# Utilization of the Water Resource

As has been noted, water is one of the basic resources that is essential to life — not only that of man, but of the animal and plant communities as well. Its role is so pervasive that it is indeed difficult to visualize any phase of natural, human, social, or economic activity in which water is not utilized in some manner or degree. For the purposes of this report, water utilization is treated in two broad categories: instream uses and withdrawal uses.

*Instream uses* are defined as those that utilize water in place in streams, lakes, and reservoirs. Instream uses include navigation, hydroelectric power generation, waste-water assimilation, recreational boating, fish and wildlife habitat, swimming, and general environmental and aesthetic values. It should be noted that instream uses necessarily involve only the surface water component of the water resource, not ground water.

*Withdrawal uses* are defined as those uses that involve the physical removal of water from its ground or surface source. Withdrawal uses include both consumptive and nonconsumptive uses. Consumptive uses are those that, because of evaporation, transfer out of the basin of origin, incorporation into manufactured products, or other processes, preclude the return of some or all of the withdrawn water to its source. Nonconsumptive uses, as the term implies, are those in which the withdrawn water is returned to the supply system essentially undiminished in volume. Examples of withdrawal uses include municipal, industrial, and rural water supplies, irrigation, and the generation of energy.

## INSTREAM USES

### Fish and Wildlife

In addition to its obvious role in sustaining life, the water resource is vital to fish and wildlife with respect to the several habitats that are closely associated with surface water. These are described as the aquatic, riparian, and wetlands habitats, and each plays a special role.

The *aquatic habitat* is that provided by water itself, as found in streams, lakes, and reservoirs. It is obviously the essential habitat for fish and other aquatic life. The aquatic habitat also serves a vital role with respect to waterfowl and other bird and animal populations whose food supply is found in whole or in part in the aquatic environment.

The utility of the aquatic habitat is a function of both water quantity and quality. Both of these vital parameters are subject to considerable variability in nature and both may be, and frequently are, affected by human, social, and economic uses.

Traditionally, Indiana streams and lakes have supported populations of typical warm-water fishes, such as bass, blue gill, crappie, other sunfishes, catfish, and their food chain. In addition, other species, such as walleye, northern pike, striped bass, and muskellunge, have been introduced into selected streams or lakes. Trout are stocked in selected streams, primarily in northeastern Indiana. The Great Lakes states, including Indiana, have introduced several varieties of salmon into Lake Michigan, which has proven to be highly successful. In addition to the salmon, Lake

Michigan supports a variety of sport fishes, including yellow perch and several varieties of trout.

During 1975 approximately 670,000 fishing licenses were issued to fishermen between the age of 17 and 65. It is estimated that an additional 398,000 individuals younger than 17 and older than 65 are also active fishermen. A statewide survey indicated that the average fisherman made 32 fishing trips during 1975. Therefore, approximately 34,175,000 fishing trips were made by Indiana fishermen. If the average catch per fisherman per fishing trip was as low as four ounces, the total harvest of the Indiana fishery exceeded 8,500,000 pounds. In order to help meet this tremendous demand on the fisheries resource, the Department of Natural Resources annually conducts fish management on over 100 lakes and streams, including Lake Michigan.

Based upon a statewide survey, the projected demands on the fisheries resource for the years 1980, 1990, and 2000 is estimated at 41.0, 42.7, and 44.0 million fishing trips, respectively.

The *riparian habitat* is composed of vegetation which requires the availability of water that a streambank or lake shore can afford. These areas generally are associated with high species diversity with respect to both vegetation and wildlife. Not only are there more types of plants and animals associated with these areas but often they occur in larger numbers than found in the upland habitat types.

The *wetland habitat* is likewise inextricably associated with the water resource. Wetlands are commonly described as marshes, swamps, bogs, potholes, sloughs, and shallow ponds or lakes. In a more technical sense, wetlands are areas in which the water table is above or sufficiently near the ground surface with such regularity or proportion of time that soils and plants characteristic of an aquatic environment predominate. The soils are generally very high in organic content, resulting from the lush vegetation of those plant species adapted to growth in water or water-saturated conditions.

Wetlands are considered to be the most productive of the natural habitat types, both as to numbers and diversity of plant and animal life. They provide a nursery both for fish populations and for those smaller organisms that provide vital links in the food chain.

It has been estimated that over one million acres of wetlands in Indiana have been drained and devoted to other uses during the past century, a reduction of more than eighty percent of the original resource. Although the major draining of wetlands is no longer in progress, some surveys estimate that 300,000 acres are drained each year on a national basis, with Indiana sustaining a share of this loss.

As of 1977, it is estimated that there are approximately 200,000 acres of wetlands remaining in the state. These are located primarily in the northern two tiers of counties and in a narrow band along the Ohio River to the south, as shown on Figure 28. In most other areas of the state, wetlands exist as only small, widely scattered areas.

In general, about fifty percent of Indiana's wetlands are classified as the open-water type. They possess high fisheries value, but have the lowest value of any wetland group for wildlife. Shallow marshes, which account for another twenty percent of the wetlands, have generally low fisheries value, but possess the highest wildlife values.

The relative values of the other wetland types for fish and wildlife vary between these extremes. The approximate distribution of the other types is as follows: deep marshes, ten percent; shallow shrub swamps, fifteen percent; and deep shrub swamps, five percent. Two other types, bogs and wooded swamps, occur in Indiana but account for less than one percent of the total.

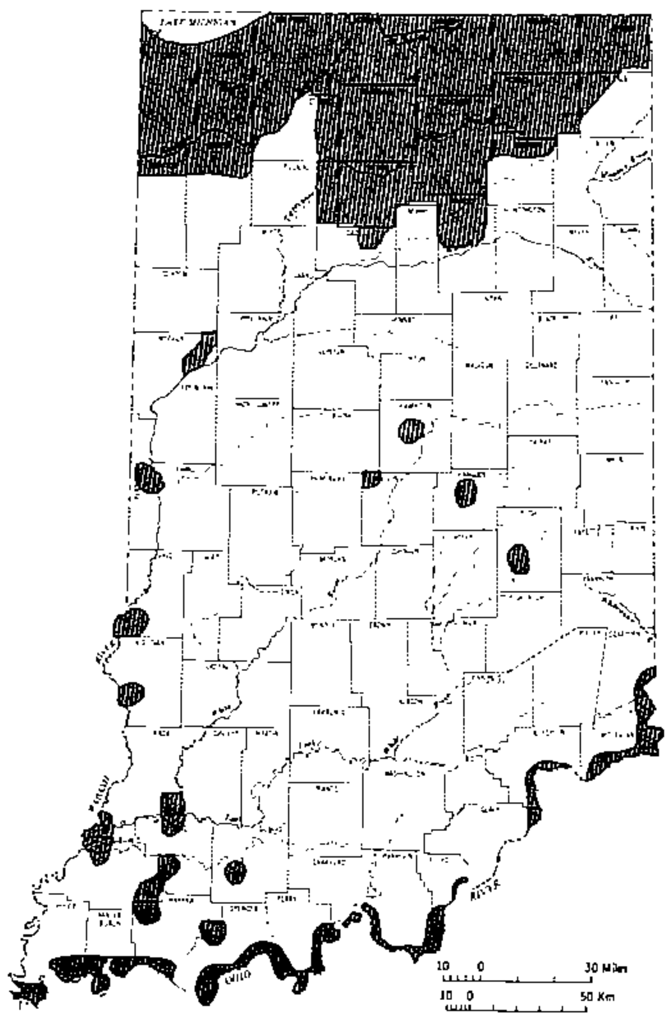

**Figure 28**
Map of Indiana showing the general distribution of wetlands.

## Outdoor Recreation

The types of outdoor recreation under consideration are those that are essentially water-related. The major activities considered are boating, canoeing, waterskiing, swimming, ice-skating, and fishing.

The rivers, streams, and lakes of Indiana provide, or have the potential to provide, a substantial measure of water-related outdoor recreation opportunities. The "inland" waters — that is, those lakes, rivers, and streams exclusive of Lake Michigan and the Ohio River — suitable for one or more recreational activities total approximately 280,500 acres. The Indiana portion of Lake Michigan exceeds 154,000 acres and there is of course free access from Indiana waters to the remainder of this 14,272,000 acre lake. The Ohio River, in its 357 mile length of the southern boundary of the state, provides approximately 94,000 acres of interstate water. It should be noted that the approximate lower 200 miles of the Wabash River, extending from the Ohio River to a point about 14 miles downstream from Terre Haute, is also an interstate stream.

These approximate totals of surface-water acreage, while useful as a measure of overall gross supply, are by no means a definitive measure of resource availability for recreational purposes. These factors should be considered:

1. What are the legal rights of the public with respect to both access to and utilization of the water area?
2. The suitability of a particular water area for various recreational pursuits should be ascertained. For example, a stream may be suitable for fishing, but not power boating.
3. Lake Michigan, while affording a very large area which is physically and biologically capable of serving such pursuits as boating, fishing, and swimming, does pose serious problems with respect to public safety because of its size. Much of its water area is at relatively long distances from shore, harbors of safety for boaters are very limited and, of major importance, very rough water not only occurs frequently but may occur with very little advance warning.
4. The lower two hundred miles of the Wabash River are interstate waters between Indiana and Illinois and thereby subject to the jurisdiction of both states. There is reciprocity between the two states with respect to license for fishing and boating.
5. The Commonwealth of Kentucky claims that the entire Ohio River is within that state and thereby subject to its jurisdiction, including license and registration for fishing and boating on the river.
6. Finally, in considering the supply or availability of water for recreational purposes, travel time or distance for the participant must be considered.

The outdoor recreational activity needs for boating, canoeing, waterskiing, swimming, ice-skating, and fishing were generated by utilizing the statistical needs analysis developed for the *1979 Indiana Outdoor Recreation Plan*, as prepared by the Department of Natural Resources, Division of Outdoor Recreation.

A statewide summary of the supply and demand analysis for the six recreational activities is shown on Table 8 for the years 1980, 1990, and 2000. Particular attention is invited to the table footnotes and to the preceding discussions of the limitations of the analysis.

**Table 8**
The statewide outdoor recreation demand and supply analysis.

| *Activity* | *Percent of Population Participating* | *Density Guideline* | *Approximate Supply* | *Existing Supply as a Percentage of Projected Demand* | | |
|---|---|---|---|---|---|---|
| | | | | *1980* | *1990* | *2000* |
| Boating | 26 | 19.6 boats/acre/year[a] | 341,250 acres[b] | 100+ | 100+ | 100+ |
| Waterskiing | 9 | 34.4 skiers/acre/year[b] | 109,650 acres[c] | 100+ | 100+ | 100+ |
| Canoeing | 8 | 585 canoes/mile/year | 2,300 miles | 100+ | 100+ | 100+ |
| Swimming | 40 | 76,600 swimmers/acre/year | 439 acres | 96 | 89 | 82 |
| Ice-Skating | 8 | 6,678 skaters/acre/year | 167 acres | 60 | 58 | 55 |
| Fishing | 45 | 66 persons/acre/year[c] | 434,750 acres[d] | 71 | 68 | 64 |

This table is based upon the 1979 Indiana State Outdoor Recreation Plan.
[a]Includes 154,000 acres of Lake Michigan, 47,250 acres of the Ohio River, and 140,000 acres of inland waters.
[b]Includes 18,400 acres of Lake Michigan (30 square miles excluding 200 feet of shoreline), 47,250 acres of the Ohio River, and 44,000 acres of inland waters.
[c]Includes 154,000 acres of Lake Michigan, 47,250 acres of the Ohio River, and 233,500 acres of inland waters.

**Indiana Natural, Scenic, and Recreational Rivers System** The Natural, Scenic, and Recreational Rivers System Act enacted in 1973 establishes a procedure whereby certain rivers, largely in a natural condition, can be protected while not excessively limiting the use of other resources associated with the river.

As of 1979, the Blue River (from U.S. 150 in Fredricksburg downstream for 45.5 miles) and Cedar Creek (from river mile 13.7 to its confluence with the St. Joseph River) are components of the Indiana Natural Rivers System. Sugar Creek (from Darlington Covered Bridge to its confluence with the Wabash River) has not been included in the system but has been placed in a special protected status by the Natural Resources Commission. Figure 29 shows the location and status of those streams in the natural, scenic, and recreational river system.

## Hydroelectric Power

Hydroelectric power generation is accomplished by utilizing the energy of falling water to drive hydraulic turbines connected to generators. The water energy available at a particular site, and hence the amount of electricity which may be generated, is a function of both the dependable flow of water and the "head" or differential in elevation above and below the turbines. This differential in elevation is most frequently provided by the construction of dams.

The five hydroelectric plants operating in Indiana in 1978 are shown on Figure 33 (page 61). The Indiana and Michigan Electric Company operates the Twin Branch Plant (Number 5) on the St. Joseph River in Mishawaka and the Elkhart Plant (Number 7) on the Elkhart River in Elkhart. Twin Branch has a capacity of 7.3 megawatts while Elkhart has a capacity of 3.4 megawatts. The Northern Indiana Public Service Company operates two hydroelectric plants on the Tippecanoe River in White County. These plants are known as the Norway (Number 9) and the Oakdale (Number 12) Plants with capacities of 6.7 and 11.0 megawatts, respectively. Public Service Indiana operates the largest hydroelectric plant in Indiana with a capacity of 81.0 megawatts. The Markland Plant (Number 27) is incorporated into the north end of the Markland Lock and Dam on the Ohio River.

The overall potential for additional hydroelectric power plants in Indiana is minimized by the low-flow characteristics of its streams and by generally flat topography. There is a potential for additional hydroelectric development at the Uniontown, Newburgh, and Cannelton Locks and Dams on the Ohio River. However, the plants at these sites would be located in Kentucky.

## Commercial Navigation

The inland waterways of the United States are a key element in the economy of the interior. Indiana is served by both of the nation's major inland waterway systems, namely the Great Lakes—St. Lawrence System and the Ohio-Mississippi—Intercoastal Waterway System. Both systems provide Indiana industries and producers access to efficient, low cost transportation.

The Great Lakes Navigational System permits ocean-going cargo vessels to ascend the St. Lawrence River into Lake Ontario. Shipping then bypasses Niagara Falls through the Welland Canal into Lake Erie. Vessels can then pass into Lakes Huron and Michigan and through the locks at Sault St. Marie to Lake Superior. Although this system gives Indiana's Lake Michigan ports access to world trade routes, the greater part of traffic movement on the Upper Lakes (Superior, Huron, and Michigan) is between inland points.

The northwest Indiana steel complex was located largely to take advantage of water transportation and industrial water supply. Iron ore, now mostly in pellet form, moves from the western end of Lake Superior through the Soo locks into Lake Michigan and thence to the mills in northwest Indiana. This traffic movement is one of the most important in all of the Great Lakes. Other traffic moving through Indiana ports consists of coal, grain, and general overseas cargo.

In order to provide for the orderly growth of Indiana commerce and industry, the 1961 session of the General Assembly created the Indiana Port Commission. This commission was given the authority to construct and operate port facilities on Lake Michigan. That authority has subsequently been expanded to cover the Ohio River. The commission, with the cooperation of the U.S. Army Corps of Engineers, constructed the Port of Indiana-Burns Waterway Harbor at Portage, Indiana. This port became operational in 1970 and has since developed a reputation as one of the finest facilities on the Great Lakes. Other Indiana lake ports include Indiana Harbor, Buffington and Gary Harbors (which are privately owned and operated), and the harbor at Michigan City which now has only limited commercial traffic.

The Ohio River is the southern boundary of Indiana with about 357 miles of river frontage. This gives Indiana shippers access to a waterway reaching from above Pittsburgh on the east to Minneapolis by way of the Mississippi River on the north and to the Gulf of Mexico on the south. Access via the Illinois Waterway is available to Chicago and the Great Lakes, to Knoxville via the Tennessee River, to Tulsa via the Arkansas River and to the entire Gulf Coast of the United States via the Intercoastal Waterway. Improvements to

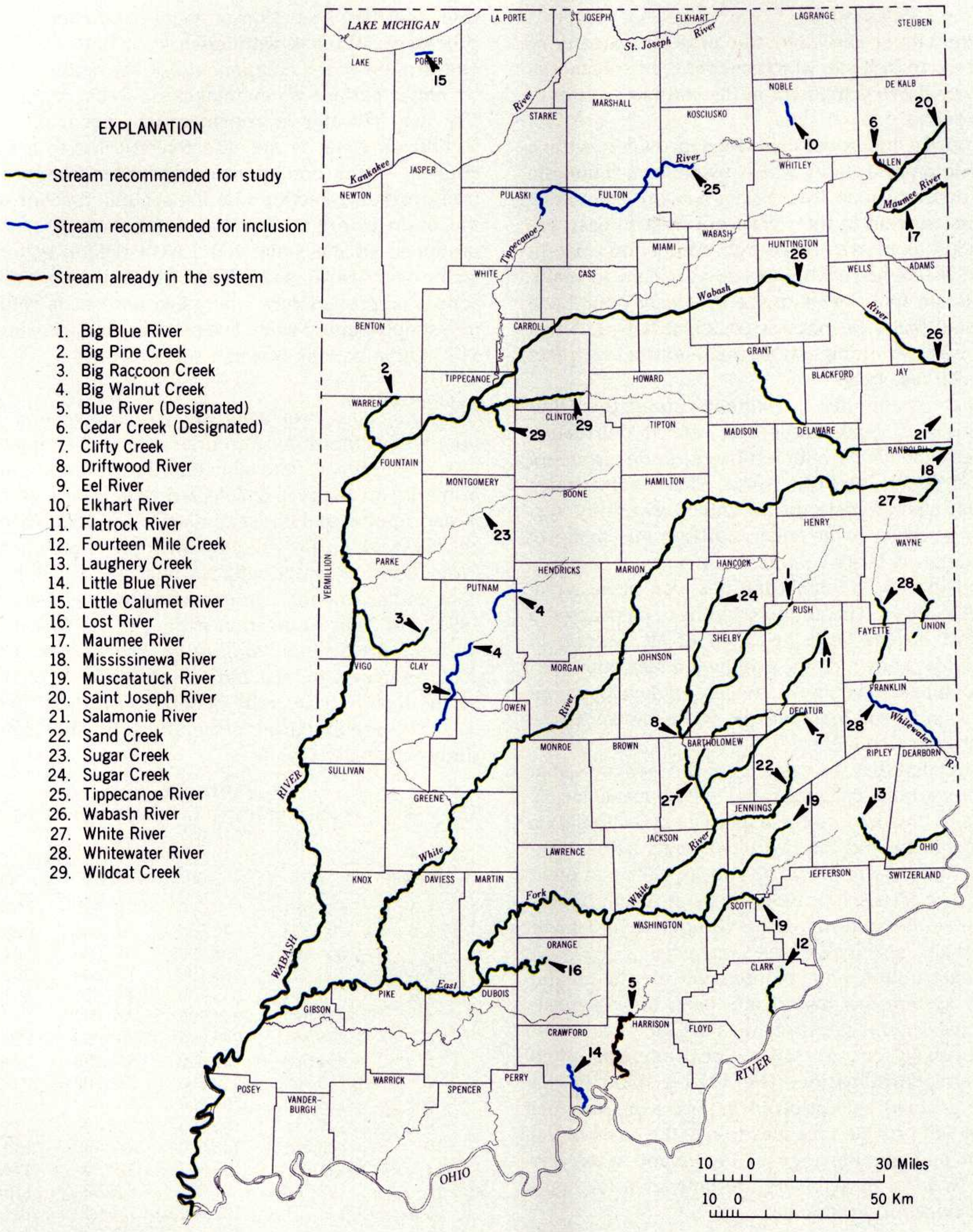


**Figure 29**
**Map of Indiana showing the location and status of Indiana streams in the natural, scenic, and recreational river system.**

navigation on the Ohio River were among the first internal transportation projects undertaken by the United States government.

The Ohio River provided the principal means of early access to Indiana, which accounts in substantial measure for the development of the state in a south to north direction.

The entire Ohio River has been provided with a series of locks and dams which maintain a minimum channel depth of nine feet. Navigation projects along the Indiana section of the river from west to east, are Smithland, Uniontown, Newburgh, Cannelton, MacAlpine, and Markland. Each consists of a dam to maintain minimum river levels in the upstream pool. Each project also has two locks, a principal lock 110 feet wide by 1,200 feet long and an auxiliary lock 110 feet wide by 600 feet long.

Principal commodity movements along the Ohio River consist of coal, crude and refined petroleum, aggregates, chemicals and fertilizers, grain, iron ore and iron products, and other ores. This list illustrates a common characteristic of the inland waterway system; that is, most of the traffic utilizing this mode of transportation is large volume, bulk cargo.

The Indiana Port Commission has also been active on the Ohio River. The commission has constructed a public port on the Ohio just east of Mt. Vernon in Posey County, known as the Southwind Maritime Center. The commission is in the process of developing an additional port near Jeffersonville to be known as the Clark Maritime Center.

It is estimated that the capacity of the Welland Canal (the bypass around Niagara Falls) will be exceeded by 1995. One of the locks on the upper Ohio (Gallipolis) is nearing capacity, and the two older dams below Indiana, Lock and Dam numbers 52 and 53, will soon be at capacity. The Mississippi River locks at Alton, Illinois (just below the mouth of the Illinois River) have reached their capacity and are congested.

The construction and maintenance of the inland waterway system has historically been the responsibility of the federal government. Port facilities, however, are usually constructed by local interests, often with federal participation. The 1978 session of the Congress enacted legislation to impose a marine fuel tax which will provide revenues to pay the costs of the operation and maintenance of the inland waterway systems. None of these rivers are now used for commercial navigation in Indiana.

## WATER WITHDRAWALS

In addition to the instream uses of the water resource, man has a variety of needs for water. These water needs include public water supplies, industrial manufacturing processes, rural water supplies, irrigation, and the production of energy and energy-related processes. Water is withdrawn from both the surface and ground-water components of the water resource by either surface-water intakes or wells. A consumptive use of water is considered to occur when the withdrawn water is not directly returned to a supply source. Water consumption includes evaporation, transpiration, injection into the ground, transfer out of the basin of origin, and the water incorporated into products. Of the estimated 13,840 million gallons of water withdrawn daily from the Indiana water resource, approximately ninety-five percent is returned to a supply source while five percent, or approximately 615 million gallons of water, is consumed.

*Estimating and Projecting the Withdrawal and Consumption of the Water Resource* Current estimates of water withdrawal and consumption rates are based primarily on a survey of selected water consumers and in part upon population estimates, economic statistics, and information provided by local and state agencies. Projections of water withdrawals are based in part upon Indiana population estimates for the years 1980, 1990, and 2000. Population estimates are based upon the *Indiana County Population Projections, 1975–2000,* prepared for the Indiana State Board of Health by the Indiana University School of Business. Table 9 lists these population projections by the eighteen study regions.

**Table 9**
The Indiana population estimates by the eighteen study regions.

| *Region* | *1975* | *1980* | *1990* | *2000* |
|---|---|---|---|---|
| 1-A | 643,084 | 666,900 | 719,500 | 767,000 |
| 1-B | 69,373 | 76,500 | 87,600 | 98,200 |
| 2 | 568,407 | 598,300 | 647,000 | 694,100 |
| 3-A | 138,497 | 151,100 | 174,500 | 200,300 |
| 3-B | 373,164 | 395,100 | 445,500 | 493,800 |
| 4 | 254,499 | 264,500 | 280,000 | 292,200 |
| 5 | 236,661 | 249,000 | 268,000 | 283,300 |
| 6 | 474,589 | 489,800 | 512,800 | 527,000 |
| 7 | 213,940 | 219,700 | 221,200 | 221,900 |
| 8 | 1,138,753 | 1,208,800 | 1,364,900 | 1,531,100 |
| 9 | 149,971 | 156,100 | 168,300 | 170,700 |
| 10 | 102,214 | 108,500 | 121,700 | 133,000 |
| 11 | 148,107 | 155,300 | 173,700 | 192,400 |
| 12 | 92,753 | 97,300 | 106,800 | 116,300 |
| 13-A | 145,721 | 152,400 | 159,000 | 164,000 |
| 13-B | 263,206 | 270,300 | 285,100 | 303,000 |
| 14 | 202,202 | 217,600 | 249,500 | 281,600 |
| 15 | 94,057 | 98,500 | 105,700 | 112,300 |
| Total | 5,309,198 | 5,575,700 | 6,090,800 | 6,582,400 |

From *Indiana County Population Projections 1975–2000,* State Board of Health and School of Business, Indiana University, 1976.

Projections of water withdrawals and consumption include an analysis of past trends and growth patterns, as well as increased conservation factors. The methods of making the projections for public water supplies, industrial self-supplied water, rural water, irrigation, energy, and energy-related processes are presented in the Appendixes. All water withdrawal and consumption rates and projections are general estimates and provide a useful water resource planning and management tool, but are not intended for design purposes.

## Public Water Supply

Any public utility which distributes water for sale to customers is defined as a public water supply. In general, a public water supply utility consists of three components: the source and intake of water, the water treatment facility, and the water distribution system.

The source of the public water supply is dependent upon the location and availability of the water resource. Approximately fifty-one percent of the water distributed by the public water supply utilities is derived from a surface-water source: from streams, reservoirs, and lakes, particularly Lake Michigan. The remaining forty-nine percent of the water supplied by public utilities is withdrawn from ground water. The location and source for public water supply systems are shown in Figure 30.

In general, the source of water for public utilities depends upon local geological and hydrological conditions. As indicated in the analysis of the statewide distribution of the water resource, the availability of ground water is greater in the northern and central portions of Indiana than in the southern part of the state. Usually, only those utilities with limited access to adequate quantities of ground water rely upon surface water sources. The four largest utilities in the state, serving the Indianapolis, Gary-Hobart, Fort Wayne, and Evansville areas, obtain at least ninety-five percent of their supply of water from surface sources.

Utilization of a surface-water source, particularly by large users or in areas of poor ground-water availability, will often require the construction of dams and reservoirs to assure a dependable supply of raw water.

The water treatment component of the public water supply system is designed to ensure that the water is safe for human consumption. Treatment of surface water is necessary to ensure adequate water quality standards as established by the Indiana State Board of Health and the United States Environmental Protection Agency. As a result of the Safe Drinking Water Act (P.L. 93-523) the Environmental Protection Agency has established federal standards for bacteriological, physical, chemical, and radiological quality of water supplied by a public water utility. In addition, the Indiana Environmental Management Board is legally responsible for enforcing standards for maintaining the quality of drinking water, although the State Board of Health monitors the water quality of these systems.

The three types of public supply systems in Indiana are the municipal, rural water, and subdivision utility systems. The municipal utility generally serves an incorporated city or town, but may serve developments outside city boundaries, and sometimes supplies water to other public water systems.

The rural public water supply systems are typically located in rural areas of southern Indiana where the water resource is limited as shown in Figure 31. These systems are usually formed by local residents after a period of time of dealing with undependable wells or cisterns. Many of these systems are financed through loans and grants from the Farmer's Home Administration. Unlike the municipal systems, the rural systems provide water only for household purposes. Due to a small capacity distribution system and higher rates, the commercial, industrial, and agricultural use of water through the rural systems is limited.

The third type of public water supply is the subdivision utility. These utilities are designed to serve only the residences within a single development. Subdivision systems have been developed for mobile home parks, isolated subdivisions, or industrial parks not having access to another water supply.

The customers of public water utilities may include anyone having access to the water mains, such as homes, apartments, various public and private institutions, commercial enterprises and industry. In 1975, sixty-eight percent or approximately 3,631,800 of Indiana's residents were supplied through a public water utility. In addition about eighty-seven percent of Indiana's industries, excluding the energy industry, were at least partially supplied by a public water utility. The water supplied to these industries represents seven percent of the total water used by Indiana industries. However, if the water withdrawals of the primary metal industry located in Lake and Porter Counties are excluded, forty-one percent of the water used by all other industries in Indiana is supplied by public utilities. Industrial customers account for less than one percent of total public water supplied, while they account for about forty percent of the total water supplied by public water utilities.

*Projections* Before projections of public water supplies may be made, it is necessary to determine the relationship between public water supplies and the self-supplied systems. In most Indiana counties there has been very little change over the past two decades

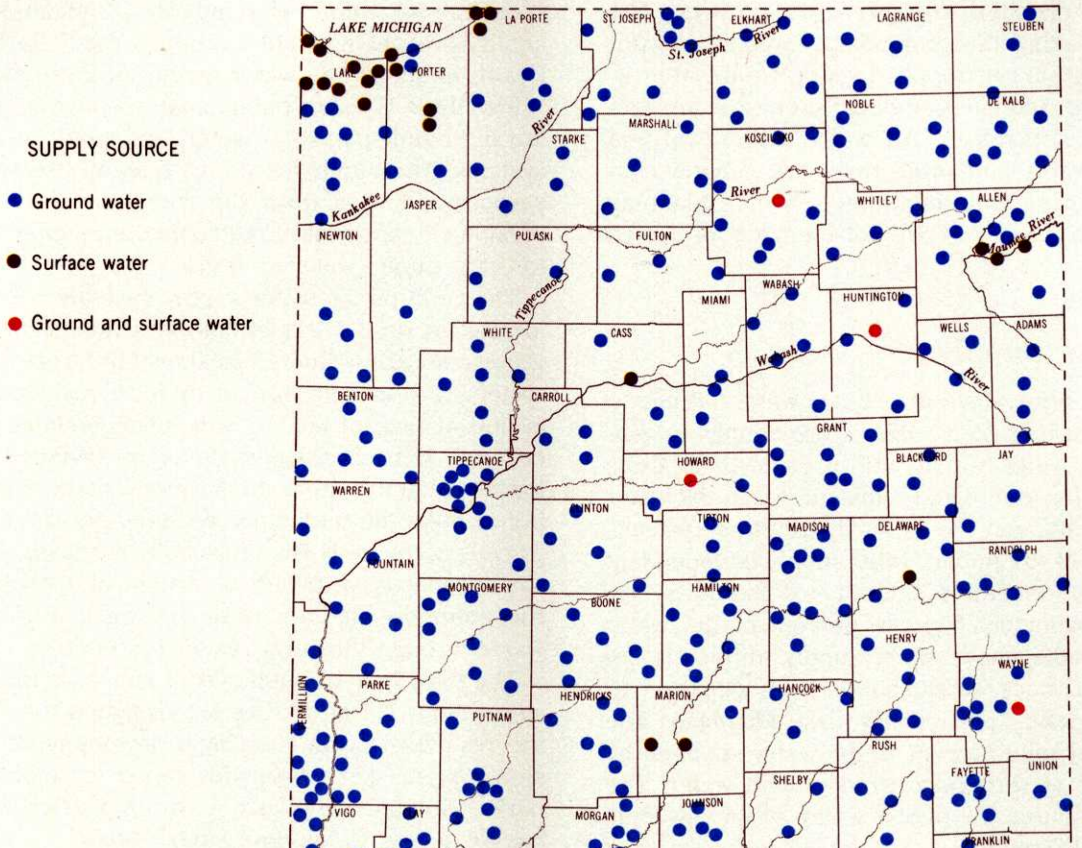


**Figure 30**
**Map of Indiana showing the general location and source of public water supply systems in Indiana.**

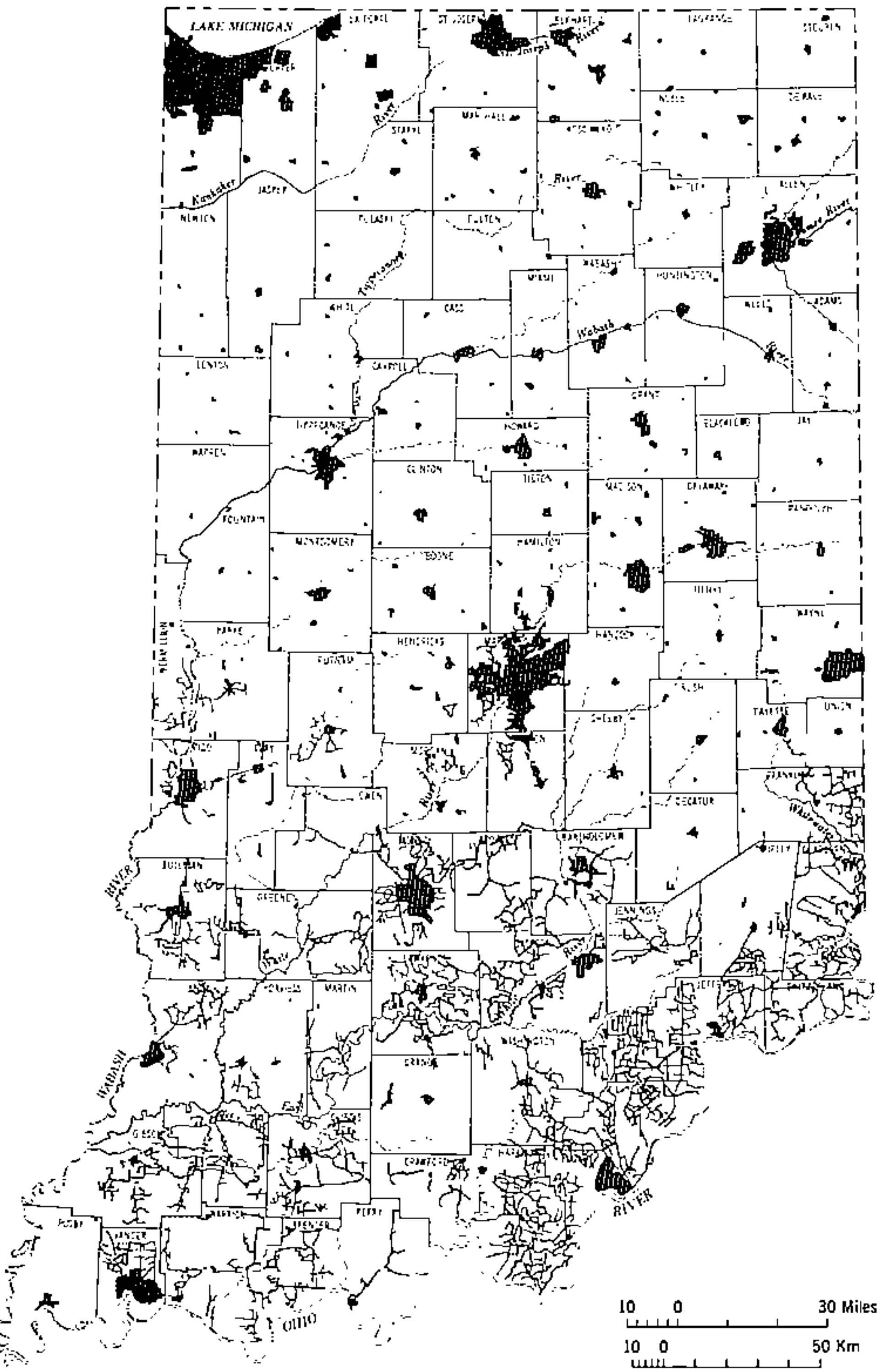


**Figure 31**
Map of Indiana showing the general location and extent of rural water supply systems.

in the proportion of the county population serviced by public water supplies versus self-supplied sources.

The water supply systems of seventeen representative counties were analyzed to predict the future proportion of Indiana citizens who will derive their water from self-supplied sources or from public water supplies. The following trends are expected to occur through the year 2000: (1) In the two large urban counties, Marion and Lake, there have been significant additions to the number of customers on public water systems, but the overall percentage of county population served has remained fairly stable. (2) There are a number of counties adjacent to major urban areas that are now undergoing rapid, suburban-type growth. Examples would be Porter, Hamilton, and Warrick Counties. In these counties, the percent of the population served by public water utilities is increasing rapidly. (3) There are a number of slower growing counties in southern Indiana with poor ground-water resources. In these counties there has been a rapid growth of rural water systems since about 1965. Consequently, there has been a rapid growth in the percent of the county population served by a water utility. This trend is expected to continue until approximately eighty to ninety percent of the county is served. (4) There are a number of counties in the north-central and northeastern parts of Indiana with abundant ground-water resources. These ground-water resources are so relatively abundant that there are a number of fair-sized towns which have no public water systems at all, and all water service is provided through individual wells. In these areas, there seems to be a modest decline in the overall percent of the county population served by a water utility.

The water withdrawal by public water utilities, from both the surface and ground-water resource, is projected to increase from approximately 554 million-gallons-per-day in 1977 to approximately 758 million-gallons-per-day by the year 2000, as indicated in Table 10. This represents an increase in water withdrawals of approximately 204 million-gallons-per-day over the next twenty-five years.

**Table 10**
Estimates of water withdrawals and water consumption for Indiana public water supplies.

| *Year* | *Population Served* | *Million-Gallons-Per-Day* | |
|---|---|---|---|
| | | *Water Withdrawals* | *Water Consumed* |
| 1977 | 3,631,820 | 554 | 69 |
| 1980 | 3,800,700 | 578 | 72 |
| 1990 | 4,153,500 | 670 | 84 |
| 2000 | 4,500,000 | 758 | 96 |

The proportion of the total population deriving its water supply from public utilities should remain relatively constant at sixty-eight percent. The method of making public water supply projections is presented in Appendix One.

The majority of the water that is distributed through the public water supply systems is returned to a source of supply, generally through sewer systems and waste water treatment facilities. The water that is not returned to a source of supply is defined as "consumed." The rate of water consumption supplied through the public water utilities is projected to increase from approximately 69 million-gallons-per-day in 1977 to approximately 96 million-gallons-per-day by the year 2000.

There are a number of trends in America today that may affect these water withdrawal and consumption projections. For example, water has been regarded in the past as a more or less "free" commodity. That is, the cost is relatively minor as to not substantially affect the overall use. As standards of treatment become more rigorous, the cost of water will increase. The development of new sources of supply to meet increased demand may also increase the cost. These increased costs will be reflected in the consumer's bill. The higher utility costs may induce both domestic and industrial customers to conserve water, thereby decreasing demand.

## Industrial Water Supply

Approximately 8,300 manufacturing establishments operate in Indiana, employing over 677,000 workers. According to the U.S. Department of Commerce (the *1976 Annual Survey of Manufactures*) the electric, electronic machinery, electrical equipment and supplies, primary metal products, transportation equipment, machinery except electrical, and fabricated metal products industries account for sixty-four percent of total employment of Indiana manufacturing establishments. The primary metal products, instruments and related products, electrical equipment and supplies, machinery except electrical and fabricated metal product industries account for sixty-eight percent of the Indiana manufacturing payroll.

Industries require the use of process water, cooling and condensing water, boiler feed water, and sanitary water. Process water, the most typical industrial use of water, comes into direct contact with the final product or materials during the manufacturing process. Cooling and condensing water is the largest single category of industrial water use. Boiler feed water is a major industrial water use to develop steam for various processes. Sanitary water is used for maintenance, health, and the general comfort of industry employees.

Industrial water intake is composed of water derived from public water supplies or from self-supplied industrial water withdrawals. Total industrial water intake in 1977 approached 3,720 million-gallons-per-day. Of this statewide industrial water use, approximately ninety-three percent was self supplied, while the remaining seven percent of industrial water use was supplied by public utilities.

The primary metal industries, located within one of the world's largest industrial centers along the Lake Michigan shoreline of Lake and Porter Counties (Region One-A), constitute over seventy-seven percent of all industrial self-supplied water withdrawals in Indiana. Excluding the Lake Michigan industrial complex, the state's industries withdrew 602 million-gallons-per-day of self-supplied water in 1977.

The significant statewide, self-supplied industrial water intake by industry group, is listed in Table 11. Of the 3,457 million gallons self-supplied by industry, approximately four percent is consumed.

**Table 11**
Self-supplied water withdrawals by industry.

| *Industry* | *Million-Gallons-Per-Day* |
|---|---|
| Primary metal products | 2,913 |
| Petroleum refining and related products | 213 |
| Chemicals and allied products | 96 |
| Rubber and miscellaneous rubber products | 30 |
| Food and kindred products | 56 |
| Fabricated metal products | 47 |
| Transportation equipment | 42 |
| Electrical machinery, equipment and supplies | 36 |
| Machinery, except electrical | 19 |
| Other | 5 |
| Total | 3,457 |

*Projections* Projections of industrial, self-supplied withdrawals and consumption were based upon a number of factors including current water use, projected population growth, projected industrial growth, and improvement in water use conservation techniques. The method of measuring current and projecting future industrial self-supplied uses is detailed in Appendix Two. Table 12 indicates the current and projected uses by industrial self-supplied systems between 1977 and 2000.

The 1977 self-supplied industrial withdrawals and the projected water withdrawals indicate that no major change in the rate of withdrawals is to be expected, although water consumption is projected to increase fifty-seven percent by the year 2000. Projected industrial self-supplied water withdrawals are expected to remain at current levels, even though Indiana industrial growth is estimated to increase by four to five percent each year. The difference between the projected water withdrawals and projected industrial growth rates is expected to be met by increasing water use efficiency and conservation practices.

**Table 12**
Current and projected self-supplied water withdrawals and consumption.

| *Year* | *Million-Gallons-Per-Day* | |
|---|---|---|
| | *Withdrawn* | *Consumed* |
| 1977 | 3,457 | 147 |
| 1980 | 3,286 | 155 |
| 1990 | 3,317 | 202 |
| 2000 | 3,430 | 257 |

## Rural Water

Water used for livestock and residential purposes, and not supplied by a public water utility, constitutes a rural water use. Livestock includes animals such as hogs, dairy cattle, beef cattle, sheep, chickens, and turkeys. The current use of water was estimated by the population of livestock by class together with residential uses of water. The methodology for estimating current and projected rural water use through the year 2000 is included in Appendix Three. Table 13 indicates the current and projected rural water use in Indiana.

**Table 13**
Current and projected rural water use.

| *Year* | *Million-Gallons-Per-Day* | | |
|---|---|---|---|
| | *Livestock* | *Residential* | *Total* |
| 1977 | 43 | 104 | 147 |
| 1980 | 44 | 111 | 155 |
| 1990 | 48 | 134 | 182 |
| 2000 | 53 | 156 | 209 |

In 1977, rural water use was estimated at approximately 147 million-gallons-per-day, with residential use constituting the largest portion at 104 million-gallons-per-day. The rural residential use of water is projected to increase by forty-four percent, while the livestock use many increase by twenty-three percent by the year 2000.

## Irrigation

Irrigation is a seasonal water use, normally beginning in June with peak application rates during the months of July and August. During the season, irrigation water represents a significant portion of Indiana's total water withdrawal. Because irrigation water is intended to replace water transpired by the treated crop, it is considered a total consumptive use. Irrigation water use will vary from year to year depending upon the amount and distribution of rainfall during the growing season. Above-normal rainfall will decrease the need for irrigation while below-normal rainfall will increase that need. Irrigation in Indiana is and will no doubt continue to be practiced as a supplement to seasonal precipitation, as opposed to the arid West where irrigation may be the major source of supply.

The purpose of irrigation is to increase crop yields by replacing water in the root zone. In general, it is those coarser-grained, reasonably well drained soils that are the prime candidates for the practice of irrigation. Figure 32 indicates the location and extent of those Indiana soil associations that appear to possess an economic potential for irrigation. Those soil associations with a *very high* rating are expected to respond yearly to irrigation. If crops respond favorably every three to four years out of five years the irrigation potential is *high*. However if crops respond to irrigation one to two years in five years the irrigation potential is *medium*. A *low* irrigation potential indicates little or no profitable response by crops to irrigation.

A soil association is a landscape that has a distinct pattern of soils. These associations are commonly composed of from two to four major soils plus a few minor soils. Indiana has been subdivided into fifty-five state soil associations. Some soil associations, identified as potentially irrigable may contain individual soils with no economic potential for irrigation.

*Projections* An extensive survey made in 1978 indicated that 64,600 acres were irrigated in 1977. It is projected that an estimated 157,300 acres may be irrigated by the year 2000. However, the total of Indiana soil associations having economic potential for irrigation exceeds 838,000 acres. Table 14 indicates current and projected agricultural irrigation water withdrawals through the year 2000.

**Table 14**

The 1977 and projected water withdrawals for agricultural croplands during wet, average, and dry irrigation seasons.

| Year | Million-Gallons-Per-Day | | |
|---|---|---|---|
| | Wet Year | Average Year | Dry Year |
| 1977 | 135 | 170 | 227 |
| 1980 | 161 | 202 | 269 |
| 1990 | 248 | 309 | 411 |
| 2000 | 335 | 416 | 552 |

The range of water withdrawals represents estimated irrigation during wet, average, and dry years, depending upon the amount of precipitation during the growing season. Golf course irrigation accounted for an additional water withdrawal of approximately 27 million-gallons-per-day in 1977. Projected golf course irrigation by 2000 may approach 36 million-gallons-per-day.

The source of irrigation water is dependent upon the water availability in the region. Table 15 indicates current and projected ground-water withdrawals for irrigation on a statewide basis. The difference between ground-water withdrawal and total water withdrawal, as indicated on Table 14 represents the surface-water withdrawal for irrigation. The methodology for making water withdrawal projections for irrigation purposes is shown in Appendix Four.

**Table 15**

Current and projected ground-water withdrawals for the irrigation of croplands during wet, average, and dry irrigation seasons.

| Year | Million-Gallons-Per-Day | | |
|---|---|---|---|
| | Wet Year | Average Year | Dry Year |
| 1977 | 67 | 81 | 107 |
| 1980 | 87 | 106 | 141 |
| 1990 | 153 | 189 | 251 |
| 2000 | 218 | 272 | 361 |

## Energy Production

The production of energy, both directly through the generation of electric power and indirectly through the extraction of coal, oil, and gas places a significant demand on Indiana's water resource. Ninety-nine percent of the installed electric generating capacity in Indiana consists of coal-fired boilers providing steam to turbines coupled to generators. This process involves substantial amounts of water for cooling and is the largest single category of water use in Indiana.

Indiana's coal production amounted to about 24 million tons in 1977. The coal reserves are estimated at thirty-three billion tons. The extraction of coal requires water for coal washing, dust control, and maintenance of surface, coal mining operations.

Oil occurs in various geological formations in the state at depths ranging between a few hundred to over three thousand feet. Oil production in 1977 amounted to 5,314,470 barrels, and commercial gas production was 183 million cubic feet. Water is used in the production of oil through the process of water flooding, whereby water is pumped under pressure into the oil bearing formations resulting in substantially greater recovery of oil. Such water flooding, or secondary recovery, operations accounted for approximately forty-five percent of total production in 1977.

The major uses of water associated with energy production are electrical power generation, coal production, and oil recovery.

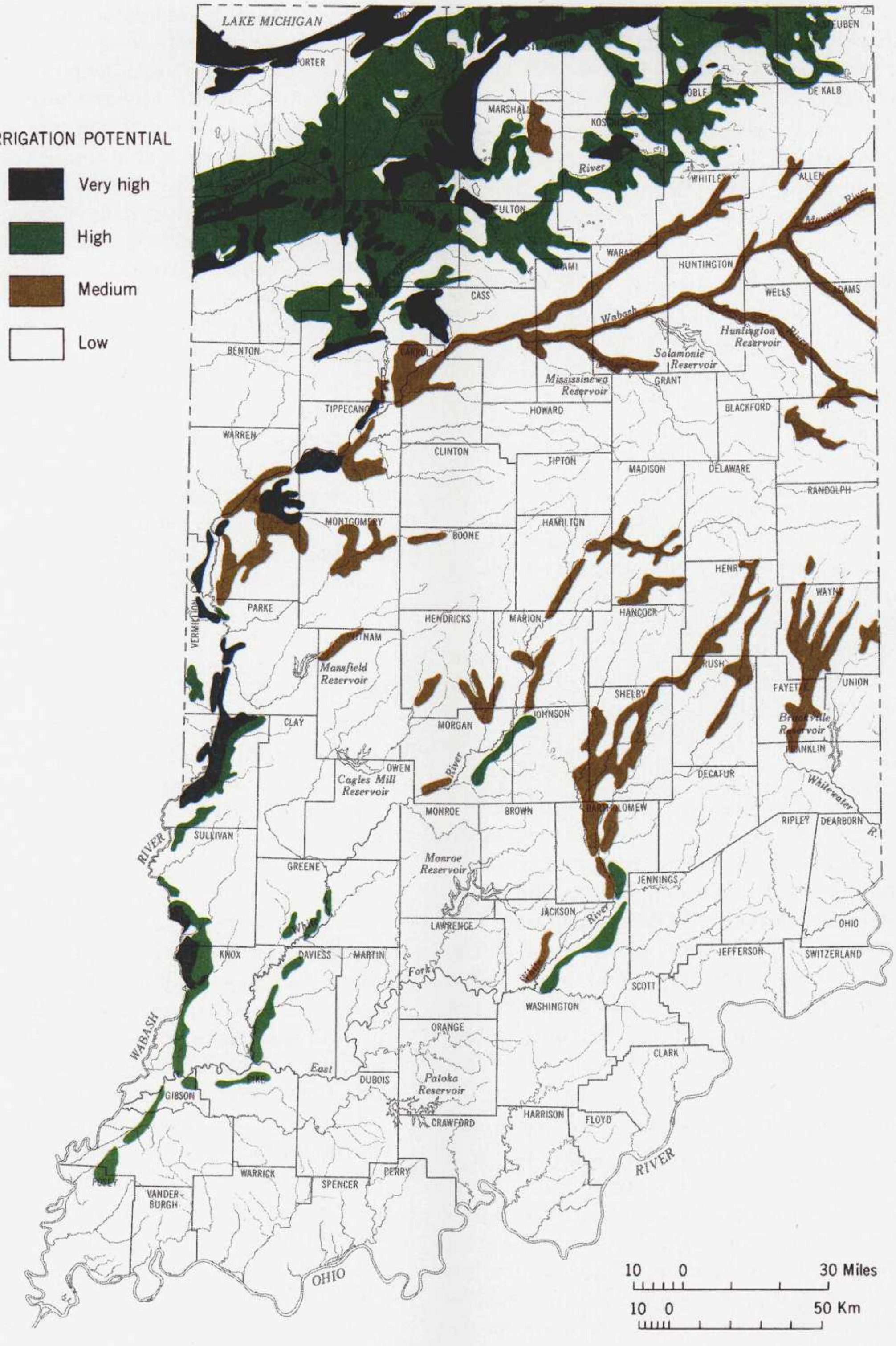


**Figure 32**
Map of Indiana showing the general location of soil associations with an economic potential for irrigation.

**Electrical Power Generation** There are three methods used to generate electrical power in Indiana: hydroelectric, internal combustion, and coal-fired. In 1976, less than one percent of electrical energy was generated by hydroelectric and internal combustion generating plants.

Hydroelectric power generation as discussed previously under "Instream Uses" does not constitute a consumptive use of water. Internal combustion generating facilities require only modest amounts of water.

Approximately ninety-nine percent of all electricity produced in 1977 was by coal-fired, steam generating plants. These coal-fired plants require substantial amounts of water. The coal-fired, steam generation process involves super-heating water to steam and passing the steam under high pressure to the steam turbines. Temperatures as high as 1,050 degrees Fahrenheit and pressures as high as 3,500 pounds per-square-inch are common in modern plants. The super-heated and pressurized steam is passed through a series of turbines, or large rotors, with affixed blades which in turn drive the electrical generators. A substantial amount of water is required to cool and condense the turbine exhaust steam back into water. As the once superheated steam is condensed back into water, it yields a significant quantity of heat. It is this heat which is removed by the cooling water. The common methods of removing this heat are once-through cooling, cooling lakes, and cooling towers.

The once-through cooling method involves withdrawing water from a river or stream and circulating this water through the condensers. The cooling water, which is heated in the process, is discharged back into the parent stream, with temperatures normally elevated from 10 to 15 degrees Fahrenheit. Small quantities of water are consumed in the process. The once-through cooling method is limited to those power plants located on or near streams with high, sustained flows.

The cooling lake method is similar to the once-through method except that water is withdrawn and returned to a lake rather than a surface stream. In order to utilize this method, the utility may create a lake by damming an existing stream or by creating an off-stream lake within containing dikes or levees. Water is circulated across the condensers in the same manner as the once-through method. The water on the surface of the lake is cooled by natural processes, giving up its heat to the atmosphere. This method has an advantage over the once-through procedure in that there are no adverse thermal impacts on streams in the area. Cooling lakes require makeup water to replace that lost by both natural and induced evaporation and hence have a much greater consumptive use of water than the once-through method.

Cooling towers are another method of dispersing the heat associated with steam turbines. In evaporative cooling towers, the warm water from the condenser is passed through the tower where it is exposed to a draft of air and the temperature is lowered, principally by the process of evaporation. The cooled water is then recirculated through the condenser. Because the cooling process is dependent upon evaporation, the water consumption rates are highest for the cooling tower method. Evaporation accounts for approximately eighty-five percent of the water consumed, with additional losses resulting from spray and the periodic flushing of the cooling towers.

The majority of Indiana's generating capacity is represented by thirty-seven plants owned by eight utilities and five municipalities. Eighty-one percent of Indiana's electrical generator capacity is operated by five major utilities: Public Service Indiana, Indiana and Michigan Electric Company, Northern Indiana Public Service Company, Indianapolis Power and Light Company, and Southern Indiana Gas and Electric Company. The service area and type of generating facility operated by each of these utilities is shown in Figure 33.

Other companies with significant generating capacity are: Commonwealth Edison Company, Indiana-Kentucky Electric Corporation and the Hoosier Energy Division of Indiana Statewide Rural Electric Cooperative, Inc. Commonwealth Edison operates the State Line plant in the extreme northwest tip of the State of Indiana. All power generated by this utility is utilized in Illinois. The Indiana-Kentucky Electric Corporation operates the Clifty Creek Plant at Madison. Power generated by this facility is used in an atomic energy processing facility located in Pike County, Ohio. The Hoosier Energy plant is used to supply part of the power needs of seventeen of the forty-two Indiana Rural Electric Cooperatives. In addition, there are five municipal plants utilizing coal-fired boilers with plant capacities ranging from 14.5 to 93 megawatts (mw).

The water use figures, shown in Table 16, represent the quantity, in million-gallons-per-day, for water withdrawals and water consumption for each major electrical generating station in Indiana based upon data provided by the electric utilities. The identification numbers of the generating stations in Table 16 correspond to the same numbers on Figure 33.

*Projections* The unprecedented growth of American industry, commerce, and standard of living which commenced in the middle of the nineteenth century is based upon liberal use of abundant sources of energy. For years, energy sources were considered to be inexhaustible. In the 1970s, the general public became

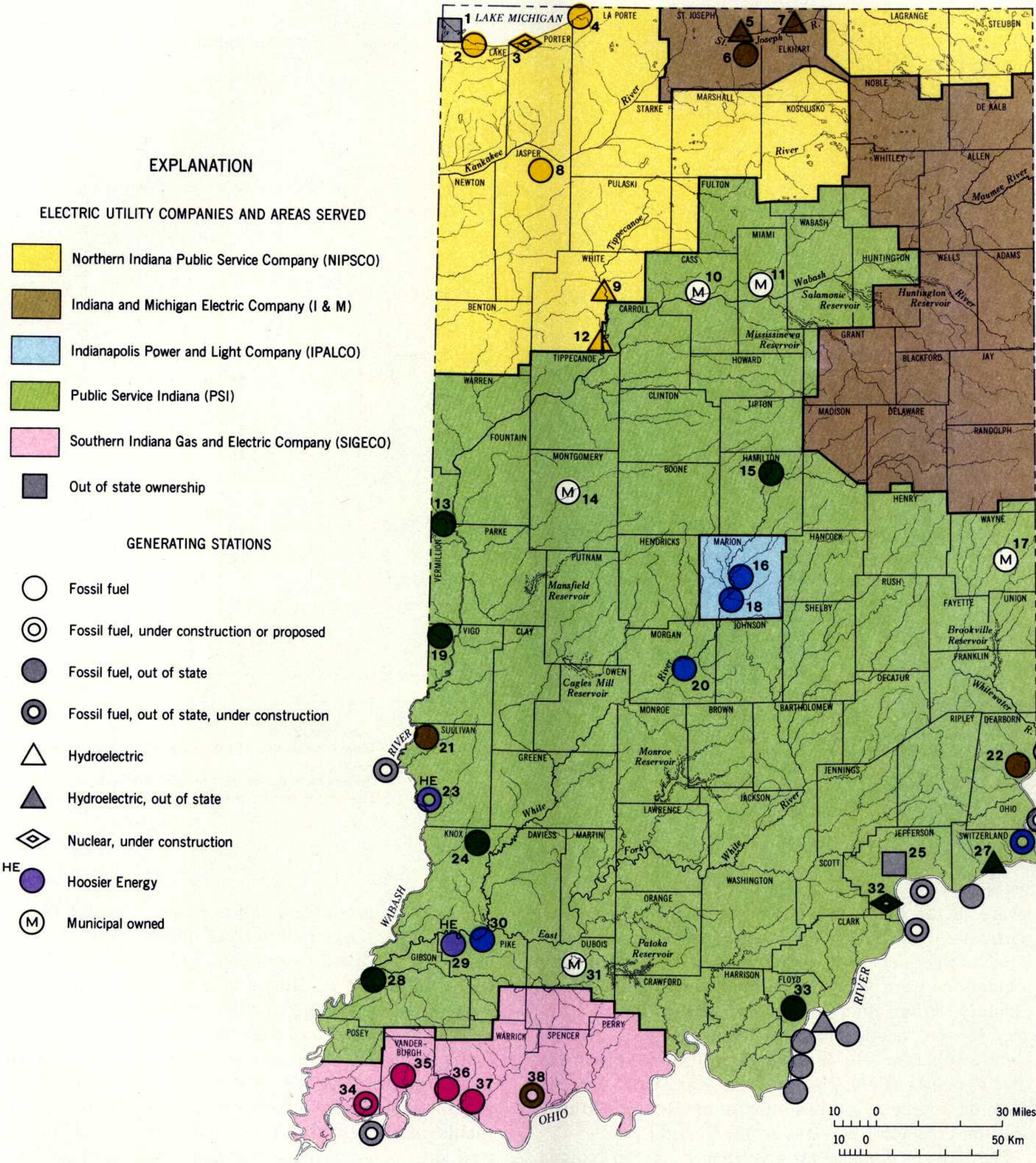


**Figure 33**
Map of Indiana showing the service areas of the major electrical utilities and the location of existing and proposed facilities. The numbers correspond to the reference numbers on Tables 16 and 17. The service areas and symbols representing generating stations are shown in corresponding colors.

**Table 16**

Indiana's electric generating stations, their gross generating potential, type, and water requirements.

| *Reference Number* | *Plant* | *Owner* | *Nameplate Rating Gross (mw)* | *Cooling Type* | *Million-Gallons-Per-Day* | |
|---|---|---|---|---|---|---|
| | | | | | *Withdrawn* | *Consumed* |
| 1 | State Line | Con.Ed.[a] | 968 | OT[j] | 750 | 0 |
| 2 | Mitchell | NIPSCO[b] | 581.6 | OT | 398 | 3.0 |
| 3 | Bailey | NIPSCO | 649.5 | OT | 341 | 3.0 |
| 4 | Michigan City | NIPSCO | 736 | OT & Towers[k] | 158 | 13.0 |
| 6 | Twin Branch | I&M[c] | 250 | OT | 275 | 0 |
| 8 | Schahfer | NIPSCO | 520.8 | Towers[l] | 6.3 | 2.8 |
| 10 | Logansport | Mun.[d] | 38.5 | OT | 29 | 0 |
| 11 | Peru | Mun. | 37.5 | OT | 29 | 0 |
| 13 | Cayuga | PSI[e] | 1,075 | OT[m] | 852 | 0 |
| 14 | Crawfordsville | Mun. | 24.15 | Towers | 0.7 | 0.7 |
| 15 | Noblesville | PSI | 111 | OT | 125 | 0 |
| 16 | Perry | IPALCO[f] | 59 | OT | 7.6 | 0 |
| 17 | Richmond | Mun. | 93 | Towers | 3.3 | 2.6 |
| 18 | Stout | IPALCO | 954 | OT & Towers[n] | 325 | 5.0 |
| 19 | Wabash River | PSI | 937 | OT | 747 | 0 |
| 20 | Pritchard | IPALCO | 412 | OT | 330 | 0 |
| 21 | Breed | I&M | 420 | OT | 318 | 0 |
| 22 | Tanners Creek | I&M | 1,066 | OT | 1,123 | 0 |
| 24 | Edwardsport | PSI | 175 | OT | 488 | 0 |
| 25 | Clifty Creek | IKEC[g] | 1,304 | OT | 1,424 | 0 |
| 28 | Gibson | PSI | 1,370 | Pond | 28.8 | 16.9 |
| 29 | Hoosier Energy | HE[h] | 255 | OT | 225 | 0 |
| 30 | Petersburg | IPALCO | 754 | OT | 386 | 0 |
| 31 | Jasper | Mun. | 14.5 | Towers | 0.18 | 0.1 |
| 33 | Gallagher | PSI | 680 | OT | 488 | 0 |
| 35 | Ohio River | SIGECO[i] | 128 | OT | 30 | 0 |
| 36 | Warrick | SIGECO | 732 | OT | 518 | 1.0 |
| 37 | Culley | SIGECO | 412 | OT | 373 | 0 |
| Total | | | 14,760.55 | | 9,492.88 | 48.1 |

[a]Commonwealth Edison Company
[b]Northern Indiana Public Service Company
[c]Indiana and Michigan Electric Company
[d]Municipally owned
[e]Public Service Indiana
[f]Indianapolis Power and Light Company
[g]Indiana-Kentucky Electric Corporation
[h]Hoosier Energy
[i]Southern Indiana Gas and Electric Company
[j]Once-through
[k]Units representing 71 percent of plant capacity on towers
[l]Cooling tower
[m]Towers used during high temperature periods
[n]One unit is cooled by tower

aware of the finite nature of the fossil fuel reserves, particularly oil and natural gas. Energy prices escalated as the effect of fuel scarcities and environmental regulations were phased into the United States energy industry. Future energy demands, and the mix of energy sources needed to meet those demands, are not clearly apparent. The forecasting of future electric energy demands is complicated by the apparent scarcity of some energy resources, environmental regulations, and the consumption rates of the general public.

The current demand for electrical power in Indiana is increasing approximately three and one-half to four and one-half percent per year. A number of studies by the utility industry, public interest groups, and various government agencies have forecast future growth rates ranging from three to eight percent per year. The midrange estimate of future growth of five percent per year is most probable. Long term growth rates of less than three and one-half percent appear to be unlikely. On the other hand if economic growth is vigorous in the remainder of this century, growth rates of approximately six and one-half percent may occur.

It is anticipated that over the next twenty-five years, a number of the older, smaller, generating stations will be retired from service. At the same time, several utility companies have announced expansions to existing plants or the construction of generating facilities at new sites. A list of these facilities is indicated on Table 17 and they correspond with Figure 33.

Assuming all of these planned facilities will be constructed as announced, Indiana's installed nameplate capacity should grow from 14,761 megawatts (mw) in 1977 to 18,000 mw in 1980; 26,500 mw in 1990; and then decrease to 21,700 mw in the year 2000 as older

**Table 17**
Announced expansion and new generating facilities, their gross generating potential, type, and water requirements.

| *Reference Number* | *Plant* | *Owner* | *Nameplate Rating Gross (mw)* | *Cooling Type* | *Fuel* | *Anticipated Consumption (mgd)* |
|---|---|---|---|---|---|---|
| 3 | Bailey | NIPSCO | 660 | Towers | Nuclear | 5.8 |
| 8 | Schahfer Unit (15) | NIPSCO | 527 | Towers | Coal | 3.1 |
| 17 | Whitewater Valley (Richmond) | Mun. | 100 | Towers | Coal | .6 |
| 23 | Merom | HE | 980 | Lake | Coal | 21.3 |
| 26 | Patriot | IPALCO | 1,950 | Towers | Coal | 25.5 |
| 28 | Gibson Unit (3,4) | PSI | 1,373 | Pond | Coal | 16.8 |
| 28 | Gibson Unit 5 | PSI | 696 | Pond | Coal | 8.5 |
| 30 | Petersburg | IPALCO | 1,064* | Towers | Coal | 6.2 |
| 32 | Marble Hill | PSI | 2,380 | Towers | Nuclear | 36.5 |
| 34 | Brown | SIGECO | 615 | Towers | Coal | 3.6 |
| 38 | Rockport | I&M | 2,600 | Towers | Coal | 32.3 |

Reference numbers correspond to plant location numbers on Figure 33.
*532 mw of the 1,064 listed became operational in 1977.

units are retired. It should be noted that the announced construction-anticipated retirement schedule is sufficient to support an approximate four and one-half percent growth rate to the year 1990, but that there may be an anticipated shortfall of 23,400 mw by the year 2000.

The electrical generating capacity necessary to support the projected five percent growth rate is presented in Table 18. Similar data for the three and one-half percent and six and one-half percent growth rates are indicated in Appendix Five. Listed under the heading "Shortfall" is the additional nameplate capacity which must be developed to sustain the possible growth rates. These predicted shortfalls may be overestimated if the utility companies leave older, less economical units in service longer than anticipated. On the other hand, the shortfall may be underestimated if the utilities do not implement their plans for new generating facilities.

**Table 18**
Projected, required, and available generating capacities based on the five percent growth rate.

| *Year* | *Required Capacity Megawatts* | *Available Capacity Megawatts* | *Shortfall Megawatts* |
|---|---|---|---|
| 1980 | 17,000 | 18,000 | 0 |
| 1990 | 27,700 | 26,500 | 1,200 |
| 2000 | 45,100 | 21,700 | 23,500 |

The translation of the shortfall capacity from terms of megawatts of capacity to numbers of new plants cannot be precise, due to the variability of size and the number of generating units installed at a particular site. However most new multi-unit plants range from 2,000 to 3,000 megawatts.

The projected electric power demand, based upon the five percent growth rate, is translated into water withdrawal and water consumption rates, as shown in Table 19. A substantial decrease in water withdrawals is projected between the years 1990 and 2000. This decrease in water withdrawals results from the anticipated retirement of a number of existing plants utilizing the once-through cooling method. The decrease from 9.5 billion gallons-per-day to approximately five billion gallons-per-day is not particularly influenced by the projected growth rates. As total withdrawal decreases, water consumption is expected to rise sharply as cooling towers and cooling lakes, with their high evaporative losses, replace the plants using the once-through cooling method.

**Table 19**
The current and projected water demands for a five percent growth rate in electric power production.

| *Year* | *Million-Gallons-Per-Day* | |
|---|---|---|
| | *Withdrawn* | *Consumed* |
| 1977 | 9,500 | 48 |
| 1980 | 9,500 | 78 |
| 1990 | 9,400 | 212 |
| 2000 | 5,000 | 354 |

Indiana is, in fact, expected to trade high water intake requirements for higher consumptive uses. As this expected transition occurs, the total water available for other purposes will decrease. Once-through cooling, while it has an adverse effect on water quality because of the increase in temperature, consumes (evaporates) substantially less water than the other cooling methods. In fact, the discharge from several existing once-through cooling stations forms part of the intake for a downstream generating facility.

New electric energy sites are expected to require water intake in the range of 30 to 80 million-gallons-per-day, depending upon the capacity of the generating station and the cooling method. About one-half of this water will be consumed. While this intake requirement is significantly lower than the intake requirements for existing plants, the state has only a few streams hydrologically capable of supporting new large scale energy facilities with their attendant consumptive uses. These streams are the Ohio River, the Kankakee River west of Starke County, portions of the St. Joseph River in St. Joseph and Elkhart Counties, the Wabash River below Lafayette, the West Fork of the White River below Marion County, and the East Fork of the White River downstream from Bartholomew County, and most of these would require supplemental storage. While Lake Michigan has the capacity to support numerous energy facilities, the shoreline of that lake is committed to other uses. The only practical way to utilize Lake Michigan waters for additional power production purposes is to convert an existing industrial site to power generation. Air quality regulations then may become the final determining factor of power plant siting along the Lake Michigan shoreline.

**Production of Coal** Indiana's annual coal production has exceeded 20 million tons since 1969. Of this amount, approximately eighty-five percent is used to produce steam for electrical generation; the remainder is used for home heating and miscellaneous uses. In 1976 about seventy-six percent of the coal produced in Indiana was mechanically cleaned in ten preparation plants by washing with water, a process that lowers the sulfur and ash content by removing parts of the pyrite, shale, and non-coal materials. These ten plants used an average of nine million gallons of water a day, and are located as shown on Figure 34.

Not all the water used in coal preparation is consumed; much is recycled. In many instances water is obtained by diverting drainage within the coal mine property to the slurry pond, or water is obtained from artificial lakes that develop in the "final cuts" of mining. Some water is lost by evaporation from the ponds but the amount of loss is difficult to estimate. Ponds that have a large surface area, such as those built in flat areas using dikes and levees, will have greater evaporation than those using a deep final cut with a smaller surface area.

*Projections* Estimates of future water needs for coal preparation assume that no new technologies will develop to change water requirements. Based on this assumption and the assumption that the same percentage of coal will be washed in the future as today, water requirements will be functions of the coal pro-

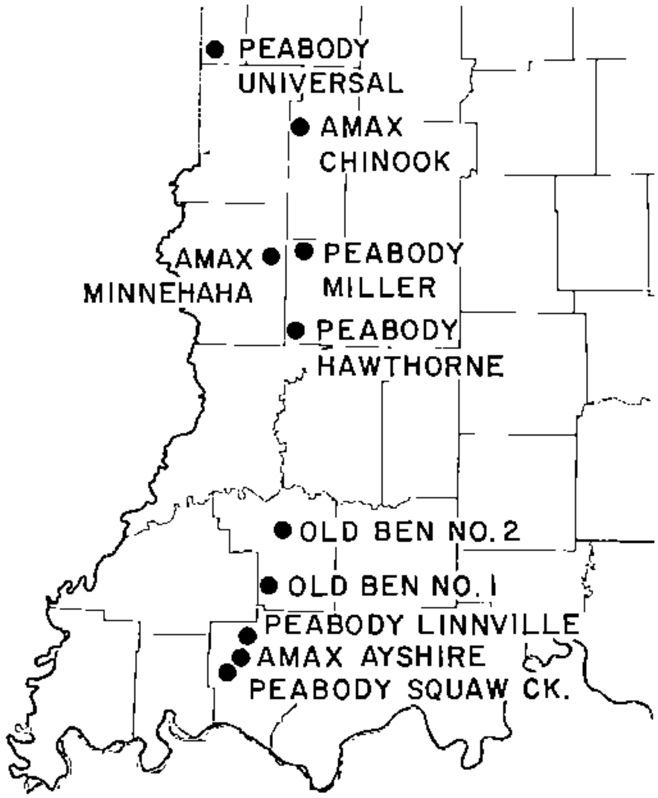


**Figure 34**
Map showing the location of coal preparation plants in Indiana.

duced. With a national effort to place more reliance on coal as an energy source, Indiana's coal production is most likely to increase in the future. The historical growth from 1967 to 1976 has been at an average four and one-half percent yearly increase. It seems reasonable to assume that the growth production will parallel the growth of Indiana power generation. Thus, water requirements for coal preparation in 1985 and 2000 are estimated at 14.9 and 31.2 million-gallons-per-day, respectively, as indicated in the following table.

**Table 20**
Water requirements to process coal by mechanical washing.

| *Year* | *Amount of Coal Processed in Million Short-Tons* | *Water Required in Million-Gallons-Per-Day* |
|---|---|---|
| 1976 | 19.3 | 9.2 |
| 1985 | 31.4 | 14.9 |
| 2000 | 65.4 | 31.2 |

**Coal Conversion** Coal is not currently being commercially converted to gas or liquid hydrocarbons in the United States. However, research sponsored by the United States Department of Energy is being conducted to determine the best practical method of coal conversion. Coal conversion to oil and gas requires large quantities of water. The single largest consumptive use of water in the conversion process is for cooling. Water also is needed to supply hydrogen that combines with carbon in coal to produce hydrocarbons, to treat waste sludge and ash, and to take care of miscellaneous mine and plant uses.

The water requirements for the different coal conversion processes currently under investigation range from about 12,000 to 22,000 gallons-per-minute for a gasification plant capable of producing 250 million standard cubic feet of gas per day. To place this in perspective, the city of Evansville uses about 20,000 gallons of water per minute; Indiana produced about 190 million cubic feet of gas during 1976. Thus, a conversion plant producing 250 million standard cubic feet per day would require about the same amount of water as the city of Evansville, but it would produce more gas in a day than is now produced in Indiana in a year. Indiana's annual consumption of natural gas is approximately 560 billion cubic feet, about fifty-five percent of which is used during the five month heating season.

**Oil Recovery** The secondary recovery of oil from the geologic formations underlying Indiana requires water. Since this water is injected into deep geologic formations, it is essentially lost for other uses. The majority of the injected water is brine water produced in oil recovery operations and ground water.

Oil producers are not required to report the amounts of water used in their operations, so there are no reliable estimates of the amount of water consumed. The best current estimates are about one million gallons-per-day of potable water being used for oil recovery. Since Indiana's oil reserves are declining, it is anticipated that this figure will decline in the future, unless more sophisticated recovery methods are developed.

## Summary

The total current and projected water demands on the Indiana water resource for public water supply, industrial self-supply, rural water supply, irrigation, energy production, coal processing, and oil well injection are shown in Table 21. As indicated, approximately 13,858 million-gallons-per-day were withdrawn in 1977 with less than five percent consumption. However, as water withdrawals decrease by the year 2000 to approximately 9,895 million-gallons-per-day, the rate of water consumption may increase more than fourteen percent. This decline in water withdrawals and increase in water consumption is due largely to a technological change from the once-through cooling method to cooling towers or cooling lakes in the production of energy. The unallocated energy category represents those additional power plants which would be constructed to meet the projected energy demand by the years 1990 to 2000.

**Table 21**
The current and projected water withdrawals and consumption
in million-gallons-per-day within Indiana.

| *Water Use* | *1977* | | *1980* | | *1990* | | *2000* | |
|---|---|---|---|---|---|---|---|---|
| | *Withdrawn* | *Consumed* | *Withdrawn* | *Consumed* | *Withdrawn* | *Consumed* | *Withdrawn* | *Consumed* |
| Public Water Supply[a] | 553.69[b] | 68.75[b] | 577.91 | 72.30 | 670.07 | 84.41 | 757.64 | 96.07 |
| Industrial Self-Supply | 3,456.94 | 146.71 | 3,286.29 | 154.69 | 3,317.45 | 201.71 | 3,430.35 | 256.53 |
| Rural Water | 147.27 | 147.27 | 155.36 | 155.36 | 182.42 | 182.42 | 209.37 | 209.37 |
| Irrigation[c,d] | 196.77 | 196.77 | 234.42 | 234.42 | 341.60 | 341.60 | 451.65 | 451.65 |
| Energy[e] | 9,492.88 | 48.13 | 9,490.68 | 77.73 | 9,359.18 | 204.73 | 4,705.33 | 203.88 |
| Unallocated Energy[f,g] | 0.00 | 0.00 | 0.00 | 0.00 | 15.40 | 7.50 | 308.00 | 150.00 |
| Coal Processing | 9.20 | 9.20 | 11.30 | 11.30 | 21.03 | 21.03 | 31.20 | 31.20 |
| Oil Well Injection[h] | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Total | 13,857.75 | 617.83 | 13,756.96 | 706.80 | 13,908.15 | 1,044.40 | 9,894.54 | 1,399.70 |

[a]Public water supplies projections are from the "13 Cities" projection series.
[b]Figures for 1975 calendar year with exception of Region 10 which is 1977 data.
[c]Represents irrigation for an average year of precipitation during the irrigation season of July through August for croplands and golf courses.
[d]1980 and 1990 values by interpolation.
[e]Represents values attributed to existing and announced energy facilities.
[f]Represents withdrawal and consumption for future electric power generating stations. Sites for these stations have not yet been identified. No allowance has been made for coal classification or liquification.
[g]Projections are based on the midrange growth rate of 5 percent.
[h]Insufficient data to project trend.