natural processes and human activities over the past 200 years was determined by comparing estimates of current wetland acreage with estimates of original wetland acreage. The original extent of wetlands was estimated using *hydric soils* data supplied by the U.S. Soil Conservation Service.

The IDNR report concluded that nearly 2200 square miles of wetlands have been eliminated in the Kankakee and Wabash River Drainage Area, one of the four regions studied (figure 22). This value represents an 88 percent loss of the original wetland acreage within the study region, which encompasses much of the Kankakee River Basin (figure 22).

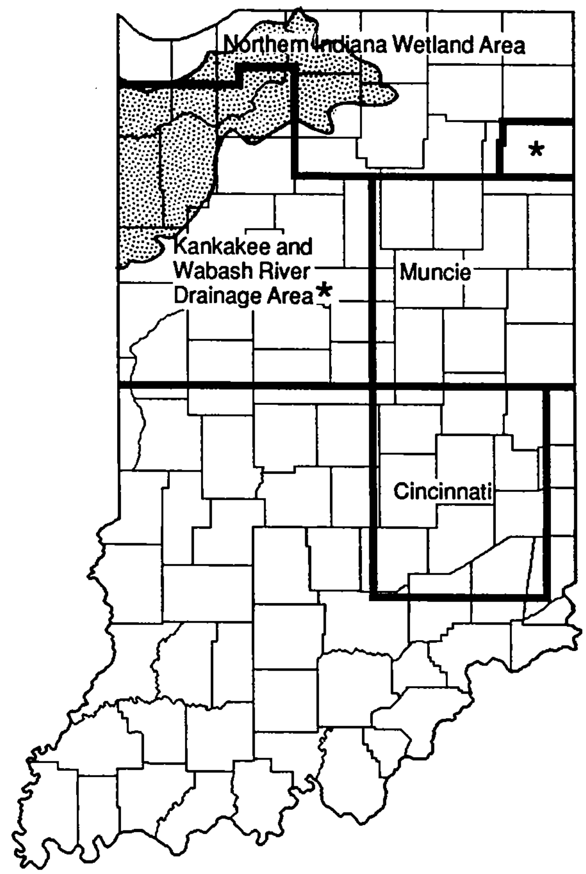

Figure 22. Location of wetland study regions

Inventory of basin wetlands

The number and acreage of wetland types remaining today in the Kankakee River Basin were estimated using the preliminary database developed by Rolley and New (1987) for the Kankakee and Wabash River Drainage Area and the Northern Indiana Wetland Area (figure 22). Estimates of in-basin wetlands were extrapolated from a 3-percent random sample of 76 1-square-mile sections in the 83 legal townships that approximately encompass the basin.

Although this sampling scheme yields reasonable estimates of the total number and acreage of the basin's wetlands, some values for specific wetland categories should be interpreted with caution. These preliminary results will be updated when a statewide geographic information system with a digital wetlands inventory becomes operational.

According to the preliminary estimates, the Kankakee River Basin contains about 17,000 to 27,000 wetlands covering a total of approximately 100 to 200 square miles (table 12), or roughly 5 percent of the basin's total land area. Palustrine wetlands constitute more than 96 percent of the basin's wetlands, and about 95 percent of the total wetland area. Riverine and lacustrine wetlands account for about 2 and 3 percent of the basin's total wetland area, respectively.

Palustrine forested and palustrine emergent wetlands together constitute nearly 75 percent of the basin's wetlands and about 81 percent of the wetland area (table 12). Staff of the IDNR have preliminarily identified these wetland classes as state priority wetland types (Indiana Department of Natural Resources, 1988c).

Palustrine forested wetlands are characterized by large, woody vegetation that is at least 20 feet tall. Palustrine emergent wetlands, commonly called marshes, meadows, fens or sloughs, are characterized by erect, rooted, *herbaceous* hydrophytes, excluding

Table 12. Estimated number and area of basin wetlands

{Values are preliminary estimates of the Indiana Department of Natural Resources, Division of Fish and Wildlife, as based upon maps and aerial photographs obtained from the U.S. Fish and Wildlife Service's National Wetlands Inventory.}

Wetland classification: Classification follows the system described by Cowardin and others (1979).

Estimated number, estimated area: Lower numbers, in italics, represent the 95 percent confidence interval.

Wetland classification	Estimated number	Percent of total	Estimated area (sq. mi.)	Percent of total
Palustrine, aquatic bed	275 *213*	1	1.4 *0.7*	1
Palustrine, emergent	9,950 *2,590*	46	52.8 *16.8*	35
Palustrine, forested	6,017 *1,677*	28	69.6 *22.0*	46
Palustrine, open water	3,382 *1,055*	16	7.1 *2.6*	5
Palustrine, scrub shrub	1,298 *533*	6	11.5 *3.9*	8
Riverine, lower perennial, open water	747 *377*	3	3.4 *1.4*	2
Lacustrine, limnetic, open water	118 *136*	1	4.6 *1.8*	3
Total	21,788 *5,314*	100	150.5 *47.2*	100

mosses and lichens. In emergent wetlands, hydrophytic vegetation is present for most of the growing season in most years.

The greatest number of palustrine forested and emergent wetlands in the Kankakee River Basin occur in the morainal and outwash areas of St. Joseph, Marshall, and northeastern LaPorte Counties. The largest tracts of contiguous palustrine wetlands are located along the middle and lower Kankakee River corridor. The five state-owned fish and wildlife areas located along or near the river contain broad zones of forested and emergent palustrine wetlands.

Open-water palustrine wetlands account for about 16 percent of the basin's wetlands, but account for only about 5 percent of the total wetland area (table 12). These wetlands typically include shallow lakes and excavated ponds, but also may include sloughs and *oxbow lakes* of the lower Kankakee River valley.

Wetlands in the Kankakee River Basin can be further characterized by the duration and timing of surface inundation, using the classification scheme described by Cowardin and others (1979). According to preliminary estimates based on this classification, about three-fourths of the basin's wetlands are either seasonally flooded (47 percent) or temporarily flooded (28 percent). About 12 percent of the basin's wetlands are semi-permanently flooded, and about 10 percent are either saturated or permanently flooded. The box on the next page describes these five wetland categories.

Water regime of wetlands in the Kankakee River Basin

Seasonally flooded wetlands contain surface water for extended periods, especially early in the frost-free crop growing season, but usually become dry by season's end. When surface water is absent, the ground-water table often is near the land surface.

In **temporarily flooded** wetlands, surface water is present for brief periods during the growing season, but the ground-water table usually lies well below the land surface for most of the season. Plants that grow both in uplands and wetlands are characteristic of the temporarily flooded regime.

Semi-permanently flooded wetlands contain surface water throughout the growing season in most years. When surface water is absent, the ground- water table is usually at or near the land surface. The basin's semi-permanently flooded wetlands typically are found along river corridors or adjacent to the larger lakes.

In **saturated** wetlands, such as fens, ground water is at the land surface for extended periods during the growing season, but surface water is seldom present.

In **permanently flooded** wetlands, water covers the land surface throughout the year in all years. Riverine and lacustrine systems constitute the majority of permanently flooded wetlands.

Wetlands in the Kankakee River Basin also can be described by size category. According to preliminary estimates, about 4 percent of the basin's individual wetlands are one acre or smaller; 42 percent are between one acre and 10 acres; 42 percent are between 10 and 40 acres; and 12 percent are greater than 40 acres. Lacustrine wetlands probably constitute most of the larger wetlands, although some palustrine wetlands along the Kankakee River corridor and a few remnant natural areas containing wetland complexes are fairly extensive.

Wetland protection programs

Once perceived as "wastelands," Indiana's wetlands historically have been ditched, dredged, tiled or filled to allow for agricultural production and other economic development. Although the perception of wetlands as barren or useless land still persists, there is a growing awareness of the valuable functions of wetlands.

Wetlands not only play a role in the hydrologic cycle (figure 2), but also provide a wide range of benefits, including floodwater retention, water-quality protection, erosion control, fish and wildlife habitat, and recreational and aesthetic opportunities (see box on next page). Although no studies have been conducted on the economic value of wetlands in the Kankakee River Basin, Indiana, an economic assessment was published for the Momence Wetlands, a 6-mile, 1900-acre swamp-marsh-upland complex located along the Kankakee River just west of the Indiana-Illinois state line (Mitsch, Hutchison and Paulson, 1979).

In general, wetland values have largely been overlooked until recent years, when state and federal agencies developed or expanded programs that at least indirectly afford some protection for wetlands. These state and federal programs generally are designed to balance the need for wetland protection with developmental and drainage needs. Appendix 4 summarizes selected programs having a good potential for protecting the wetlands of northern Indiana, including the Kankakee River Basin.

The Indiana Flood Control and Lake Preservation Acts and the federal 404/401 permit process afford some protection to wetlands that meet specific criteria. Because the number and extent of wetlands protected through these regulatory programs are limited, however, non-regulatory programs involving land acquisition and voluntary measures often are the major factors in wetland protection.

Changes in land use are limited on lands acquired for specific purposes, such as parks or nature preserves. Moreover, many financial incentive programs and public-private partnership programs discourage certain developments or land-use changes that would harm wetland habitats.

In the Kankakee River Basin, significant wetland tracts totaling about 3 square miles are being protected on the following state-owned properties: 1) Menominee, Round Lake and Koontz Lake wetland conservation areas in Starke and Marshall Counties; 2) Kankakee Fen (St. Joseph County), Fish Creek Fen (LaPorte County), and Beaver Lake (Newton County) Nature Preserves; and 3) Potato Creek State Park (St. Joseph County).

More than 14 natural areas containing small but significant wetland tracts are being protected voluntarily through the Indiana Natural Areas registry as of early 1990. Some partially protected wetlands also are located in Lake County's 1.5-square-mile Grand Kankakee Marsh County Park and in other county and municipal parks along the Kankakee and Yellow Rivers.

Several contiguous tracts of floodplain forest and/or artificially manipulated wetlands are found in LaSalle, Willow Slough, Kankakee, Jasper-Pulaski and Kingsbury State Fish and Wildlife Areas. A total of about 10 square miles of marshes and open-water areas have been constructed or restored on these properties. In addition, a total of about 10 square miles are composed of floodplain forests and seasonally flooded lands, including cropland.

In general, water levels in the artificial wetlands and

Wetland values and benefits[1]

Wetlands as a landform provide a unique **water storage** function in river basins by temporarily retaining water in upstream reaches and slowing its release to downstream reaches. During flood periods, the storage capacity of the low-lying areas characteristic of wetlands can help to decrease floodwater velocity and increase the duration of flow, consequently reducing flood peaks. During dry periods, some of the stored water may discharge into the main river channel, thereby helping to maintain stream flow.

The beneficial water storage provided by the former Grand Kankakee Marsh was recognized in a report by the U.S. Army Corps of Engineers (U.S. House of Representatives, 1916). The report noted that the marsh and the permeable soils acted as a shallow reservoir, impounding waters from the watershed upstream of Momence, Illinois during highwater periods, then slowly releasing the waters to downstream reaches.

In the present-day Kankakee River valley, the floodwater storage provided by wetlands and other depressional areas helps reduce the velocity of overland runoff and attenuate flood peaks. Because some depressional areas have no defined drainage outlet, they do not contribute directly to surface runoff during flood events. Many of these noncontributing areas may contain lakes, ponds or other wetlands.

Under certain conditions, water from wetlands situated within a regional topographic high may supplement **ground-water recharge** at certain times of the year. Local ground-water recharge may occur in the vicinities of Pine Lake and adjacent lakes in the city of LaPorte, and Bass Lake in Starke County.

In most of the Kankakee River Basin, however, lakes and other wetlands primarily act as areas of **ground-water discharge**. These wetlands typically have formed where the ground surface intersects the *water table*. Wetlands are most likely to serve as ground-water discharge points at depressional lakes and along major river systems where regional ground-water flow patterns are toward the main channels. Ground-water dicharge into floodplain wetlands is especially significant during dry periods because the ground-water seepage helps to maintain stream flow. Similarly, ground-water discharge into lacustrine and palustrine wetlands can help maintain water levels in these systems.

Wetlands can play an important role in **water-quality maintenance** and improvement by functioning as natural filters to trap sediment, recycle nutrients, and remove or immobilize pollutants, including toxic substances, that would otherwise enter adjoining lakes and streams. Although natural wetlands in Indiana cannot be used for wastewater treatment, a few artificial wetlands have been created to filter wastewater effluent. For example, just south of the Kankakee River Basin boundary at Lake Maxinkuckee, sediment traps are being built and wetlands are being restored to filter pollutants before they reach the lake. At Marsh Lake in extreme northeastern Indiana, artificial wetlands have been created to act as a natural wastewater treatment system. In the Kankakee River Basin, a project is underway at Koontz Lake that involves artificial wetland construction.

Wetlands play a role in **erosion control** along lakeshores and streambanks by stabilizing substrates, dissipating wave and current energy, and trapping sediments. Lakeshores frequently subjected to wave action generated by heavy boat traffic can especially benefit from the stabilizing effect of adjoining wetlands. Along the Kankakee River and its tributaries, riparian vegetation helps decrease scour of the sandy streambanks and spoil banks.

The value of wetlands as **fish and wildlife habitat** has long been recognized. Most freshwater fish species can be considered wetland-dependent because 1) almost all important game fish spawn in the aquatic portions of wetlands, 2) many fish use wetlands as nursery grounds, and 3) many species feed in wetlands or upon wetland-based food. A variety of game fish in the Kankakee River use the oxbows and sloughs for cover (Robertson and Ledet, 1981).

Hundreds of species of vertebrate animals found in Indiana require wetlands at some time in their lives. Muskrats and beavers are examples of common Indiana furbearers that are totally dependent on wetland environments.

The popularity of waterfowl hunting relates directly to the importance of wetlands as feeding, nesting, resting, and wintering grounds for waterfowl. Waterfowl habitat management is a primary purpose of the five state-owned fish and wildlife areas located within the Kankakee River Basin. The presence of wetland habitats within these and other areas has played a major role in the re-establishment and enhancement of nesting populations of giant Canada geese.

Wetlands in the Kankakee River Basin also provide habitat for many bird species. Migratory wetland-dependent species designated by the U.S. Fish and Wildlife Service as regional species of special interest include the wood duck, mallard, black duck, redhead, canvasback, several species of geese and swans, osprey, sandhill crane, woodcock, least tern, common tern, great blue heron, and bald eagle.

Heron rookeries are located in forested floodplain wetlands of the Kankakee River. In 1987, the Division of Nature Preserves identified a total of 261 nests at five rookeries along middle and lower reaches of the river corridor. Three of the rookeries were located on state-owned fish and wildlife properties.

In the southeast part of the Kankakee River Basin, wetlands and food plots at the Jasper- Pulaski Fish and Wildlife Area serve as major resting and feeding sites during the spring and fall migrations of the eastern population of sandhill cranes. It is estimated that about 90 percent of the sandhill crane population east of the Mississippi River uses the area as a semiannual stopover point.

Wetlands provide the natural habitat necessary for the survival of some endangered species. In Indiana, more than 120 plant species and 60 animal species that depend on wetlands at some time in their lives are considered as either endangered, threatened, rare or of special concern. In the Kankakee River Basin, a number of these state-listed plant and animal species depend entirely on wetlands for their continued existence.

Although the greater prairie chicken is now extirpated in Indiana, populations once thrived in an elevated area of the former Grand Kankakee Marsh known as the Beaver Lake District. This unique area and other regions south of the Kankakee River once contained a mixture of wet prairies, forested sandhills, and other prairie and savanna features. Today, only remnants of the prairie-grass communities remain along some railroad rights-of-way and highway corridors. Oak-savanna remnants occur only in isolated parcels.

Many **recreational activities** take place in and around wetlands, including hunting, fishing, nature study and birdwatching. Because of the aesthetic quality of wetlands, these lands often are key features of public parks and outdoor recreation areas. In the Kankakee River Basin, wetlands are an important visitor attraction at most state-owned properties and at many public and private parks, recreation areas, and natural areas.

[1]Portions of this discussion were adapted from a report by the Division of Outdoor Recreation (Indiana Department of Natural Resources, 1988c).

open-water areas on these properties are regulated by extensive systems of dikes, levees and water control structures. In late spring, certain tracts are drained to allow plantings of corn, buckwheat or millet as food for migratory waterfowl and other wildlife. Some of these food plots and other marshy or forested areas are later flooded to attract waterfowl during the fall migration and consequently to improve hunting.

A project involving the creation of artificial wetlands is being conducted at Koontz Lake in Starke County as part of the state lake-enhancement program. This program, administered by the IDNR's Division of Soil Conservation, provides financial assistance on a cost-sharing basis for projects that will improve water quality in public freshwater lakes by controlling sedimentation in the lake and its tributaries.

The IDNR's various wildlife habitat programs (appendix 4) are helping to protect, enhance or restore a small portion of Indiana's remaining wetlands. In addition, the 1990 state legislature appropriated $1 million to the IDNR for the purchase or restoration of Indiana wetlands. These programs, however, currently do not include any wetlands within the Kankakee River Basin.

Other state programs which may indirectly contribute to wetland protection but do not currently encompass basin wetlands include the Indiana waters program; the clean lakes program; and the natural, scenic and recreational rivers program. Non-regulatory federal programs which provide the potential for wetlands protection include the wetlands restoration program; the land and water conservation fund; the wildlife refuge system; the natural landmarks program; and various fish and wildlife programs, including the North American waterfowl management plan.

Lakes

Freshwater lakes are a distinctive feature of the Kankakee River Basin. Most of the basin's natural lakes probably were formed in depressions left by the irregular deposition of glacial drift. Other lakes, known as kettle-hole lakes, probably were formed by the melting of isolated masses of buried glacial ice. A few lakes which occur as part of a narrow lake chain may have been formed by the erosion and subsequent damming of glacial meltwater streams.

An unknown number of lakes in the Kankakee River Basin have been totally destroyed or greatly diminished in size by artificial drainage. Other lakes have been filled in gradually by natural or man-induced sedimentation and *eutrophication*.

Two of the largest natural lakes in Indiana once were located in the Kankakee River valley, but both lakes were destroyed by drainage activities. English Lake was a 12-mile long lake which was a wide, permanent spread of the Kankakee River in western Starke County (figure 21). It was the largest lake shown on early state maps, but was totally drained after the Kankakee River dredging project was inaugurated in the late 1800s.

Beaver Lake in northern Newton County once occupied the interior of a nearly flat, slightly elevated 50-square-mile basin surrounded by sand ridges and other high ground. By 1917, the large, shallow lake had been diminished to 16 square miles (Lindsey, 1966), and has since disappeared entirely as a result of successive drainage projects. Figure 21 shows the approximate location of the former lake.

Upland lakes similarly have been affected by human activities. In the early 1800s, for example, Lower, Clear, Lily, and Stone Lakes in the present-day City of LaPorte formed a single 1.3-square-mile lake. Pine and North Pine Lakes formed a slightly larger lake of 1.4 square miles (Tucker, 1922a). Activities related to agricultural drainage and urban development later diminished the total lake area and eventually resulted in the current cluster of smaller lakes, which today represents approximately half of the total area of the original lakes.

Other upland lakes have been either greatly diminished in size or totally drained by ditching, dredging and tiling activities. The water level of Cedar Lake in Lake County, for example, was lowered 8 to 12 feet, and the normal shoreline receded 50 to 90 feet from its former margins as a result of ditching (Blatchley and Ashley, 1901). The water level of Flint Lake in Porter County was lowered by channelization of the stream draining it (Doggett, 1933).

The majority of naturally formed lakes remaining today in the Kankakee River Basin are located in morainal and outwash regions of St. Joseph, LaPorte, Starke and Marshall Counties. At least 30 of the more than 60 named lakes shown on recent topographic maps occur in clusters or chains located west and southwest of South Bend in St. Joseph County; west and southwest of New Carlisle and along the northern edge of LaPorte in LaPorte County; west and southwest of Plymouth in Marshall County; and just north of Valparaiso in Porter County.

Some small, shallow lakes remain scattered along middle and lower reaches of the mainstem Kankakee River corridor. These lakes, most of which are remnant oxbows of the old river channel, typically are classified by the U.S. Fish and Wildlife Service and the IDNR Division of Fish and Wildlife as palustrine wetlands because of their shallow depth and because they are not considered as part of the main channel. Most oxbow lakes are only temporarily or seasonally flooded, but some may be semi-permanently flooded.

In one sense, the remnant lakes (wetlands) of the Kankakee River corridor are man-made because they were formed when the river was dredged and straightened. In another sense, they are considered as natural lakes because oxbow lakes commonly are formed along meandering rivers. Regardless of type, shallow remnant oxbows probably account for the majority of small lakes in the lower Kankakee River valley.

Appendix 5 presents information on 37 natural and seven manmade lakes throughout the Kankakee River Basin having a surface area of at least 25 acres. The table also includes two smaller lakes which have historical and current gage records. The locations of most lakes in the basin are apparent from fold-out maps or plates presented elsewhere in this report.

According to Hoggatt (1975), the drainage basins of most natural lakes in the upper Kankakee River Basin contain depressional areas which do not contribute directly to surface runoff (appendix 5, column 2). Many of these lake systems once occupied closed basins having no defined inlet or outlet. Lake levels in some closed systems would have been maintained primarily by ground-water seepage through either the lakebed or side slopes and by direct rainfall onto the lake surface. Water loss would have occurred by evaporation and *percolation*.

Bass Lake in Starke County, for example, formed a closed drainage system before drainage ditches and an artificial outlet were constructed in the early 1900s. Because the lake occupies a shallow basin on a regionally elevated ridge, natural surface drainage primarily slopes away from the lake.

Springs in the lakebed and the waters of nearby flowing wells once were thought to be the major source of lake water (Blatchley and Ashley, 1901). However, later investigators pointed out that the lake may receive ground water from more than one water-bearing zone, including an unconfined surficial aquifer. Ground-water conditions around Bass Lake are briefly discussed in the ***Ground-Water Hydrology*** section of this report under the subheading entitled ***Ground-Water Levels***.

The drainage systems of the lakes in the city of LaPorte have involved only subsurface routes since the middle or late 1800s, when a surface outlet to Clear Lake ceased flowing (Tucker, 1922a). Despite extensive development during the late 1800s and early 1900s that drastically changed the drainage system, no surface outlet to these lakes has ever been constructed.

The 37 natural lakes tabulated in appendix 5 occupy a total of about 6500 acres, or 10 square miles. Six lakes having surface areas of at least 250 acres account for about 60 percent of the total acreage of all natural lakes. These six lakes, in order of decreasing size, are as follows: Bass Lake, Cedar Lake, Pine Lake, Hudson Lake, Lake of the Woods and Koontz Lake (appendix 5, column 4).

At their maximum pool level, six large man-made lakes constitute a total of about 2500 acres, or approximately 4 square miles. Worster Lake (Potato Creek Reservoir) and Lake of the Four Seasons were constructed primarily for recreational purposes such as fishing, swimming, and boating. J.C. Murphey Lake in Willow Slough State Fish and Wildlife Area and Ringneck Lake in Jasper-Pulaski Fish and Wildlife Area are shallow impoundments which are managed primarily for fishing activities and waterfowl habitat management. Lake Dalecarlia in Lake County and Lake Latonka in Marshall County are two slightly smaller lakes used primarily for recreation.

Skitz Lake in Starke County was a shallow, 1400-acre impoundment which once occupied the northeastern portion of the Kankakee Fish and Wildlife Area (formerly the Kankakee Game Preserve). The impoundment, which was located between the Kankakee and Yellow Rivers near Highway 8, was used primarily to attract migratory waterfowl and improve hunting opportunities. From 1949-53, records of daily lake-level fluctuations were maintained by the Division of Water in cooperation with the U.S. Geological Survey.

Skitz Lake probably was destroyed in the 1950s when severe floods caused extensive damage to levees throughout the area. Although no identifiable lake currently exists on the fish and wildlife property, a system of levees and water control structures allows certain areas between the rivers to be temporarily flooded for waterfowl habitat management.

Lake of the Woods, Cedar Lake, Hudson Lake and Koontz Lake have the largest storage capacities of the natural lakes for which capacity data are available (appendix 5, columns 4 and 5). Each of these lakes, in addition to the man-made Worster Lake, holds at least 1 billion gallons at either the average or established level. Although the storage capacity of Bass Lake has not been accurately determined, it has been estimated to be 1.5 billion gallons (McCormack, 1947). These six natural and man-made lakes account for about half of the known total capacity of 16 billion gallons for all basin lakes.

The mean depths of basin lakes are quite variable. South Clear and Mud Lakes in St. Joseph County have mean depths of only 2 feet, whereas Saugany Lake in LaPorte County has a mean depth of 30 feet (Indiana Department of Environmental Management, 1986). Maximum depths of basin lakes range from less than 4 feet at Ringneck Lake to about 70 feet at Pine Lake (appendix 5, column 6).

Since 1942, records of the water-surface elevations of many Indiana lakes have been collected by the U.S. Geological Survey through a cooperative agreement with the Indiana Department of Natural Resources (formerly the Indiana Department of Conservation). Before 1976, lake stations generally were equipped with a staff gage which was read once daily by a local observer. Automatic digital water-stage recorders have since been installed at many lake stations, including 12 of the 13 stations currently gaged in the Kankakee River Basin (appendix 5, column 8).

Lake-level data today are used primarily to monitor maximum and minimum levels, determine the location of shoreline contours for lakeshore construction projects, and investigate water quality and flooding problems. Gage records also are used in the occasional establishment of normal water-surface elevations, as described in Indiana law (I.C. 13-2-13). As of January 1990, levels have been established at about half of the major lakes in the basin (appendix 5, column 7).

Between 1954 and 1968, the U.S. Geological Survey in cooperation with the Indiana Department of Natural Resources mapped more than 200 natural and man-made lakes in Indiana, including more than 20 lakes in the Kankakee River Basin. Although originally intended for use in the establishment of normal water-surface elevations, these depth contour maps have since been used for many purposes, including fisheries studies and recreation. A map of Bass Lake completed in 1988 is available from the Division of Water.

Lake-level fluctuations

The historic drainage projects conducted throughout the Kankakee River Basin since the 1800s have greatly affected the basin's natural lakes. In general, ditching near a lake can intercept or divert surface drainage which normally would have entered the lake basin, thus reducing the drainage area contributing to the lake. If the ditch is constructed downgradient of a lake, ground-water leakage may be induced from the lake to the ditch. Moreover, lowering the local water table by surface or subsurface drainage or ground-water pumpage can reduce the amount of ground-water inflow to lakes.

State laws enacted since the 1940s have helped protect public freshwater lakes of natural origin from detrimental development and excessive water-level fluctuations (see box below). Although many lake-level problems have been eased by provisions found in these

Lake regulations

Because water-level fluctuations in lakes can restrict their usefulness for recreation, residential development, flood control and water supply purposes, state and local organizations have attempted to maintain average water levels on many lakes. In accordance with a 1947 state law (I.C. 13-2-13), the Indiana Department of Natural Resources (formerly the Indiana Department of Conservation) is authorized to have normal lake levels established by appropriate legal action. The Department also has the authority to initiate and supervise the installation of dams, spillways, or other control structures needed to maintain the established levels.

Established lake levels typically represent the average water-surface elevation that has prevailed for several years. Once an average normal water level is established by a local circuit court, the average lake level is to be maintained at that elevation. Temporary lowering of a lake level below its designated level requires prior approval from the local court and from the Natural Resources Commission, the administrator of the lake-level law. Such approval typically is granted only for shoreline improvements or lake restoration procedures.

A related lake law (I.C. 13-2-11.1) enacted in 1947 and amended in 1982 requires prior approval from the Natural Resources Commission for any alteration of the bed or shoreline of a public freshwater lake of natural origin. Permits are required not only for minor projects such as the construction of seawalls or sand beaches, but also for larger projects such as channel or lakebed dredging, boat-ramp construction and boat-well construction. In addition, a permit is required to pump water from a public freshwater lake.

Under a law passed in 1947 and amended in 1987 (I.C. 13-2-15), a permit is required for the construction, reconstruction, repair or recleaning of a ditch or drain that has a bottom elevation lower than the normal average water level of a public freshwater lake of 10 acres or more, and that is located within one-half mile of the lake.

statutes, undesirable fluctuations continue to occur on some lakes, including Bass and Pine Lakes in the Kankakee River Basin.

Problems with low lake levels have been documented at Bass Lake since the 1920s. As mentioned in the previous section, Bass Lake is located on a topographic high, and once formed a closed basin with no natural inlet or defined outlet (Blatchley and Ashley, 1901).

Various investigations beginning in the 1920s typically ascribed the major causes of undesirable water-level declines at Bass Lake to 1) evaporation from the large lake surface; 2) lack of surface inflow from the small drainage area; 3) leakage from the old dam; and 4) diversions or lowered ground-water levels from ditching, dredging and drainage activities near the lake (Doggett, 1924, 1941, 1947). Moreover, because the lakeshore slope is unusually flat, slight reductions in water-surface elevation can cause the water's edge to recede hundreds of feet, exposing vast expanses of the lakebed.

Proposed solutions to the low water levels at Bass Lake have included diverting the flow from streams or ditches into the lake, and controlling or impounding water in these watercourses to help reduce ground-water leakage away from the lake (Doggett, 1941). Although these suggested solutions were never implemented due to their impracticality and cost constraints, further investigations led to a petition by property owners to maintain the lake level by ground-water pumpage from a deep well (Doggett, 1947; McCormack, 1947; Indiana Department of Conservation, 1956).

In 1964, a 110-foot well rated at 1-3 mgd was installed on the east shore of the north lobe. Although pumping has occurred periodically since that time, the success of the well in alleviating low water levels is not clearly defined in lake-level records.

Early studies (Doggett, 1947; Indiana Department of Conservation, 1956) had postulated but had not conclusively demonstrated a hydrologic connection between the surficial sand aquifer intersecting the lakebed and the deeper confined aquifer which would later be utilized by the high-capacity well. However, if a connection were to exist in the vicinity of the lake, pumpage from the confined aquifer would to some extent merely recirculate the lake water (Indiana Department of Conservation, 1956).

In the late 1980s, the Division of Water investigated reports of residential well problems near Bass Lake. Investigators found that pumpage from the high-capacity well on the shoreline was lowering ground-water levels near the lake and adversely impacting some domestic wells. Two years later, the division noted that potential ground-water level declines induced by high-capacity pumpage from a proposed second well could further impact some nearby domestic wells, especially those equipped with shallow-well jet pumps (Division of Water, written communication, 1989).

The group of lakes in the city of LaPorte near the Kankakee River Basin's northern boundary have experienced problems with both above- and below-normal water-level fluctuations. Unacceptably low levels documented since the 1920s resulted in several investigations, proposed solutions, and the eventual diversion of some surface runoff into the lake through a constructed drain (Tucker, 1922a; Indiana Department of Conservation, 1963; Link, 1963; Indiana Department of Natural Resources, 1982c).

In the 1960s, a property owners association financed the installation of a ground-water well on the south shore of Pine Lake to augment lake levels. The well probably was used, but no data are available to determine what effects the pumping had on lake levels (Indiana Department of Natural Resources, 1982c).

A period of high lake stages caused severe flooding around the lakes in the 1950s. A deep well was drilled to allow disposal of excess water into a porous formation, but the well was not used (Indiana Department of Natural Resources, 1982c).

After the lakes rose to unusually high levels in 1982, investigations (Indiana Department of Natural Resources, 1982c; Baxmeyer, 1982) led to the establishment of procedures by which excess lake water could be released through a water pipeline for eventual discharge into the Kankakee River via the Little Kankakee River.

Between about 1983 and 1986, water was pumped from Lily Lake for brief periods following severe rainstorms to help alleviate flooding on Pine and Stone Lakes. The capability still exists for using the diversion during extreme flood events; however, the pipeline currently is being used for water-supply purposes rather than flood control (T. Taylor, Water Superintendent, City of LaPorte, personal communication, 1989).

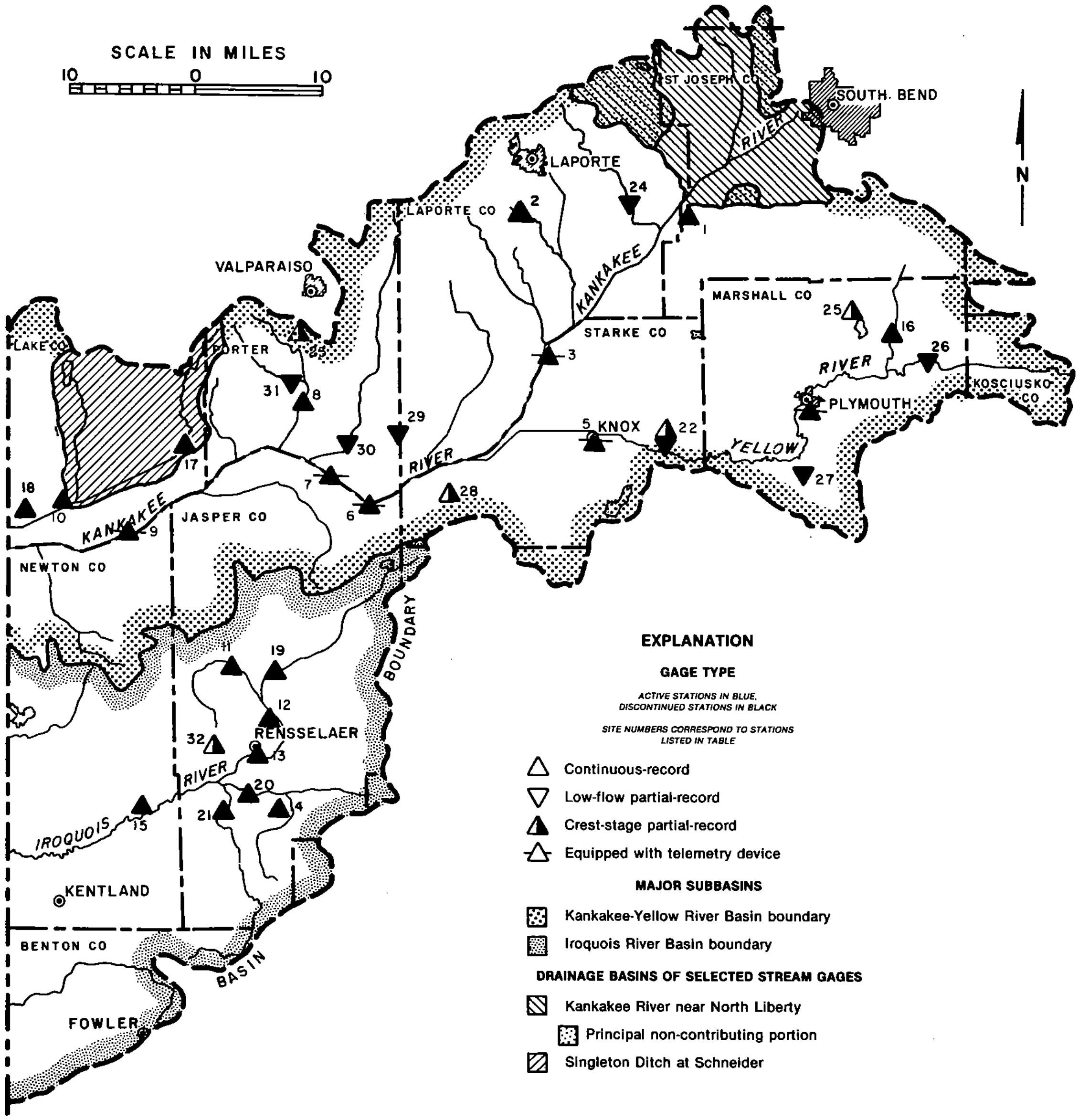

Figure 23. Location of stream gaging stations and selected subbasins

Streams

The Kankakee River Basin in Indiana consists of the drainage basins of the Kankakee River and its principal tributaries, the Yellow and Iroquois Rivers. About 64 percent of the Kankakee River Basin in Indiana lies within the Kankakee-Yellow River Basin, and the remaining 36 percent lies within the Iroquois River Basin (figure 23).

A high degree of channelization exists on rivers and streams of the Kankakee River Basin. The entire length of the Kankakee River in Indiana is characterized by straight channels produced from ditching, dredging and channelization associated with agricultural development in the late 1800s and early 1900s. All tributaries to the Kankakee River have been either partially or wholly reconstructed. The IDNR Division of Fish and Wildlife has estimated that of the 1200 miles of streams

Table 13. Stream gaging stations

Map number: Station locations are shown in figure 23.

Station number: Numbers are U.S. Geological Survey downstream-order identification numbers. Lettered abbreviations are as follows: T, telemetered station; S, satellite station; L, low-flow partial-record station, frequency data published in Stewart (1983); C, crest-stage partial-record station, frequency data published in Glatfelter (1984).

Contributing drainage area: Portion of watershed that contributes directly to surface runoff. Total drainage area is shown in parentheses for watersheds with non-contributing portions. Area data are taken or derived from Glatfelter and others (1986), Glatfelter (1984), Stewart (1983) or Hoggatt (1975), depending on station type.

Period of record: Refers to calendar year, whether or not data encompasses entire year. Years of record are tabulated through 1985 inclusive for active stations.

		Map no.	Station no.	Station name	Contributing drainage area (sq mi)	Period of record: Years	Period of record: Dates
Continuous-record	Active	1	05515000	Kankakee River near North Liberty	116 (174)	35	1951-
Continuous-record	Active	2	05515400	Kingsbury Creek near LaPorte	3.0 (7.1)	16	1970-[1]
Continuous-record	Active	3	05515500 T	Kankakee River at Davis	400 (537)	62	1905-[2]
Continuous-record	Active	4	05516500 T	Yellow River at Plymouth	272 (294)	38	1948-
Continuous-record	Active	5	05517000 T	Yellow River at Knox	384 (435)	43	1905-[2]
Continuous-record	Active	6	05517500 T	Kankakee River at Dunns Bridge	1160 (1352)	38	1948-
Continuous-record	Active	7	05517530 T	Kankakee River near Kouts	1182 (1376)	12	1974-
Continuous-record	Active	8	05517890	Cobb Ditch near Kouts	30.3	18	1968-
Continuous-record	Active	9	05518000 S	Kankakee River at Shelby	1578 (1779)	64	1922-
Continuous-record	Active	10	05519000	Singleton Ditch at Schneider	123	38	1948-
Continuous-record	Active	11	05521000	Iroquois River at Rosebud	35.6	38	1948-
Continuous-record	Active	12	05522000	Iroquois River near North Marion	144	38	1948-
Continuous-record	Active	13	05522500	Iroquois River at Rensselaer	203	38	1948-
Continuous-record	Active	14	05523000	Bice Ditch near South Marion	21.8	38	1948-
Continuous-record	Active	15	05524500	Iroquois River near Foresman	449	38	1948-
Continuous-record	Discontinued	16	*05516000*	*Yellow River near Bremen*	*135*	*19*	*1955-73*[3]
Continuous-record	Discontinued	17	*05518500*	*Singleton Ditch near Hebron*	*34.2*	*3*	*1949-51*
Continuous-record	Discontinued	18	*05519500*	*West Creek near Schneider*	*54.7*	*24*	*1948-72*[2]
Continuous-record	Discontinued	19	*05521500*	*Oliver Ditch near Aix*	*79.6*	*4*	*1948-51*
Continuous-record	Discontinued	20	*05523500*	*Slough Creek near Collegeville*	*83.7*	*35*	*1948-82*[2]
Continuous-record	Discontinued	21	*05524000*	*Carpenter Creek at Egypt*	*44.8*	*35*	*1948-82*[2]
Partial-record	Active	22	05516950 LC	Eagle Creek near Grovertown	29.9(31.9)		1973-
Partial-record	Active	23	05517780 C	Cobb Ditch near Valparaiso	0.4		1973-
Partial-record	Discontinued	24	*05515100 L*	*Little Kankakee River near Mill Ck.*	*22.3(33.8)*		*1960-69*
Partial-record	Discontinued	25	*05516150 C*	*Walt Kimble Ditch near Lapaz*	*1.5*		*1973-82*
Partial-record	Discontinued	26	*05516300 L*	*Dausman Ditch near Bremen*	*47.8(53.4)*		*1956-69*
Partial-record	Discontinued	27	*05516650 L*	*Wolf Creek near Argos*	*21.4(31.1)*		*1970-78*
Partial-record	Discontinued	28	*05517400 C*	*Payne Ditch trib. near North Judson*	*2.6*		*1973-82*
Partial-record	Discontinued	29	*05517550 L*	*Reeves Ditch near Lacrosse*	*44.1*		*1960-69*
Partial-record	Discontinued	30	*05517750 L*	*Crooked Creek near Kouts*	*64.6(69.9)*		*1975-78*
Partial-record	Discontinued	31	*05517880 L*	*Wolf Creek near Kouts*	*13.8*		*1975-78*
Partial-record	Discontinued	32	*05524300 C*	*Yeoman Ditch trib. near Rensselaer*	*0.6*		*1972-81*

[1]Discontinued in 1986.
[2]Gaps occur in years of record.
[3]Continued as a partial-record station through 1984.